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Ministry of Higher Education &
Scientific Research University of Anbar

The Second International Scientific Conference of Water

Towards Strategic Vision for Water Management and Achieve Sustainable Development

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15-16/ March/ 2023
University of Anbar, Iraq

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The Second International Scientific Conference of Water

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The Index

Introduction:

Scientific research is the pillar of the renaissance and the axis of the basis for comprehensive development, and the Euphrates River represents the lifeline of vast areas of Iraq and this river has been known as the River of Civilizations for the succession of giant civilizations on its wonderful banks since the dawn of history and any serious study in the development of this region must be concerned with the study of the Euphrates Basin and its enormous natural and human resources, hence the interest of the University of Anbar to develop a research centre that carries this message of great importance in bringing about comprehensive development through conscious management of resources this basin is strategic.

Since its establishment on 28/10/2008, this research centre has been keen to establish a scientific activity on the occasion of World Water Day (March 22 of each year) and openness to society through the establishment of research stations that were started with a terminal station in a modern dam for the importance of the place and its privacy, and this conference was one of the fruits of tireless scientific efforts through which the centre seeks to achieve the goals set, including optimal water management in this region to be the main supporter of other scientific and research activities through which we hope to achieve Sustainable Development Goals:

The most important activities of the centre since the date of inception can be summarized as follows:

- Creating a research line in the designs of small multi-purpose dam chains and supervising a number of master's students in the Faculty of Engineering in this field.
- Creating a station to measure evaporation from under the soil surface and installing it at the university site and supervising master's students in Anbar engineering in this specialization.
- Obtaining a patent in irrigation water management.
- Manufacture of various hydrological devices for sediment shop measurements in rivers (in cooperation with the Engineering Consulting Office).
- Concluding research and scientific cooperation agreements with the Spanish Centre (CITA), Salahaddin University – Erbil, and other research and academic institutions.
- Establishing three specialized laboratories in the centre containing many of governing bodies.
- Develop weather monitoring stations that work around the clock in data collection.
- Publication of more than 160 scientific papers in international and international refereed scientific journals.
- Contribute too many international and local conferences.
- Holding many of seminars and seminars and crowning the experiences gained in this field in the establishment of the Second International Water Conference, in which manyof specialists participated and hundreds of those interested in water sciences, from inside and outside Iraq.
- Completion of many studies in areas that suit the research lines of the Centre.

Date: October 2023

Developing A Series of Weirs to System Improve Hydraulic Properties and Generate Hydroelectric Power in Rivers

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Abstract. In present paper, attempts were made to develop a system of weirs along Euphrates River in Iraq to solve the problem of the deficit in power and water resources. Geometric numerical models were created with geographic information system (GIS) with digital elevation model (DEM). The model includes visual basic programming to evaluate the power potentials according to an economic methodology based on the cost-benefit ratio (CBR). It estimates the cost, power profits, and determines the optimal height and number of small dams along the study reach. A system of three dams with a (4.3 m) in height can generate expected power of (45 MW) within (99%) of CBR. The system is simulated with the numerical model (HEC-RAS) to evaluate the river behavior with minimum, average, and maximum discharge values (270, 543, 815 m3/s) and study the hydraulic effect on the river. The hydraulic properties improve by (28%), the average depth increase with (27%), and a decrease in the variation caused by discharge changes. The river tendency is to store water with limited expansion in the surface area. The average surface area expands with (5%), the average storage increase with (35 %) especially in cases of low discharges.

1. Introduction

More than 50% of the inflow water to the Euphrates River in Iraq originate in the upstream riparian as shown by Al-Iessa etal [1]. Iraq suffering from a decrease in the water flow rate of Euphrates River because of the climate changes and drought resulted from the unequal sharing of water resources with Turkey, Iran, and Syria [2]. According to Al-Ansari [3], the discharges of Euphrates River decrease in Iraq sharply in last years because of Turkey's massive GAP project as well as projects in Syria as shown in figure (1). These means will reduce Iraq's share of the Euphrates from 19-21 billion cubic meter to just 9 and less in a drought year. Based on Sulaiman, etal [4]In 2035, if Turkey and Syria work towards achieving and complete the full plans for these programs, the amount of water flowing into Iraq will drop by 24%.

Figure 2, shows the effects of dam's project on the discharge in Euphrates River. The decreasing of discharges in Euphrates River causes significant negative effects on the irrigation, and agriculture projects when the decreasing flow rate lead to drop water level in river. Also, the major hydro-electric power station in Haditha dam was affected and the production energy reduced more than 50%. The river salinity can increase because of dam's construction of the neighboring countries, which lead to decrease of flow rate in river as shown by Abbas, etl [5]. The decrease in water flow rate leads to an increase in the concentration of polluted materials. Pollution causes a high level of toxic in water for the plants and animals in the river basin. The World Health Organization [6], achieved and conducting tests to know the water quality. It is found there is a high level of heavy metals as well as ammonia and bacteria. Rahi [7] reported the quality of water in Euphrates River depends on flow rate in river. He concluded the minimum flow rate in river should be maintained at (178 m3/s) to save water river with acceptable limit for irrigation. Rahi referred also that the mixing of high salinity water with fresh water from reservoirs can dilute the high concentration of salinity. Another problem with the Euphrates River is the absence of the international agreements to distribute and determine each country's share of the water.

Based on the above, it is necessary reconsideration into the adoption of water resources management; including future construction of hydraulic structures like dams, weirs, and regulators for

Date: October 2023

irrigation and electrical power plants. With the need for sustainable projects, third-world countries are developing greater resource development because of the expectations of the increasing number of people that lead to increased needs of local citizens especially the need for water and energy. These expectations refer to the population increasing by more than 80% in additional demand for food [8, 9].

The maturity of consumption, in terms of energy and water, makes the necessary of using the technologies and effective techniques [10].

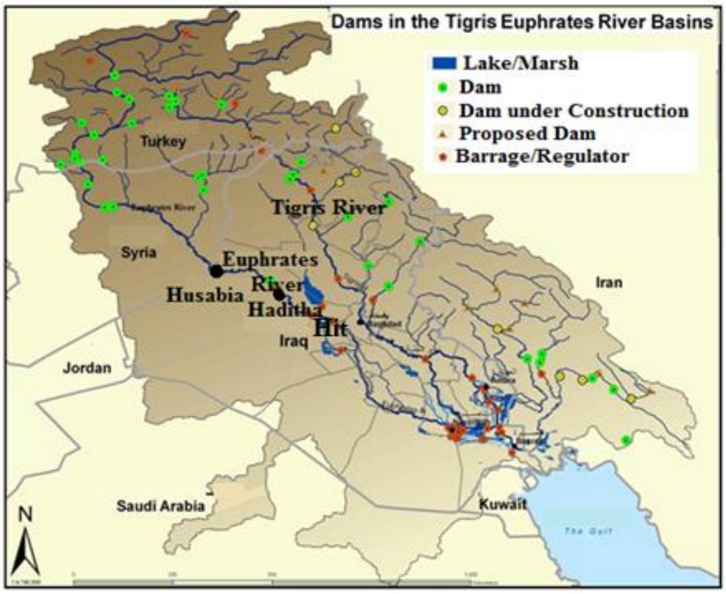

Figure 1. Dams in the Tigris-Euphrates River Basins

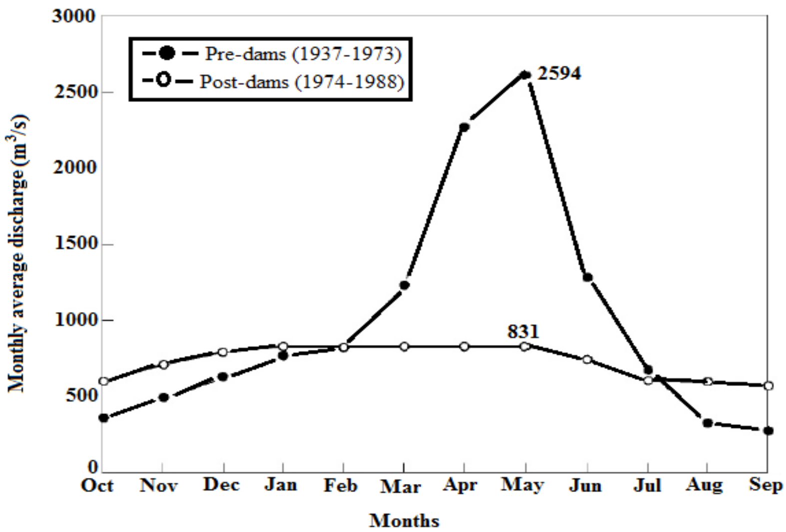

Figure 2. Comparison of Euphrates River discharge at Husaba (Iraq-Syria Border), Partow [11]

In the present study, a series of small dams system is suggested to raise the water level in river reach and save the elevations of water at design elevations of water supply, and irrigation projects. The behavior of river with series of small dam is studied to know the effects of it on the characteristics of flow. Also, the effort directed to use new technology like small hydro-power stations with optimal usage of valid water resources. The small hydro-power or the low-head hydro stations are developed to generate the hydropower from the series of small dams along the river as a source of renewal and green energy. In most countries over the world, hydropower is introduced as a good option because 71 percent of the land is covered by water, allowing for the generation of cheap and environmentally sustainable electrical energy that can grow rapidly [12].

Date: October 2023

This energy can be used to operate water treatment project and satisfy the increasing demand of energy. The two basic functions of dams are to form a water pond or reservoir that can use to storage water. This pond or reservoir can be used for mixing water with fresh water from Haditha dam for water quality improving. The second is to raise water levels to operate the irrigation, agriculture, and water supply projects along the river. Computer modeling and software can help us to study several scenarios for determining the efficiency of above technique for example, number, optimal height, and location of dams in the area under study and their effects on the river system.

2. Materials and Methods

The methodology includes modeling the extracted geometry from the study area with river modeling software from US Hydrologic Engineering Center-River Analysis System (HEC-RAS). Then, test the hydraulic and spatial variation in the river because of water surface change when establishing a series of weirs along the specified reach of the river. The number and height of dams are specified by the Small Dams Hydropower Evaluating Model (SDHEM) that is developed in present study depending on economic optimality to estimate the power potentials in the river. Geometry, hydraulic, and economic are the most important data that are needed. To achieve the research objectives, the tools obtained through the research methodology are employed according to the procedure in figure (3).

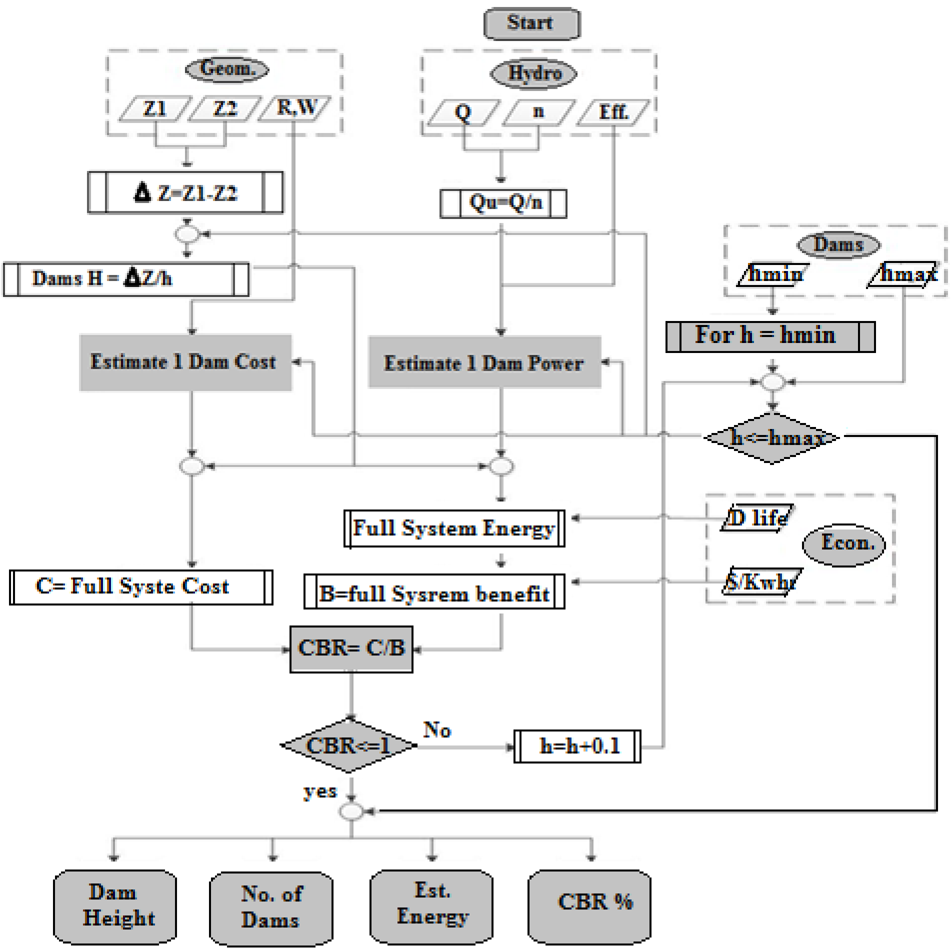

Figure (3), SDHEM logic flow chart

Visual Basic is selected because it provides a rich set of technically oriented commands and functions that will prove more than sufficient for solving any engineering problems. The model processes to determine and estimate the power potentials and related weir height and number are illustrated in figure (3).

Date: October 2023

One of the essential inputs in the system is the power selling price ($/Kwh), which is relative to the power production cost which widely varies depending on spatially, technically, and economical aspects, so in the model we make it the user defined value for more choices. The estimated cost will be converted to a power production cost ($/Kwh) according to the designed life of the system which is also user defined value, which will be one of the system optimality constrains. The cost/benefit ratio (CBR) is the main constrain of the model which will be the main decision station in the system. Its value initially assumed 100% to neglect the expected revenue from the system and suggesting system according the balance between the cost and the benefit, and it can be changed in the model base program. Also the CBR target value can be changed by reprograming the statement related to it in the model program. If the calculation crosses with constrains, the model will jump to the output phase or it will start over with other value of height, the outputs will include the suggested dam height, the number of dams, and the total potential power estimation. The resulted model is named Small Dams Hydropower Evaluating.

2.1. Cost Estimation of Low-Head Hydraulic System

A similar methodology is applied for developing the model which is unparalleled among RETScreen technology models. It offers two ways for costing the project including the method of detailed costing, and the formula costing. The last one is based on empirical equations developed to relate costs to crucial project parameters. The costs of numerous projects have been used to develop the formulae according to RET Screen [13].

Model (SDHEM) which is totally differ from RETScreen model and only sharing the costing formulas which can be replaced with any set of formulas in the same form of height and power. The VB model is iteration based program through looped process constrained by balancing limit, while RETScreen is Excel based worksheet process using the inputs in continuous methodology to determine the required outputs

2.3. Digital Elevation Model (DEM)

Based on the DEM used in the present study (figure 4), the river reach starts at station (0) [(64500) m] NW of Heet station and ends at a station (37500) upstream. The number represents the distance of the station from the reach start figure (4). The cross-sections were surveyed along the river between Heet and the city of Haditha with 197 stations.

Figure 4 DEM and satellite image for the studied reach

2.4. Geometry of River Reach

Reach-average hydraulic geometry (RHG) represents the relations of the average hydraulic variables (water depth, velocity, channel width) with the discharge. According to Navratil [14], these relations, as follows:

$$W = \alpha Q^{b} \text{.........}(1)$$

$$D = cQ^{f} \text{..........}(2)$$

$$V = kQ^{m} \text{..........}(3)$$

Date: October 2023

When, W mean width, D the reach means depth, V the mean velocity, and Q the flow rate or discharge. The above equations used to compare the average hydraulic variables with six parameters: include three coefficients (α, c, k) and three exponents (b, f, m). Hydraulic geometry are studied with fluvial geomorphologists for decades, but with more investigated by stream ecologists. A total of (54) cross-section were processed in the present study and tagged according to location system combine between the original survived study and the present research requirements.

In HEC-RAS [15], the Manning coefficient values were determined for each cross-section based on Al-Fahdawi[16] who shows a good agreement between the stage of river observed in Heet gauge station and the calculated value using a numerical model. The Manning roughness for river channel = 0.033 and for the floodplain roughness = 0.05. Contraction or expansion of flow resulted from the cross section changes cause energy losses along the reach. Where the change in river cross section is small, and the flow is subcritical, coefficients of contraction and expansion are typically on the order of 0.1 and 0.3, respectively as shown by Bedient P. B. et al, [17].

2.5. Hydropower Evaluation Model

The main objectives in the study are the evaluation of power potentials in study reach. Cost / benefit ratio (CBR) is selected to be the dominant element controlling the evaluation process. Cost-benefit analysis is used to determine the economic feasibility of the system. On the cost side, Thomas [18] shown the main direct expenses are listed, including but not limited to, construction costs, future operation and maintenance expenses represented by the system of equation described before. The idea is establishing a system employs a set of costing equations to be compared with expected benefit from the suggested small dams through iteration process for dams' height within a user defined range. Small dams hydropower evaluation model (SDHEM) is windows program established in the present study to deal with a set of equation obtained from internationally certified program known (RETScreen) which is linked with power production equations (table 1). The equations are a function of the dam height (h) and solved for optimal height using Microsoft visual basic programming within economic optimality. On the benefit side, the project main purpose is the hydropower income; the dominant variables in this side are the design life and the power selling price that is left to be user defined values for more economical choices.

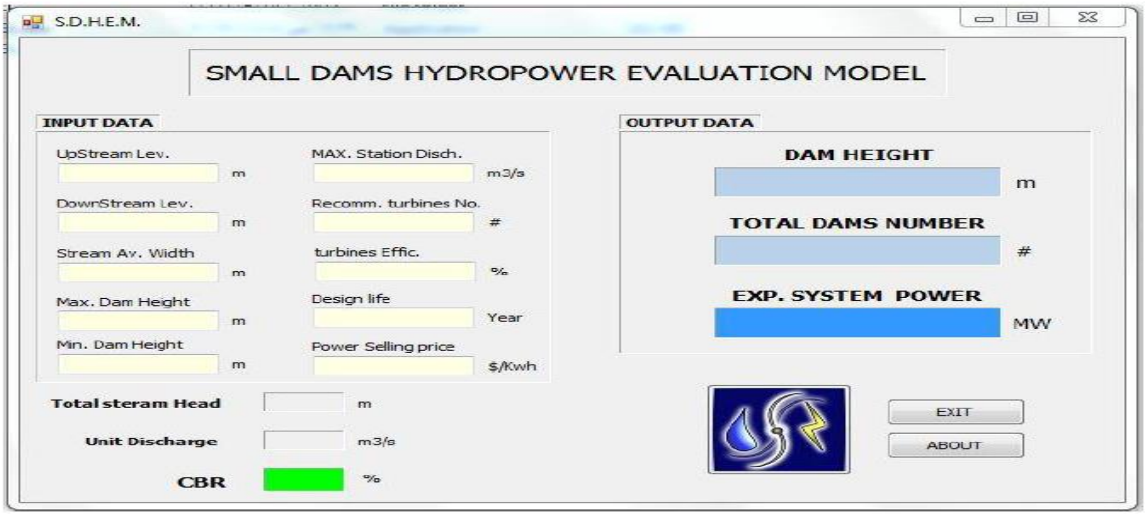

Figure 5 SDHEM interface

The program interface, figure (5) includes a field for CBR value, if it is less than 100%, it means that the system is profitable and the box will indicate green color, but if the system is not profitable it will show the value and indicate red color, in this case, the user has the choice to change one of the user defined fields especially the power selling price to meet the optimal case. If any data previously entered had been changed recalculation is required for new outputs.

3. Results and Discussion

To achieve the research objectives, the tools obtained through the research methodology are employed according to the following procedure, figure (6) describes the schematic flowchart for the procedure:

Phase I: Simulate the reach with three recorded discharge releases (lower, average, and higher).

Phase II: Using median discharge value and the extracted geometric characteristics to model the system in SDHEM for optimal height and number of small dams along the study reach, as well as the hydropower expected.

Phase III: Using AutoCAD and the geometric techniques to locate and add the small dams to the system.

Phase IV: Simulate the reach with small dams installed to determine the hydraulic and geometric changes within the same discharge values simulated in Phase I. Any discharge value can be modeled in the same procedure, but in SDHEM the values of dam height and recommended number of dams will be different, average discharge is selected as a benchmark for the present data. The tools obtained from methodology are not limited to use according to the present procedure, it can be used in other procedures for other set of data.

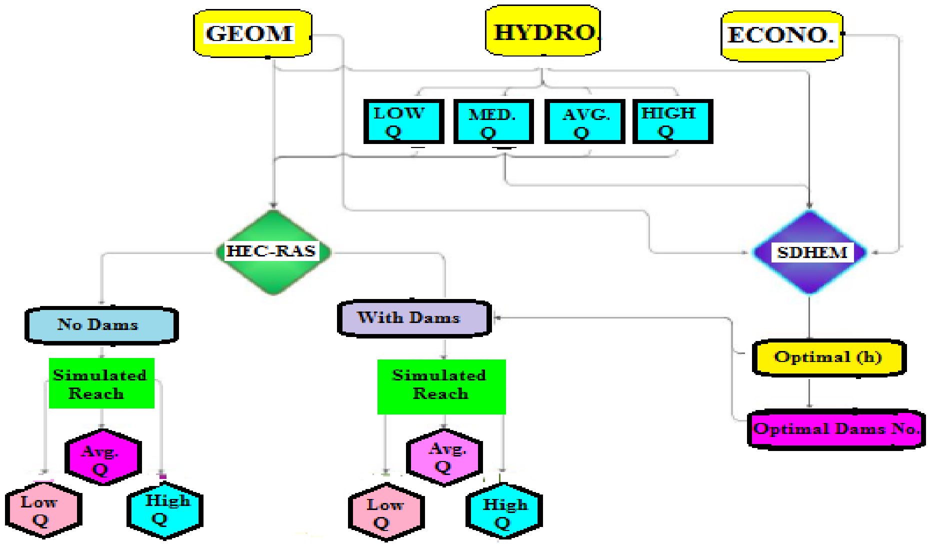

Figure.6 Research application flow net

3.1. Phase I: Present Reach Simulation

This phase starts with completely entered geometry and analyzed hydraulic records to HEC-RAS.

3.1.1 The Discharge Values: Haditha dam daily discharge records for 23 years (1985-2008) that are provided from Dam Administration [19] are statistically analyzed by Microsoft excel for the minimum, average, median, and maximum values. The median discharge value (450m3/s) is applied in SDHEM to design the weir system because it represents the normal variation of the weir releases. The absolute average value (543 m3/s), the minimum (270 m3/s) which is considered equal to the average minus the standard deviation, and the maximum (815 m3/s) which is considered equal to the average plus the standard deviation discharges are simulated to determine the water surface profile for average and extreme discharge conditions before then after establishing the suggested system of small dams to examine the changes related to the aim of this study.

3.1.2. THE BOUNDARY CONDITION: The average slope of the study reach (= 0.00027) form a boundary condition of the reach downstream (normal depth option) in HEC-RAS.

Date: October 2023

*3.2 P*hase *II: Estimation of Optimal weir System*

The geometric data calculated by simulation and analyzing process are maximum elevation for the reach (85.7 m), minimum elevation (71.2m), while the average river width is (331 m). The maximum weir heights assumed as (5 m), beside this value is user defined. The minimum weir height is assumed as (3.5 m), also this value is user defined. It affected by engineering sensitivity to the average water depths but it can provide a good solution to fix the maximum number of small dams in cases of limitation like but not limited to geological, economic, and social reasons. The hydraulic data are represented by the median discharge value (450 m3/s), and generating system of (4) turbines in duty which assumed as user defined option as mentioned before, currently it has direct effect on the system cost because it is related to the electro-mechanical equipment purchasing and O&M (operating and maintenance) costs, This option can also be useful if turbines manufacturer's limitation is considered especially if it is related to turbine inlet dimension, which means this value will have linked effect with the minimum dam height. According to Ozan K.,[20] the Small hydro turbines can attain efficiencies of about 90%, but we recommend (80%) for modeling as reasonable value for present electro-mechanic equipment. HATCH energy [21] reported the economic data includes the system design life which is assumed 50 years, and the unit selling price which has direct effects on the cost/benefit ratio thus it can effect on the whole system, so it can be reassumed by increase or decrease to meet the system optimality with reasonable CBR. It assumed depending on Wikipedia [18] (0.015 $/Kwh) which matches the international electricity selling prices.

3.3 Phase III: Small Dams Locating

HEC-RAS profile plot window includes a useful option in file menu [write DXF file]; with this option, the resulted profile drawing exported to a format is supported by AutoCAD which includes geometrical abilities used in locating the system of small dams along the reach. The exported file scaled to (y= 1/1) and (x=1/1000) for easy processing and navigating in AutoCAD. The opened file in AutoCAD process starts with dividing the vertical elevation difference into segments, its distance is equal to the optimal height of dam calculated by SDHEM, and then the recommended number of dams is distributed to cover the total reach height. In the present model, the total height difference = 14.6 m, and the recommended number of dams is 3 with a height of 4.3 m, which means it will cover (4.3x3= 12.9 m). The difference between reach height and covered height equal to (1.7 m) gives the system additional flexibility in locating the dams if there are any limitations.

3.4 Reach with Small Dams Simulation

The same geometric and hydraulic data plus the suggested system of small dams is simulated with HEC-RAS to calculate the new water profiles and the data related to it. The Table (1) describes the water surface profiles calculated through the simulation process. HEC-RAS provides 274 types of data related to the calculated water surface profile and other geometric and hydraulic options, and for the objectives of the present research. The obtained data for all cross-sections along the reach are statistically analyzed for average values and standard deviation for each discharge results to determine the major changes between calculated profiles. The data related to the previous three profiles are analyzed as illustrated in the table (2).

Table 1. details of simulated water surface profiles by HEC-RAS

Water Surface Name	Simulatn Condition	Simulated Discharge(m3/s)	Boundary Condition	Flow Regime
WSN270	*No Dams*	*270*	*Normal Depth*	*Subcritical*
WSN543	*No Dams*	*543*	*Normal Depth*	*Subcritical*
WSN815	*No Dams*	*815*	*Normal Depth*	*Subcritical*
WSN270	*Small Dams*	*270*	*Normal Depth*	*Subcritical*
WSN543	*Small Dams*	*543*	*Normal Depth*	*Subcritical*
WSN815	*Small Dams*	*815*	*Normal Depth*	*Subcritical*

Date: October 2023

Table 2. analyzed results for simulation process without dams

Profie	Q m3/s	Vavg m/s	SD	Flow Area m2	SD	Top Width (m)	SD	Hydraulic Radius (m)	SD	Water Depth (m)	SD	Surface Area (1000m2)	Water Volume (1000m3)
WSN270	270	0.69	0.23	426.21	116.2	309.6	80.7	1.41	0.3	2.76	0.5	10931.3	15135.5
WSN543	543	0.88	0.27	655.55	146.5	337.9	78.1	1.98	0.4	3.48	0.6	12076.2	23390.8
WSN815	815	1.01	0.26	843.17	168.7	355.6	73.4	2.41	0.4	4.03	0.6	12741.2	30194.2

The program interface with running return values , optimal dam height (4.3 m), recommended number of dams to be installed along the reach (3 dams) , the expected hydropower power production (45Mw) . The recommended system's expected CBR are equal to 99% and this value can also be recalculated by changing the user defined inputs and running the program again. The developed system profile and the resulted dams' system is added into HEC-RAS reach geometry are illustrated in Figure (8).

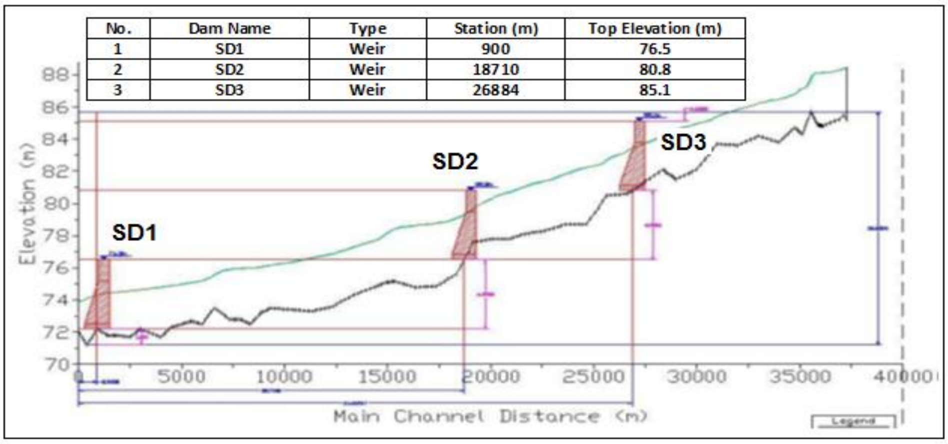

Figure 8 small dams locating, AutoCAD

7.4.1 Small Dams Water Surface Profiles: The data related to the new water surface profiles are also calculated and analyzed as shown in table (3):

Table 3. analyzed results for simulation process with small dams installed

Profile	*Q m3/s*	*Vavg m/s*	*SD*	*Flow Area m2*	*SD*	*Top Width (m)*	*SD*	*Hydraulic Radius (m)*	*SD*	*Water Depth (m)*	*SD*	*Surface Area (1000m2)*	*Water Volume (1000m3)*
WSN270	270	0.52	0.29	686.66	391.8	330.2	88.5	2.02	0.8	3.3	1.1	11741.5	23918.6
WSN543	543	0.74	0.32	858.55	352.3	352	84.4	2.42	0.7	3.8	1.1	12585.2	30122
WSN815	815	0.9	0.31	1006.07	327.3	366.3	78.9	2.75	0.7	4.2	0.6	13121.5	35466.9

3.5. Combined Analysis for Both Systems

According to Linsley R. K etl [19], the equations drawn as straight lines on a log-log sketch, the slope of the lines represented by the exponents and the coefficients the intercept when Q=1. The table (4) includes the calculated coefficients and exponents:

Tables 4. RHG variables for the study reach

Condition	Coefficients			Exponents		
	a	c	k	b	f	m
No small dams	***153.27***	***0.4073***	***0.0999***	***0.1256***	***0.3415***	***0.3452***
With small dams	***195.44***	***0.9669***	***0.0321***	***0.0936***	***0.2188***	***0.4975***

Helmio T. [22], explained depth will increase when discharge somewhat faster than does the width (f > b), in general, the exponent f is high and value of b is low in cohesive bed rivers when comparing the values presented by Bathurst. Also, the average depth leads to an increase in flow area, relative to the top width of the river cross-section, as discharge increases. Due to the depth of flow increasing higher than the width, the ratio of width to depth decreases when the discharge increases. The condition above reflects the stability of narrow channels when the banks are resistant the erosion relatively as offered by Rhodes [23]. Which is in the study case described by the tendency to flow and store water within the side banks of the reach. The velocity exponent m=0.4975 exceeds the water-surface width exponent b=0.0936 and mean depth exponent f=0.2188 and is greater than the sum of b and f. The exponent m refers to the rate of velocity change (and flow resistance) with discharge. High values of exponent m in natural rivers indicated that longitudinal channel variation had significant resistance effects through low water. In the present study, this resistance is described by the dams' role in bounding the flowing water especially in the low rates of discharge, against higher rate of release in case of increased discharge. These results indicate that a change in the reach width for a unit change in discharge is less for the reach with dams than for the original conditions, but it is correspondingly wider. Streams in the reach with dams are slightly deeper than those of the original conditions for the same discharge while the comparison between f exponent values indicates a higher response to increasing in depth against discharge variation in the original conditions than the system with small dams. Also, this is a result of dam's role in increasing the base depth of the reach. Examination of the width-to-depth ratios versus discharge indicates that the stream in the reach with small dams tends to be relatively more narrow and deep (i.e., lower width-to-depth ratios) at lower discharges, and hence smaller drainage areas, than the stream in the original conditions. When discharges and thus drainage areas increase, stream in the reach with small dams tends to widen slightly faster and become deeper more slowly than those of the original conditions. The negative sign of the exponent value in curves indicates that the stream in both conditions had a greater tendency to be deeper. For the cross section of the channel for conveying a given discharge, for given slope and roughness factor, some shapes are more efficient than others. The best hydraulic section is one that has the least wetted perimeter. Hydraulic radius is defined as the ratio of the channel's cross-sectional area of the flow to its wetted perimeter. So it is a measure of the channel flow efficiency, where the greater the hydraulic radius, the greater the efficiency of the channel and the less likely the river is to flood. The hydraulic radius values tend to increase as discharge increase in both conditions, but the value generally increases in case of established small dams. The total increased value at (815 m3/s) discharge is (12%), while it increases by (30%) at (270 m3/s) discharge, so the river will tend to the natural flow behavior in case of flood against an obvious increase in flow efficiency in case of low discharges. The magnitude of the bounded water volume and surface area expansion for the simulation discharges are extracted as shown in the table (5).

Table 5. Bounded Water Volume and Surface Area Variations against Discharge Variation

Q(m3/s)	*Bounded Water Volume (1000 m3)*	*Increased Surface area (1000 m2)*
270	***8783.11***	***810.24***
543	***6731.21***	***508.97***
815	***5272.73***	***380.36***

The reach tendency to storing water against less increase in surface area is clear especially for the low rates of discharge. The negative exponential sign in both curves indicates the decrease in small dams' impact as the discharge increases, meaning the river tends to the natural behavior in cases of high flood discharges.

4. Conclusion:

The sharp increase in the resources deficit because of the developed projects in riparian countries within the Euphrates river basin is reflected by the wide variation in the water discharge releases values from Haditha dam. The discharge variation affects the downstream river flow efficiency and its hydraulic properties. The present study suggests the series of small dams along the river to improve the hydraulic properties of river and provide hydroelectric power to make the system economically

feasible. The study concludes the following: The optimally estimated system of small dams consists of (three) dams with height of (4.3 m) each dam, and they located at the following coordinates:
a. Small dam (#1): 33°52'19.03"N 42°31'35.73"E. b. Small dam (#2): 33°59'4.30"N 42°32'52.31"E. c. Small dam (#3): 34° 2'8.21"N 42°29'37.04"E .The developed reach behavior tends to store water against limited surface area expansion, where the average surface area expanded by (5%) against (35 %) increase in average storage. This will decrease the effect of evaporation on the stored water quality. The developed reach with small dams system will have the ability to bound (8,783,000 m3 which equal to 58 % of base storage) in the low discharge flow (270 m3/s) while it stores only (3,800,000 m3 which equal to 17 % of base storage) in high flow discharge (815 m3/s). The system provides an optimal solution for resources defect. The improvement of the river properties when a series of the weir are developed, investigated properties show a decrease in the effect of lower discharge values, with less effect on the behavior of the river at flood discharge, where: The seasonal water depth variation decreased by (28%) and the average depth increased by (27%). The average flow area increased by (25%) against a decrease in mean velocity average by (16%). The flow efficiency increased by (19%) because of the increase in average hydraulic radius value with a decrease in variation by (27%). The expected potential power is (45 Mw) [15Mw from each station], ready to be generated through low head turbines technologies within Run of River power stations attached to the small dams. Within power selling price equal to (0.015 $/Kwh), (50 years) of design life, and (99%) expected cost-benefit ratio, the investment in the suggested system of small dams is feasible.

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Date: October 2023

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Date: October 2023

Calculation of Evaporation Losses for Center Pivot Sprinkler Irrigation Systems Type (Lindsay) by Effect of Timer Percentage of Speed and the Increase of Sprayer Nozzles from Soil Surface

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Abstract. The experiment was conducted during summer season (July, August, September) 2019 in some field in Anbar governorate, Saqlawiya city, Gisaba area to calculate water losses by evaporation through water depths by calculating the discharges that come from nozzles and water depths to collect in side cans while calculating uniformity coefficient above soil surface. The results showed that the increase of spray nozzles in soil surface at 1.0m gave the lowest depths from evaporated water by changing the timer speed percent; where it was 0.18mm 100% speed, while increased to 3.39mm at 20% speed compared 0.66mm at 100% speed till 5.91mm at 20% speed when expanding the sprayer nozzles to 1.50m from soil surface. The 100% speed gave low percentage of losses (1.79%) and the high percentage was obtained at 20% speed (33.70%) at 1.0m height, which is better that height of 1.50m in rationalizing water in order to irrigate new areas that water was not enough for. this is due to variation in the height of spray nozzles above the ground, as well as variations in temperature and wind speed steadfastly speed up the system.

Introduction

Food security is increases by reducing the water deficit, benefiting from the available water resources and reducing the percentage of waste and water losses, including the benefits of evaporation. Sprinkler irrigation is an alternative to the traditional irrigation methods in irrigation and water management, and an essential means of rationalizing water, reducing water losses and improving the performance efficiency of modern irrigation systems Ahmed [1]. Tarjuelo [2] showed that the appropriate and accurate understanding of environmental and climatic factors, including air temperature, relative humidity, and wind speed, which have an effective impact on evaporation losses from sprinkler irrigation systems, is a key factor in the maintenance and development of those systems to reduce the percentage of those losses. Seginer [3] classified the water losses in the sprinkler irrigation networks as of the exit of the water from the nozzles as follows: Evaporation losses in the air from the water bundle leaving the nozzles before falling on the ground and inside the collection pots, and their percentage depends mainly and directly on the temperature and relative humidity, and to a lesser degree, on wind speed. The other part of the losses are the water drops swept by the wind outside the field, and the last part of the losses are the back splashes from the inside of the collecting pots, which are scattered outside the collecting pots or stick to their inner walls. Green, [4] indicated that by increasing the operating pressure, the water droplet size decreases to fall away from the sprinklers, and the sprinkler circuits grow larger and overlap among them, leading to an increase in the irrigation uniformity. While Angier [5] and Chirman [6] indicated that the size of water droplets is large at low operational pressures, and they fall close to the sprinklers, which leads to their small diameters and the lack of overlap among them, affecting the uniformity of water distribution within

Date: October 2023

the field. Al-Mehmdy [7] obtained that the best operating pressure of the of irrigation system type (Lindsay), which was 30 pounds inch^{-2} because it gave the best value for the irrigation uniformity, which amounted to 89%, and to achieve the best depth of water on the surface of the soil. While Robert [8] indicated that the best design for the center pivot irrigation system is when water is added uniformly on the surface of the soil, and taking into account the operating pressure, the size of the nozzle, air temperature, relative humidity and water infiltration rate when designing. Camp [9] showed that the distribution of water under sprinkler irrigation systems is affected by many factors such as the operating pressure, the distance between the nozzles, their height from the soil surface, the device's speed, wind speed and direction, and temperature. Fedro [10] mentioned the phenomenon of drifting of water losses as a result of the wind attempt to prevent the fall of the water drop on the area to be irrigated, as well as the absence of plants growing on that area. The same researcher indicated above that evaporation losses can be reduced by one or both of the following variables: increasing the nozzle diameter and reducing the operational pressure, ensuring that any defect in these variables will make the water distribution model weak and thus increase evaporation losses and reduce the water depth achieved. Alghobari [11] conducted a study to estimate evaporation losses under center pivot sprinkler irrigation system under field conditions, he found that evaporation losses decrease with increasing water depth achieved on the soil surface and along the center pivot sprinkler line. Al-Mehmdy [12] showed that the rates of evaporation benefits ranged from 2.13% to 38.00%, this came through a study he conducted to estimate evaporation losses for the center pivot sprinkler irrigation system under the conditions of the Al-Jazirah desert in Iraq. While Al-Hadithi [13] obtained a percentage of evaporation losses under the center pivot irrigation system from the electrical conductivity measurements of irrigation water in Iraq that ranged from 9.36% to 20.25% when they studied the estimation the evaporation losses under the center pivot irrigation system. Al-Rawi [14] obtained that the average evaporation losses under the center pivot irrigation system is 9.38% of the amount of added water. Fedro [10] indicated that during irrigation operations from center pivot sprinkler irrigation systems, water is lost as a result of the rotation of the system pivot around itself, due to the friction that occurs between the air and the surfaces of the spray drops, which causes a large loss in the quantities of that water, and the same researcher indicated that in the absence of the effect of wind, the size of the drops and their distribution depends mainly on the design and mechanics of the nozzles, as well as the operational pressure and the height of the spray reed above the soil surface, as well as the wind speed. Of the utmost importance in estimating evaporation losses under center pivot sprinkler irrigation systems to determine their efficiency, this study aims to know the amount of water lost by evaporation by knowing the depth of water when calculating the discharge of water coming out of the nozzles, as well as the depth of the water descending into the collection vessels when calculating the consistency coefficient on soil surface.

Materials and Methods

2. A field experiment was conducted during summer months (July, August, and September) in 2019 in a field located in Anbar Governorate - Saqlawiya, Gisaba village under the Lindsay center pivot irrigation system in order to determine the evaporation losses under the above irrigation system, depending on the values of the uniformity coefficient and drainage of nozzles located at a height of 1.0 m, 1.50 m from the soil surface, as well as the depths of the water collected in the water collection pots at an operating pressure of 30 pounds Inch^{-2} at speed percent of 20, 40, 60, 80, 100% during the research period for the months mentioned above. Table 1 shows some details of the sprinkler irrigation system using 54 cans cylindrical water collection pots, with a diameter of 7 cm and a depth of 14 cm along the length of the system arm of 328 m. The nozzle discharges was measured using 32 cm diameter cylindrical-shaped pot with 25 cm depth (10382 cm^3 volume) by determining its time taken to be full, with 3 replicates at the same speeds and operational pressures.

The uniformity coefficient was calculated using Christiansen [15].

$$UC = [1 - \frac{\bar{R}}{\bar{x}}] \quad (1)$$

$$\bar{R} = \frac{\sum R}{n} \quad (2)$$

$$\bar{x} = \frac{\sum X}{n} \quad (3)$$

Where,

Date: October 2023

UC= Uniformity coefficient (%).
$\bar{R}$= Average absolute deviations to the absolute depths (mm).
$\bar{x}$= Average depths (mm).
$\sum X$= Water depth volumes in the collection pots.
$\sum R$= Volumes of absolute values deviations.
n= Number of views.

Table 1. Some details of the Lindsay center pivot sprinkler irrigation system

Number of spans	6.00
Length of arm (m)	54.60
Experiment area (m^2)	30000
Height of spray tubes (m)	3.00
Spray discharge (m^3h^{-1})	155.00 (Table 3)
Operational pressure (pound in^{-2})	30.00
Height of nozzles above soil surface (m)	1.00, 1.50

Water depth was determined by dividing water volumes over surface area of the pot, then depth rates achieved at each speed was calculated. All the measurements was conducted in the period 4:30-6:30 pm with wind (8-11) $km.h^{-1}$ at similar climatic conditions. Table 2 shows the temperature and evaporation of the study area

Table 2. Temperature and evaporation of the study area

Month	**Temperature (C°)**			**Evaporation**
	Max.	**Min.**	**Rate**	**(mm)**
July	32.10	48.40	40.25	516.00
August	31.00	47.50	31.25	472.00
September	25.70	45.00	35.35	371.00

The discharges of the sprayer's nozzles and water depths were estimated using the following equations:

QT= v (4)
Ad= v (5)
d= V/A (6)

Where,
Q= Water discharge leaving the nozzles (cm^3s^{-1}).
T= Time required to fill the pot (s).
v= Water volume (cm^3).
d= Water depth (cm).

Date: October 2023

Table 3. Total discharge of the device according to the sequence of towers and the number of spray nozzles at 30 pound.in^{-2} operational pressure

Sequence of towers Nozzles Sequence	**Sequence of spray nozzles according to its discharge (L.min^{-1})**					
	First	**Second**	**Third**	**Forth**	**Fifth**	**Sixth**
1	4.60	10.40	22.00	29.00	29.00	50.0
2	4.60	7.4	15.70	22.00	27.50	29.0
3	4.60	7.4	15.70	22.00	27.50	29.0
4	4.60	7.4	15.70	22.00	27.50	29.0
5	4.60	10.4	15.70	22.00	27.50	29.0
6	4.60	10.4	15.70	22.00	27.50	29.0
7	4.60	10.4	15.70	22.00	27.50	29.0
8	4.60	10.4	15.70	22.00	27.50	29.0
9	4.60	10.4	18.3	26.0	27.50	29.0
10	4.60	10.4	18.3	26.0	29.0	29.0
11	4.60	10.4	18.3	26.0	29.0	29.0
12	4.60	10.4	18.3	26.0	29.0	48.0
13	4.60	11.0	18.3	26.0	29.0	48.0
14	4.60	11.0	18.3	26.0	29.0	48.0
15	4.90	11.0	18.3	26.0	29.0	48.0
16	4.90	11.0	18.3	26.0	29.0	48.0
17	4.90	11.0	18.3	26.0	29.0	48.0
18	4.90	11.0	18.3	26.0	29.0	50.0
19	7.40	11.0	22.0	26.0	29.0	50.0
20	10.40	22.30	27.50	29.00	50.00	84.0
Total	101.80	214.80	364.40	498.00	589.00	812.00

Total discharge of the device= 2580 L.min^{-1}=2.58m^{3}.min^{-1} =155 m^{3}.h^{-1}

Table 4. Calculations of evaporation sprinkler irrigation system at an operating pressure of 30 pound in^{-2} and the height of the sprinkler nozzle 1.0 m on the soil surface

timer ratio	Horoscope sequence	Water depths achieved on the basis of (mm)		amount Loss evaporation	average	Lost* rate	Volume** of water evaporated total area
%	N0.	**discharge**	**homogeneity**	**mm**	**mm**	**%**	**M^3**
20	1	27.3	24.14	3.16	3.39	33.70	1285.88
	2	28.65	24.70	3.95			
	3	31.00	27.71	3.29			
	4	31.00	27.62	3.38			
	5	31.00	27.77	3.23			
	6	31.00	27.66	3.34			
40	1	16.00	12.97	3.03	3.05	30.32	1156.61
	2	16.62	13.36	3.26			
	3	17.80	14.87	2.93			
	4	17.98	14.95	3.03			
	5	17.98	14.95	3.03			
	6	17.98	14.97	3.01			
60	1	12.16	10.26	1.09	1.90	18.88	720.56
	2	13.45	11.63	1.82			
	3	13.50	11.69	1.81			
	4	13.64	11.62	2.02			
	5	13.50	11.52	1.98			
	6	13.64	11.76	1.88			
80	1	9.80	8.22	1.58	1.54	15.31	599.16
	2	10.38	8.75	1.63			
	3	10.62	9.19	1.43			
	4	10.73	9.22	1.51			
	5	10.73	9.22	1.51			
	6	10.73	9.16	1.51			
100	1	7.00	6.80	0.20	0.18	1.79	68.18
	2	7.33	7.18	0.15			

Date: October 2023

3	7.58	7.35	0.23
4	7.66	7.44	0.22
5	7.66	7.47	0.19
6	7.75	7.66	0.09

Notes:* Calculate the percentage of evaporation losses, as shown below /Collect evaporation losses for all velocity ratios 3.39+3.05+1.90+1.54+0.18=10.06 mm
at the ratio of the timer 20%
3.39 × 100 / 10.06=33.70%
In the same way, evaporation losses were calculated for the rest of the irrigation system speed ratios (40 , 60 , 80 , 100) %

** The volume of water lost was calculated on the basis of the total area of the system, which is 135 dunums, based on what was achieved in the study area of 12 dunums.

After that, relationship between the timer with the losses by evaporation, also the timer with evaporated water volumes when the height of spray nozzles is 1.00m and 1.50m then the relationship between the timer and the losses by evaporation when spray nozzles height is 1.00m above soil surface because it gave the lowest losses.

Table 5. Details of time required rotation of the sprinkler irrigation system around itself

Timer percentage (%)	Time required for the rotation (min)
20	458
40	238
60	153
80	114
100	92

Results and Discussion

Relationship between the device speed and the depth of water lost by evaporation

3. Figure (1) shows the relationship between the speed of the Lindsay center pivot sprinkler irrigation system and the depths of water lost by evaporation when there is a variation in the height of the spray nozzles above the soil surface level. It turns out that when the heights of the spray nozzles were within 1.0 m from the soil surface, the values of the lost water depths were within 3.39, 3.05, 1.90, 1.54, 0.18mm, the device speed ratios change from 20 to 40, 60, 8, 100%, respectively, when depending on an operational pressure of 30 pounds Inch^{-2}. As for raising the spray nozzles at a distance greater than the first case, i.e. within 1.50 m from the surface of the soil, we notice that the depth of evaporation losses increased than before, and the values reached 5.91, 5.42, 4.43, 1.83, 0.66 mm when changing the speed ratio of the device from 20 to 40, 60, 80, 100%, respectively, and at the same operational pressure applied previously. In both cases (the change in the height of the spray nozzles above the soil surface), it was found that the relationship between the speed ratios of the device and the depth of the water lost by evaporation is inversely proportional, and that these losses increased more as the increase in distance between the surface of the soil and the head of the spray nozzles, and this is due to the change in climatic conditions, especially the high temperatures in the three months (July, August and September) during which the experiment was conducted (Table 2), as well as the increase in the time required for irrigation (Table 5).

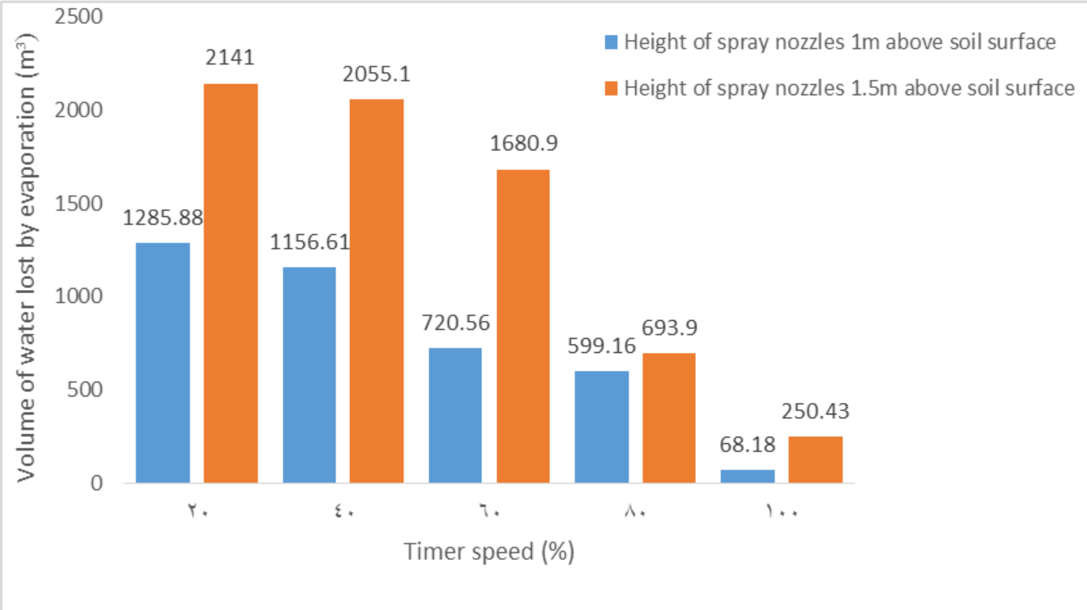

Figure 1: Relationship between timer speed and volumes of water lost by evaporation at 30 pound.in^{-2} for different heights between spray nozzles and soil surface

When the timer indicator of the device is set to speed ratio 100%, which means that the last tower completes the irrigation of the distance of 135 dunum in 92 minutes (Table 5). When the timer indicator of the device is set to 20%, the cycle time is 458 minutes. This makes that the amount of water leaving the nozzles needs more time to reach the collection pots, which causes more losses by evaporation and therefore the the water depth achieved in the pots will be as low as possible, and this what actually occurred when the distance between the spray nozzles and soil surface is increased (1.50 m). This is consistent with [9] also with [10].

3.2 The relationship between device speed and volume of water lost by evaporation

Figure 2 shows the relationship between the speed of the Lindsay pivot sprinkler irrigation system and the volume of water lost by evaporation, when there is a variation in the height of the nozzles above the soil surface level. When placing the spray nozzles at a height of 1.00 m from the soil surface, the volumes of water lost by evaporation were within the limits of 1285.88, 1156.61, 720.56, 599.16, 68.18 m^3 along the length of the system arm of 328 m, by changing the speed of the center pivot sprinkler system from 20 to 40, 60, 80, 100%, respectively. When depending an operating pressure of 30 pounds inch^{-2}, while by raising the spray nozzles to a distance of 1.50 m from the surface of the soil, it was found that the volumes of water lost as a result of evaporation, have increased significantly and their values reached 2141.00, 2055.1, 1680.90, 693.90, 250.43 when changing the speed of the center pivot system to the same mentioned above, and for the same operating pressure approved in advance. It is clear from Figure 2 that the difference in the volume of water lost due to evaporation, when comparing the two heights (1.00 and 1.50) m of the spray nozzles from the surface of the soil and by increasing the speed from 20 to 40, 60, 80, 100%, were within 882,12, 898.49, 960,34, 94.74, 82.25 m. As these differences constitute a volume of lost water, it can be used to irrigate other areas of desert lands that are not secured by the water, and this happened as a result of the difference between the speed of the device, which was reflected in the time of rotation of the pivot of the system around itself, which increased the time required for the rotation of that system (Table 5) and thus the water coming out of the nozzles until they reach the water collection vessels, was exposed to the

Date: October 2023

effects of high temperatures for the months of the study (Table 2) as well as the increase in the distance between the head of the nozzles and the soil surface, due to the height of the nozzle (1, 50 m), compared with the lower height (1.00 m), at which the evaporated water volumes decreased. This is consistent with what [11] and [10] indicated, who showed that through the irrigation processes in the center pivot irrigation systems, water is lost as a result of the rotation of the system pivot around itself, as well as the effect of the operational pressure and the height of the spray pipe above the surface of the soil.

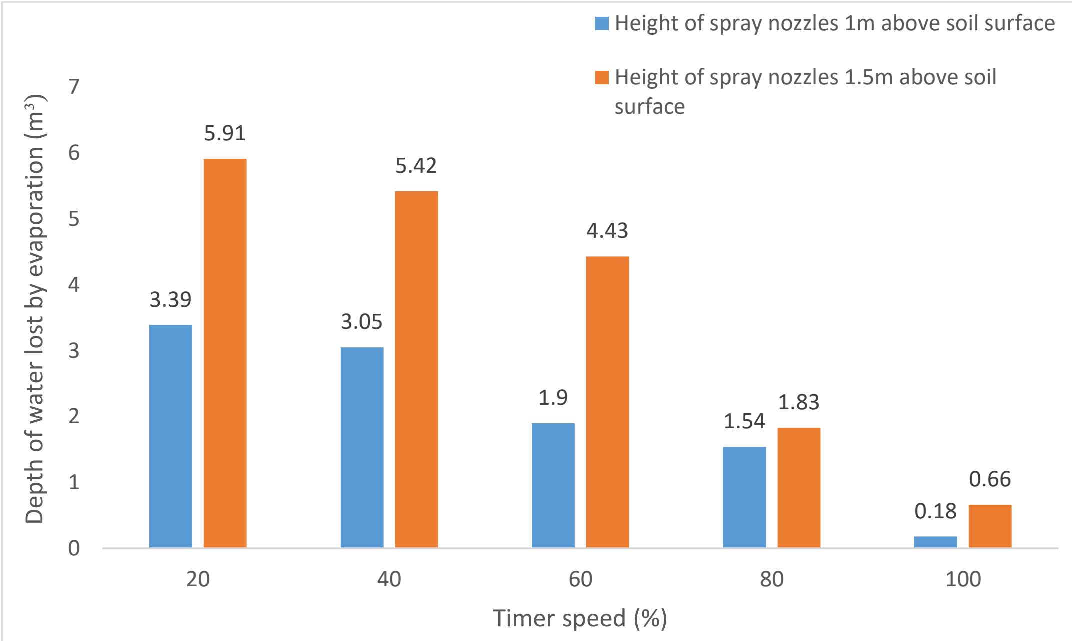

Figure 2: Relationship between timer spped and depths of water lost by evaporation at 30 pond.in^{-2} for different heights between spray nozzles and soil surface

3.3 The relationship between the device speed ratio and evaporation losses

Figure 3 shows the relationship between the speed of the Lindsay center pivot sprinkler irrigation device and the evaporation losses when the spray nozzles were at a height of 1.00 m from the soil surface. The highest percentage of evaporation losses between the end of the spray nozzles and the soil surface was 33.70% (1285.88 m) (Table 3and 4) for the entire experiment area of 135 dunum, when the timer indicator of the center pivot sprinkler irrigation device was set at a speed of 20%, then the losses decreased gradually to 30.32, 18.88, 15.31, 1.79, 1156.61, 720.56, 599.16, 68.18 m^3, when increasing the rate of irrigation device speed to 40, 60, 80, 100%, respectively, at an operational pressure of 30 pounds inch^{-2} [12]. These percentages of evaporation losses from water are related to the operating time and environmental conditions, as well as heterenity ver the height of the spray nozzles. (Table 2 and Table 5). The reason for the decrease in the evaporation difference by the increase in the speed is due to the decrease in the irrigation time, when the area is set, the speed indicator of the center pivot device is 100%, and this means that the last tower completes the irrigation of 135 dunum with a time of 92 minutes (Table 5). But when the speed indicator of the center pivot device is set to 20%, the cycle time is 468 minutes. The decrease in water evaporation losses may be mainly due to this is due to variation in the height of spray nozzles above the ground, as well as variations in temperature and wind speed steadfastly speed up the system. the increase in temperature (Table 2). Since the study was conducted under conditions of static winds (8-11) km/h and with an operational pressure of 30 pounds inch^{-2}, water distribution uniformity of 89% was obtained, and the experiment measurements was conducted in hot conditions (July, August and September), and this is consistent with [7] and [12].

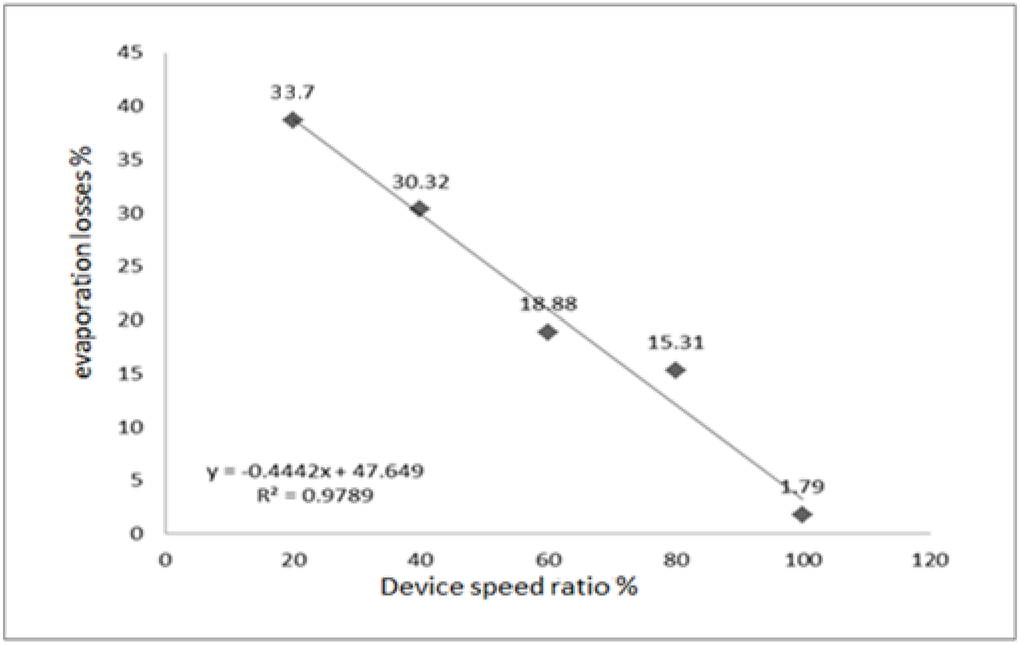

Figure 3: Relationship between device speed evaporation losses at operational pressure 30 pound in^{-2} and 1m height of spray nozzles above soil surface

4. Conclusion

The results of this study showed that when operating the Lindsay center pivot sprinkler irrigation system at a speed of 100% and an operational pressure of 30 pounds Inch^{-2}, and a height of nozzles of 1.0 m above the soil surface, gave the lowest percentage of evaporation losses, which was 1.79%, compared to 33.70% at a speed of 20% under the same environmental and operational conditions. Based on the data of the study, we recommend operating the Lindsay center pivot irrigation device at a speed of 100% and an operating pressure of 30 pounds inch^{-2}, with fixed irrigation intervals, and making the height of the spray nozzles 1.0 m above the soil surface, when using this system for irrigation in the hot summer months (July, August and September) to reduce evaporation losses and to benefit from the rationalized water in irrigating new lands for which the water share was not previously secured.

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Date: October 2023

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Date: October 2023

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The Effect of Operating Pressures and Speed Ratios on The Evaluation Criteria of The Center Pivot Irrigation System (Valley) in Al Baghdadi Region

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Abstract. A study conducted during the 2021winter season in Al Baghdadi region (150) km west of Ramadi City (Iraq) to show the effect of operating pressure and equipment speed on evaluation criteria of the center Pivot Irrigation Systems. Three operating pressures were used in the experiment, which are 25, 30 and 35 pounds inch^{-2}, with three speeds of 25%, 50% and 75% for each pressure. Study result showed that The pressure 30 pounds inch^{-2} achieved the highest values for the average of the studied traits, as it was 97.22% while the lowest value was recorded at a pressure 25 pounds inch^{-2} which amounted to 88.70% with a decrease Ratio 9.6%. The pressure 35 pounds inch^{-2}achieved the lowest average water depth 24.13 mm, while the highest average depth of water was at pressure 30 pounds inch^{-2} 35.89 mm with a height Ratio 32.7%. The lowest average value of the water depth variance (qvar.) was 8.34% at pressure 30 pounds inch^{-2} while the average of this value increased to 28.63% at pressure 35 pounds inch^{-2} with increase 70.8%. The ratio of the rotational speed of the arm of the system significantly affected the values of each of the studied traits, the velocity 25% achieved the highest average values 30.93 mm and 93.10%, while the speed 75% achieved the lowest rate 26.58 mm and 89.63% With a decrease 16.4% and 3.8% for each of the applied water depth and Uniformity coefficient, respectively. This speed 25% also achieved the lowest average water depth variance, which amounted to 16.02%, while speed75%achieved the highest value of water depth variance, which amounted to 26.59%, with an increase rate 39.7%.

1.Introduction

Center pivot sprinkler irrigation system is one of the perpetual motion irrigation systems that operate in a continuous rotational movement during the irrigation process, as this system is currently considered one of the systems that is characterized by a high level of technology and has multiple and wide capabilities in irrigating irregularly shaped lands as well as it is characterized by the high ability to distribute water Fertilizers and Pesticides Systematically[14]. [15] indicated that the purpose of evaluating the pivot sprinkler irrigation system is to determine the efficiency of the system and increase it in applied practical conditions, as well as to provide the most important necessary information needed by specialists in choosing the appropriate design and the most efficient system with economic feasibility, in addition to the values obtained from Measurements must not contradict the reality of the field and have an interrelated relationship with it.[12] mentioned that the advantage of the center pivot irrigation system is represented by its work at different speeds and with a uniform distribution of water. The importance of evaluating the performance of the center pivot irrigation system by specialists comes to processing deficiencies in the irrigation Grid in a timely manner and to identify problems arising from the design or Operating. The results of [4] when evaluating the energy efficiency of a pivot sprinkler irrigation system that operates in areas with variable terrain, indicated that this system operates with good energy efficiency even after more than 10,000 operating hours.[10] conducted a study conducted in the Nile River State in Sudan on the evaluation of center pivot sprinkler irrigation system. There is a decrease in the performance of this system in the River Nile

Date: October 2023

State from the recommended values compared to the North and Khartoum states. The reason for this was attributed to problems related to design, operation and management. Best management practices for an irrigation system and for evaluating a center pivot irrigation system under field conditions should be approved and followed immediately after design and during use.[17] indicated that the total depth of irrigation decreases with increasing the speed of the arm of the system. It also provides a consistent water depth at an acceptable rate. The irrigation rate increases as we move away from center pivot sprinkler irrigation system, and this confirms that the length of the arm of the pivot system is a major factor in the designs of those systems.[5] explained that regulating the depth of addition is through controlling the movement of the arm of the pivot sprinkler irrigation system, as the lowest depth of water is added at the maximum speed of the system, which leads to reducing surface runoff problems, so the system movement speed must be appropriately to obtain. The best consistency of water distribution, taking into account the relationship between the rate of water addition and its tip in the soil,[8] indicated that it is possible to obtain a specific volume of water at any position in the field with the same amount through the continuous movement of the arm of the pivot sprinkler irrigation system.

The Uniformity Coefficient is considered the important step in evaluating the regularity of water distribution along the axial spray line. This is done by placing 2-3 rows of measuring containers at equal distances, according to the American Society of Agricultural Engineers [3], it is also expressed in the degree of Uniformity of the turbid water in the depth of the soil and the extent of its regular distribution along the runoff.[13]assert that knowledge of Uniformity Coefficient for an irrigation system is essential for accurate irrigation management.[19] showed that when estimating the Uniformity Coefficient for a pivot sprinkler irrigation system under certain conditions, the estimated Uniformity Coefficient for another irrigation system will be different from its counterpart under the same conditions, due to the presence of fixed variables involved in the design of the system, such as the manufacture of the system, the amount of operating pressure for the sprinkler, The size and type of extruders and the distance between them. Water Distribution Efficiency refers to the extent of regularity and consistency of water distribution along the spray arm, as the crop response and productivity are high under the conditions of regular distribution of soil moisture in the root zone. Conversely, the inconsistent distribution of irrigation water leads to deterioration of crop productivity in Areas that do not receive enough water, in addition to the salinization phenomena that appear under these conditions,[16].

[2]found that the coefficient of water Uniformity in the center pivot sprinkler irrigation system may be greatly affected by the wind speed, as the value of the Uniformity Coefficient was 81% and 86% at wind speeds of 11.4 and 8.1 km h1 - according to the sequence.[11] indicated that there are factors that affect the Uniformity of water distribution and the diameter of the sprinkler service circle, which are the operating pressure, the specifications of the sprinkler hole, its rotation rate, and its geometry. [1] confirmed that the Uniformity coefficient decreases with an increase in the operating pressure at the sprinkler opening as a result of the cleavage of water droplets emerging from the extruders and their transformation into droplets of small sizes, which increases the effect of wind speed on them.[18] explained in a study he conducted to evaluate the performance of the sprinkler irrigation system in Beheira Governorate in Egypt. The study elements included the distance between sprinklers, operating pressure and soil slope. It was found that these elements greatly affected the Uniformity Coefficient (UC) and Distribution Uniformity (DU) and coefficient of variation (CV), which are good indicators for evaluating the performance of the sprinkler system.

The scientist[9] conducted a study for the field evaluation of water losses in pivot sprinkler irrigation systems under dry conditions, It was found that most of the pivot irrigation systems were low in the values of Uniformity coefficient and distribution Uniformity values for the lowest quarter. The values of (UC) ranged between 69.2-89.2%, the values of (UD) ranged between 54.1-81.6%, and the values of irrigation water losses ranged between 7.83. - 13.57%.

The objective of this study is to evaluate evaluation criteria of the Valley pivot irrigation system under desert conditions for the western region of Iraq.

Date: October 2023

2.Materials and Methods

2.1. Study Site

A study conducted during the 2021winter season in Al Baghdadi Rejoin (150) km west of Ramadi City (Iraq) to show the effect of operating pressure and speed on Evaporation Losses under center Pivot Irrigation Systems. Three operating pressures were used in the experiment, which are 25, 30 and 35 pounds inch^{-2}, with three speeds of 25%, 50% and 75% for each pressure.

Operatin	Speeds Ratio%

2.2. The irrigation system used in the experiment

A pivotal sprinkler irrigation system (Valley) was used, which consists of four towers (Spans) connected to each other by rubber dividers with a total arm length of 243.30 m, so that the total area of this system is 18.6 hectares.

2.3.Water Depth applied from the speed of system

The speed of the device was calibrated with the depth of the water achieved from that speed. Three speeds and different operating pressures were adopted in this study, as mentioned above, by placing 48 cylindrical metal cans with a known diameter and depth along the arm of the system of 243.30 m, with a distance of 5 m between one can and another. The process was repeated three times for each speed ratio of the above velocities, and the measurements were taken in the early morning and evening when the wind is still (8 km h^{-1}) and for all the operating pressures selected above. The volumes of water collected in each container were converted into depths by dividing them by the surface area of the container. The rate of water depths applied was calculated at the ratio of each speed of the equipment speed as shown in Table 1.

2.4. Uniformity coefficient(UC)

The Uniformity coefficient was measured depending on the water depth rates achieved at different speed ratios 25% ,50% and 75% with
different operating pressures 25,30 and 35 pounds inch^{-2}according to the [7]using the following equation:

UC = 100 [1.0 – Σxi / mn] ……………….(1)

Uc Uniformity coefficient as a percentage(%)

xi Numerical deviations of water depths from their average (mm).

m Average Falling Water Depths (mm).

n Number of locations for measuring the depth of falling water.

2.5.Variance of Water Depth achieved from Speed of System(q var.)

The percentage of variation in the water depths achieved was calculated based on the highest value of the water depth (d max) and the lowest value (d min) as in the equation mentioned by[6] along the arm of the system as follows:

d var. of depth = (d. max. – d. min.) / d. max. *100………(2)

Table 1. The values of applied water depth, water depth variance (qvar.) and uniformity coefficient at an operating pressures and a speed Ratio for each it in the Valley pivot sprinkler irrigation System

d. var = Percentage variation in the depth of the water applied (%).

d. max = The highest water depth applied along the arm of the system (mm).

d. min = The minimum water depth applied along the arm of the system (mm).

Date: October 2023

	25%			50%			**75%**		
	applied water depth	water depth variance (qvar.)	Uniformity Coefficient (UC)	applied water depth	water depth variance (qvar.)	Uniformity Coefficient (UC)	applied water depth	water depth variance (qvar.)	**Uniformity Coefficient (UC)**
	mm	%	%	mm	%	%	mm	%	**%**
25	26.67	24.00	92.50	25.10	26.08	89.90	24.08	30.27	**86.14**
30	38.21	5.11	98.24	36.45	7.89	97.7	33.00	11.43	**95.65**
35	27.21	20.97	92.51	24.11	27.43	88.87	22.63	37.48	**87.08**

3.Results and Discussion

Table 2.shows the effect of operating pressures and equipment speed ratios on the applied water depth values, where the results showed that there is a significant effect of the operating pressure on the applied water depth, the pressure35 pounds inch^{-2} achieved the lowest average of applied water depth values which is 24.65 mm, while the highest average depth of water was at pressure 30 pounds inch^{-2} amounted to35.89 mm with a height Ratio 31.3%. This can be explained by the fact that the high operating pressure leads to a decrease in the size of water droplets and the rate of addition with the increase in the diameter of the nozzle service circle, and in contrast to that in the low operating pressure, and this is consistent with [1] and [20]who explained that increasing the pressure leads to an increase in the spray range until reaching to the optimal range after which this range decreases when the pressure is increased from this limit.

The ratio of the rotational speed of the arm of the system significantly affected the values of the applied water depth, the velocity 25% achieved the highest average which is 30.70 mm while the speed 75% achieved the lowest rate amounted to26.58 mm With a decrease rate 15.5%, Since the depth of the water applied is related to the operating time of the pivot sprinkler irrigation system, when the timer indicator of the equipment is set to a speed of 100%, this means that the last tower is moving without stopping ,while when setting the timer indicator of the device at a speed of 50%, the last tower moves 30 seconds and stops 30 seconds every minute, this is consistent with [5] and [17], who confirmed that the total irrigation depth decreases with increasing the speed of the arm of the system. It also provides a consistent water depth at an acceptable rate.

Table 2.Effect of operating pressures and equipment speed ratios on the applied water depth values for the center pivot irrigation system (Valley).

Applied water depth values (mm)				
Speed Ratio% / Operating Pressure(pounds inch^{-2})	25	50	75	Average
25	26.67	25.10	25.28	26.04
30	38.22	36.45	33.00	35.89
35	27.21	24.12	22.63	24.65
Average	30.70	28.56	26.58	
		Per.	P	P*per
LSD $_{0.05}$		1.066	1.066	NS

Date: October 2023

Table 3. Shows the Effect of operating pressures and equipment speed ratios on the variation values (qvar.) in the water depths applied, where the results showed that there is a significant effect of operating pressure on the values of variation, as the lowest average value of the variation was 8.34% at pressure 30 pounds inch^{-2}while the average of this value increased to 28.63% at pressure 35 pounds inch^{-2}with an increase ratio 70.8%.The reason for this is that by increasing or decreasing the operating pressure, the difference between the highest and lowest pressure inside the water distribution pipe increases, after that the size of the falling water droplets decreases, thus increasing the effect of the wind, leading to a non-homogeneous distribution of water and a difference in its depths.

As for the speed of rotation of the arm of the system, it also had a significant effect on the difference in water depths, as the speed achieved 25%, the lowest average value for the water depth variance, amounting to 16.02%, while the 75% speed achieved the highest value for the water depth variance, amounting to 26.59%, with an increase of 39.7%.The reason for this is due to the effect of the wind, which is more effective at high speeds. When the wind speed increases, the depth of irrigation increases in the areas located towards the wind and reduces the area served by the sprinkler. The effect of the interaction between the operating pressure and the rate of the speed of the device was significant in the values of the variation water depths, when the operating pressure of 30 pounds inch^{-2} and a speed of 25% achieved the lowest value of the variation amounted to5.11%, while the highest value was at the interaction of the operating pressure of 35 pounds inch^{-2} and a speed of 75%, which amounted to 37.49%, with an increase of 86.3%, and the reason for this is due to the positive relationship between these two variables (operational pressure and device speed ratios), whose effect was in one direction.

Table 3. Effect of operating pressures and equipment speed ratios on the variation values (qvar.) for the center pivot irrigation system (Valley)

variation values qvar. (%)				
Speed Ratio% / Operating Pressure(pounds inch^{-2})	25	50	75	Average
25	21.97	26.08	30.27	26.11
30	5.11	7.89	12.01	8.34
35	20.97	27.43	37.49	28.63
Average	16.02	20.47	26.59	
		Per.	P	P*per
LSD $_{0.05}$		0.759	0.759	1.315

Table 4. Shows the Effect of operating pressures and equipment speed ratios on the Uniformity Coefficient values, where the results showed that the highest values of the uniformity coefficient were recorded at pressure 30 pounds inch^{-2}which amounted to 97.22%, while the lowest values were at pressure 35 pounds inch^{-2}which amounted to %89.49 with a decrease rate8.63%, This can be explained by the high pressure causing splitting of the water droplets emerging from the extruders and turning them into droplets of small sizes, which increases the effect of the wind on them, which reduces the value of the uniformity coefficient, and this is consistent with[1].

As for the effect of the speed ratio on the uniformity coefficient, it was found to have a significant effect, as we note that high speeds led to a decrease in the average value of the uniformity coefficient, We notice that the speed 25% has achieved the highest values of uniformity coefficient which amounted to 94.42%, while the lowest value of uniformity coefficient was at the speed, which is89.63% with a decrease ratio5.3%.

We also note that the overlap between the speed ratios and the operating pressures had a significant effect on the value of the uniformity coefficient Fig.1,2 and 3.Where it was found that the pressure of 30 pounds inch^{-2} and arm speed 25% achieved the highest uniformity coefficient, which reached 98.25%, while the lowest value of uniformity coefficient was at the depending of the operating pressure 25 pounds inch^{-2} and the speed 75%, which amounted to 86.14%, with a decrease ratio 14%.

Table 4. Effect of operating pressures and equipment speed ratios on the Uniformity Coefficient values for the center pivot irrigation system (Valley).

Uniformity Coefficient values UC(%)				
Speed Ratio% / Operating Pressure(pounds inch^{-2})	25	50	75	Average
25	92.50	89.90	86.14	89.50
30	98.25	97.76	95.65	97.22
35	92.51	88.88	87.09	89.49
Average	94.42	92.18	89.63	
		Per.	P	P*per
LSD $_{0.05}$		0.603	0.603	1.045

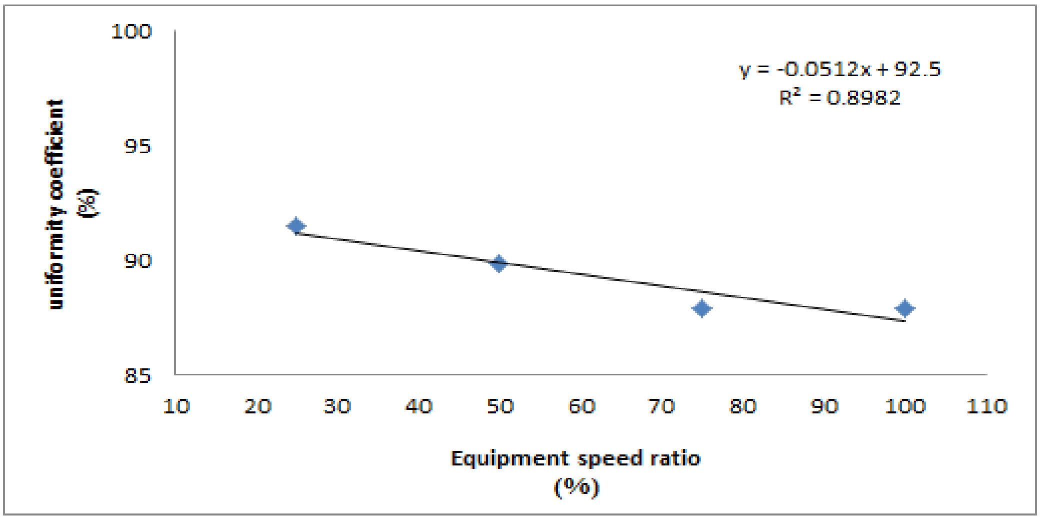

Figure1-The relationship between the ratio of equipment speed and the uniformity coefficient at an operating pressure of 25 pounds inch^{-2}

Date: October 2023

So it was valuable of R^2 0.8982,0.9855 and 0.9065 for operational pressure 25,30 and 35 pounds inch^{-2},by respectively. When the pressure is constant, the change from one speed to another, there is a small change in uniformity coefficient as a result of concussion of water inside the tube. This led to the operating pressures 30 pounds inch^{-2} ,give the highest value of R^2.

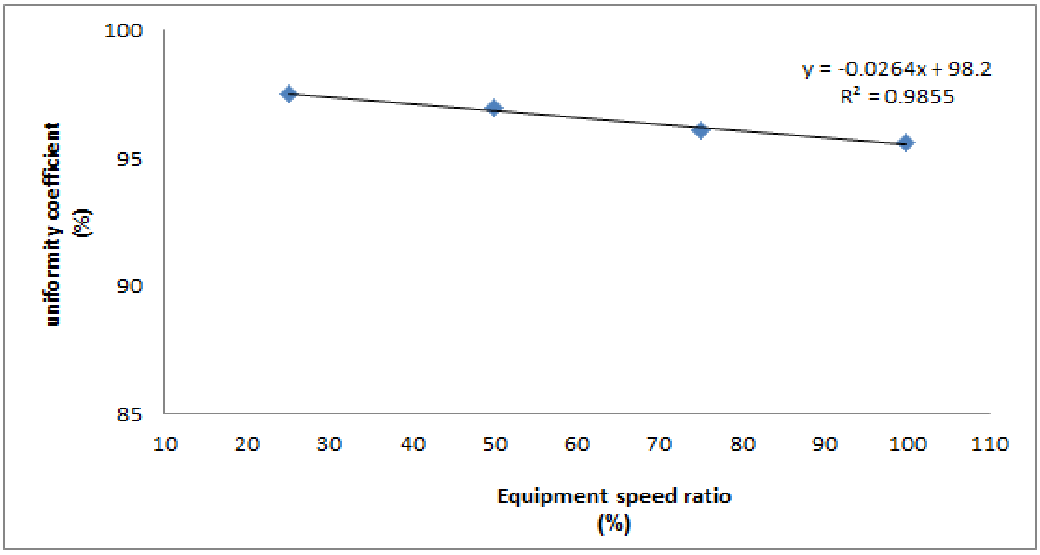

Figure2-The relationship between the ratio of equipment speed and the uniformity coefficient at an operating pressure of 30 pounds inch^{-2}

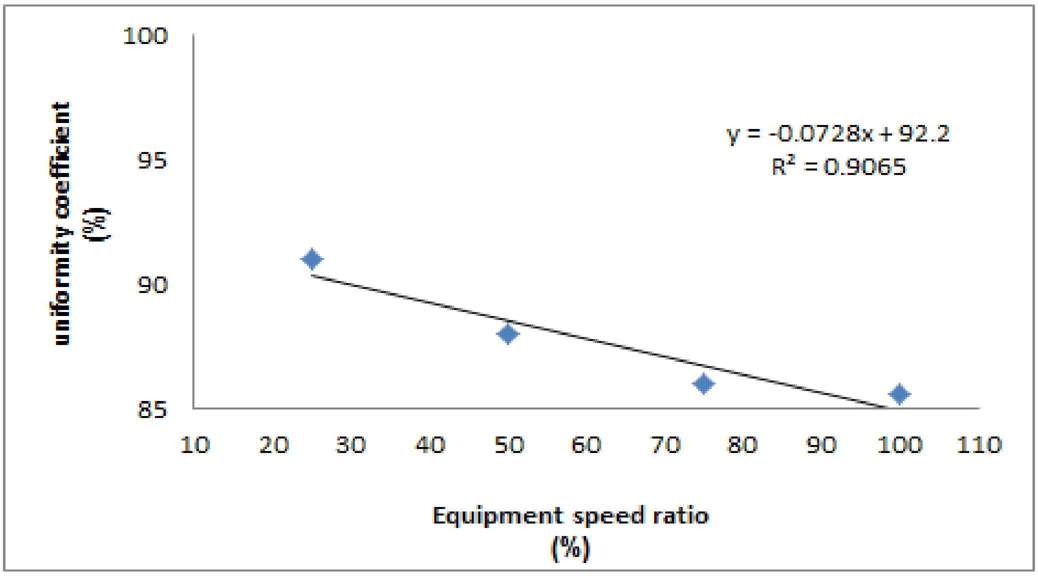

Figure3.The relationship between the ratio of equipment speed and the uniformity coefficient at an operating pressure of 35 pounds inch^{-2}

4.Conclusions

The operating pressure 30 pounds inch^{-2} was the most appropriate among the operating pressures chosen in the experiment, as it achieved the highest values for the depth of applied water and uniformity Coefficient, and the lowest values for the variation of the depth of water added. The speed ratio 25% achieved the highest values for the evaluation criteria mentioned above, while the speed 75% recorded the lowest values for the variation in the depth of applied water compared to other speeds. So we recommended adopting Operation pressure 30 pounds inch^{-2} and speed ratio 25% ,Operation of the center pivot sprinkler irrigation system in condition similar to study.

Date: October 2023

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Simulation Design and Analysis for Water Network Inside Building Using Elite(S-Pipe) Software

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Abstract: Humanity is looking for a way to face the problems of lack of habitable land, and the vertical housing method and multi-story buildings was the most appropriate solution for housing a large number of residents in the same space. In this study, the work was to analyze the existing design and re-design for the water supply network inside the building in Bismayah city consists of multi-story buildings of 10 floors, and each floor consists of 12 apartments, 100,000 housing units for the whole city. The water supply network inside the buildings is the only source of water for the residents in the city for drinking and use in various daily activities, taking care of the design of this network guarantees the success of the city. The results showed that the riser pipe in the water supply network inside the building had a diameter range from (3 to 1.5) inches, while the redesign was done by manual calculations and Elite(S-Pipe) software according to the International Plumbing Code 2021. The pipe diameters ranged from (2 to 1) inch, also the main horizontal pipe feeding the riser pipes in the network has a diameter of (4) inches, while the redesign showed the pipe with a graduated diameter from (3 to 2) inches. In general, the study showed that the used diameters are larger than the designed diameters according to the International Plumbing Code 2021, which will negatively affect the performance of the water supply network inside the buildings, in addition to increasing the cost of the network.

Introduction

The unprecedented revolution of development that humanity is witnessing in all economic, scientific, literary and artistic fields has led to a large consumption of natural resources, and the most important of these resources is water, as it is the main reason for life and is included in all daily activities of man and in most industries, as well as in the sectors of energy production. It is necessary to preserve the investment of all scientific methods when using water in an economic manner that preserves this important resource [1]. This prosperity witnessed by humanity led to a large increase in the population, matched by a large decline in the lands suitable for housing, so the ideal solution to this problem was the optimal use of the lands suitable for habitation, so multi-story buildings were used that provide housing for a large number of the population using small spaces, and for the success of this type of buildings must that the potable water be provided for the multi-story buildings by designing networks that ensure the provision of the appropriate need for water and with the appropriate pressure that ensures the optimal operation of the network, as well as following the systems that work to save water consumption [2].

The design importance of water supply networks inside buildings has emerged to provide the daily demand for water for drinking, cooking, showering, and various activities, the design is depends mainly on calculating the demand of water consumed and the appropriate pressure for operation [3], the process of calculating the water demand for the design of water supply networks inside buildings is depending on the Hunter curve method [4], which depends in its calculations on giving each fixture in the network a numerical value that depends on the fixture's consumption of water simultaneously, this value is called the Fixture Unit and by using Hunter curve to find the water demand of building [5]. The appropriate design pressure value for the water supply network inside the building to exceed the height difference between the water source in the network and the highest fixture in the network, the network operating pressure value represents the pipes friction losses in the network, and the pressure

Date: October 2023

required to operate the fixtures, [6], depending on the procedures in the global or local codes like (The American Society of Plumbing Engineers (ASPE), Uniform Plumbing Code, National Standard Plumbing Code, International Building Code (IBC), International Plumbing Code (IPC)) and using the values extracted from the water demand calculations and the design pressure to operate the water supply network inside the building, the sizes of the parts of the network are calculated such as tanks, pipes, fitting and also the pumps discharge and head[7].

The water supply networks are distributed inside the buildings in several different ways, including the up-feed system, in this system, water is pumped from the tanks placed at the bottom of the building to the rest of the building by pumping stations (booster pump) and through vertical and horizontal pipes to feed all the fixtures inside the building. This system depends on the pressure of the pumps to provide the appropriate pressure for the operation of the network. The down-feed system, in this system the water is pumped from the public network to tanks located at the top of the building by lifting pumps, and water is supplied to the building from the upper tanks through a group of vertical and horizontal pipes to feed all parts of the building with water. This system depends on providing the appropriate pressure to operate the water supply network on gravity and the level difference between the tank and the rest of the building parts [8], also a system can be used that depends on merging between the two systems and dividing the building into several parts, one part is fed by booster pumps from the bottom and the other part by gravity tanks. This system is called the Combination Up-feed/Down-feed Systems [2].

The selection of the water supply networks distribution systems inside buildings depends on several factors, including the height of the building, the size of the tanks, the structural design of the building, the spaces available for the tanks, the amount of energy consumed to supply the building with water, the economic cost, etc. [9]. Compliance with the instructions and specifications of international and local codes that approved in the design of water supply networks inside buildings ensures that these networks are optimally designed with high efficiency and flexibility, which also increases the life usage of the network parts and reduces breakdowns and maintenance, as well as providing the user with water at peak times and also avoiding design problems such the use of oversize and undersize in pipes diameters which leads to increase in cost, reduction of network efficiency, and increase in breakdowns, and not providing the appropriate pressure to operate the fixtures or using pumps with pressure higher than the network design pressure, which leads to damage to the fixtures, pipe connections and pipes [6].

Scientific development in the software engineering that helps to improve the design and analysis process in various engineering fields, as well as increasing the speed of completing designs and displaying design plans in more accurate and clear forms, which helps in ease of reading and implementation, and in the field of designing plumbing systems and water supply networks [10]. The Elite software is considered one of the good software in the design and analysis work because of the speed of design and analysis, accuracy and ease it provides in the process of entering data and reviewing the results clearly and accurately [11]. Therefore, this research aims to evaluate of design the water supply network inside multi-story buildings, and a study area will be taken to implement these goals.

Materials and Methods

Case Study Description

The Bismayah New City is located in the capital, Iraq, Baghdad. It consists of multi-story residential building, as shown in Figure.1. The building consists of 10 floors, each floor contains 12 apartments, as shown in Figure. 2. The total number of apartments is 100,000 apartments in the city.

Data Collection and Analysis

The executive plans for the Bismayah New City project were obtained by the company executing the project, the Korean Hanwa Company, as these plans were designed by Hanwa Company and approved by the Ministry of Construction and Housing - the National Center for Engineering Consultations on 31/7/2013.

Date: October 2023

3. Results and Discussion

3.1.Water Supply Network Design Concept

The water supply network inside the building is designed according to the International Plumbing Code (IPC) 2021, and to extract the diameters of the pipes and the pressure and discharge of the pumping station for the building, the procedures is followed to find the diameter of the pipe feeding a group of fixtures. E103.3 (2) determines the value of load values, in water supply fixture units (wsfu) and then uses the table E103.3 (3) and according to the system used, either a flush tank or a flush valve, the demand is extracted from water in units of gallons per minute and from the figures number E103.3 (2) to E103.3 (7) and according to the type of pipe material, the appropriate diameter of the pipe is determined and within the velocity limits recommended in the code (5-8) ft/sec. Also, extracts the value of pressure drop per 100 feet of tube, pounds per square inch, and from knowledge of the length of the pipe, losses inside the pipe are determined, and the procedures are repeated to design the entire water supply network inside the building. The pressure needed to operate the network is calculated from the sum of the pressure required to operate the highest fixture in the network from the pressure losses from friction inside the pipes in addition to the static pressure and the pressure required to operate the fixture [12].

3.2. The Elite (S-Pipe) Software Concept

The Elite (S-Pipe) software is used to calculate the sizes of hot and cold water pipes inside both residential and commercial buildings, by following the procedures in international codes such as UPC, IPC, etc. in the calculations. Where the data of water supply network is entered like the name of the pipe, the type of pipes material, the height, the length, the fittings related to the pipe, the fixtures, the approved code in the calculations, the available pressure, the maximum speed limits and the highest pressure drop rate to the program through an input window as shown in Figure (3). The program performs the required calculations and presents the results in a report as in Figure (4) containing the sizes of the pipes, the speed, the losses resulting from friction inside the pipes, and the pressure required to operate the network **[11]**.

Figure 1. The Bismayah New City Multi-Story Buildings

Date: October 2023

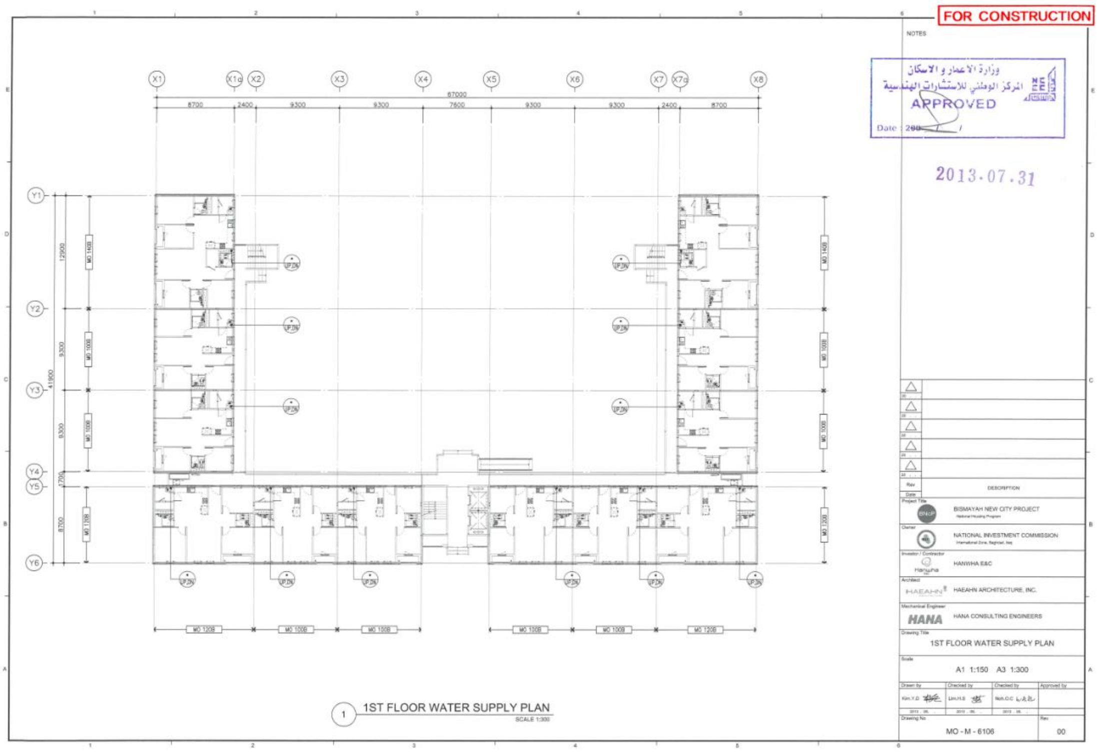

Figure 2. Typical Floor for Buildings in Bismayah New City Multi-Story Buildings

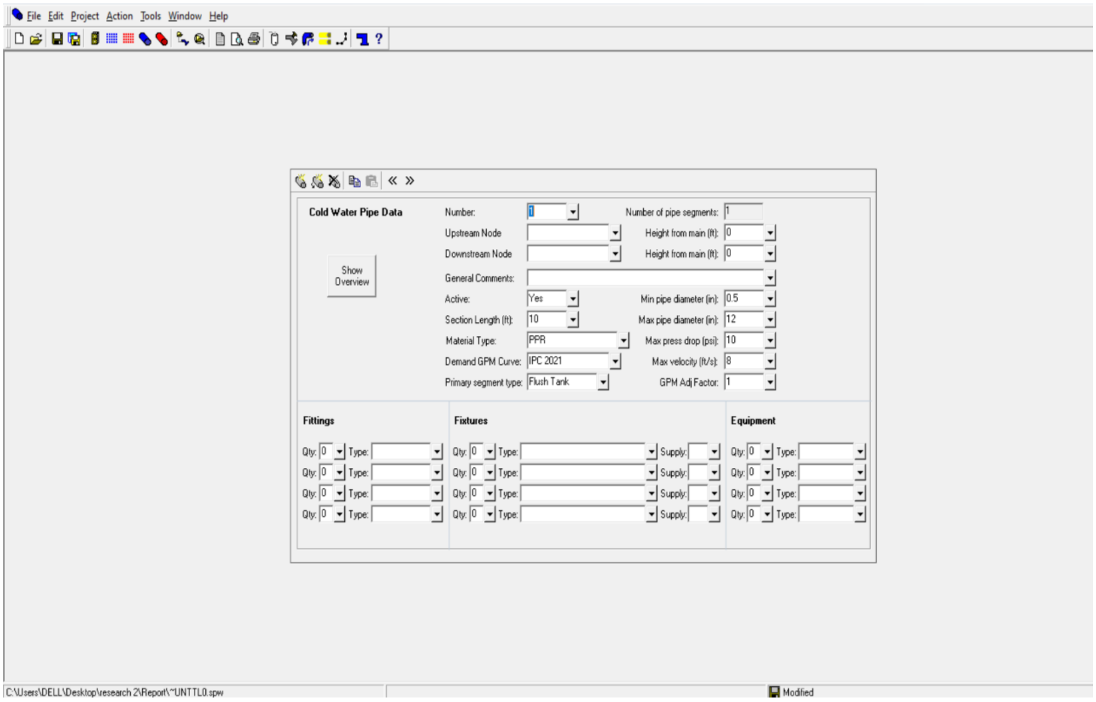

Figure 3. The Elite (S-Pipe) Software Input Window

Date: October 2023

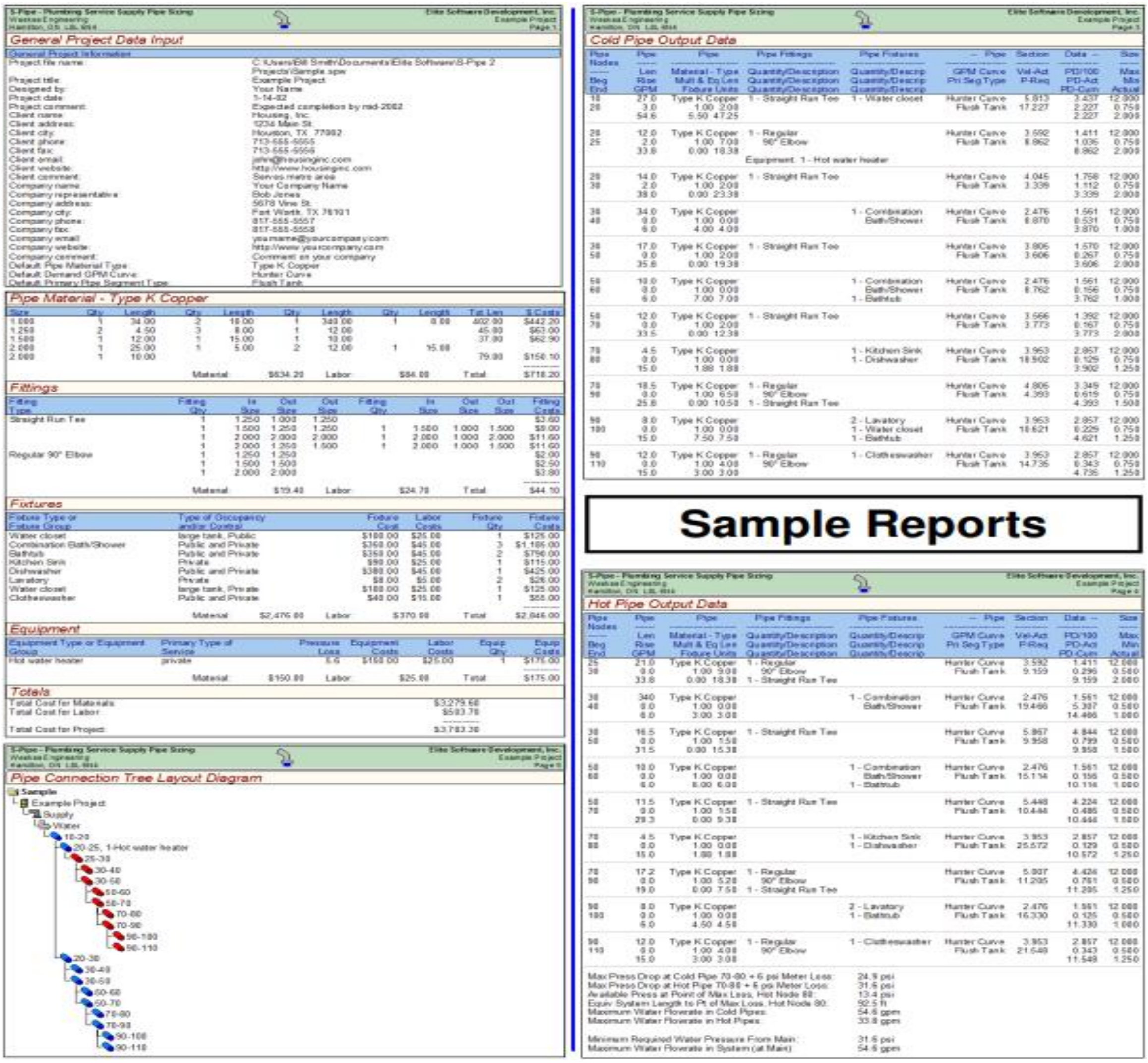

Figure 4. The Elite Software Report

3.3.Design And Analysis Of Water Supply Network Inside Building

The Distributing of water supply network inside the buildings of Bismayah City with the up-feed system, where the building was divided into two parts equally. Each part feeds by a main pipe from the public network, and each pipe feeds 6 riser pipes. Each riser pipe feeding 10 floor, one apartment on each floor, as shown in Fig. 5, the apartment contains a two Showers Of one Sinks, three W.C, three Washbasins, and one from each Dishwasher and clothes washer, with a total of 16 fixture units for each apartment as shown in Fig. 6. According to the International Plumbing Code, 2021, the existing water supply network inside the building was Analysis and redesigned with the same existing distribution system for the network by manual calculations and using the Elite(S-Pipe) software where the results were as follows:

Date: October 2023

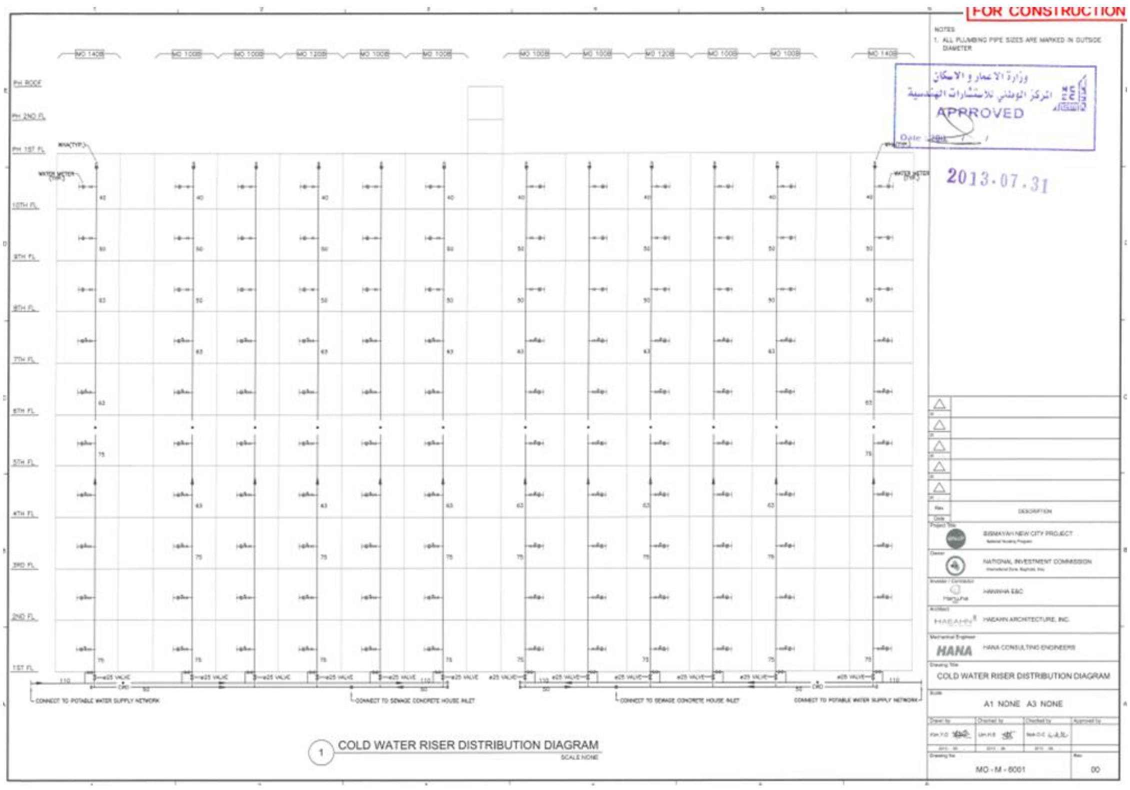

Figure. 5 Water Riser Distribution Diagram

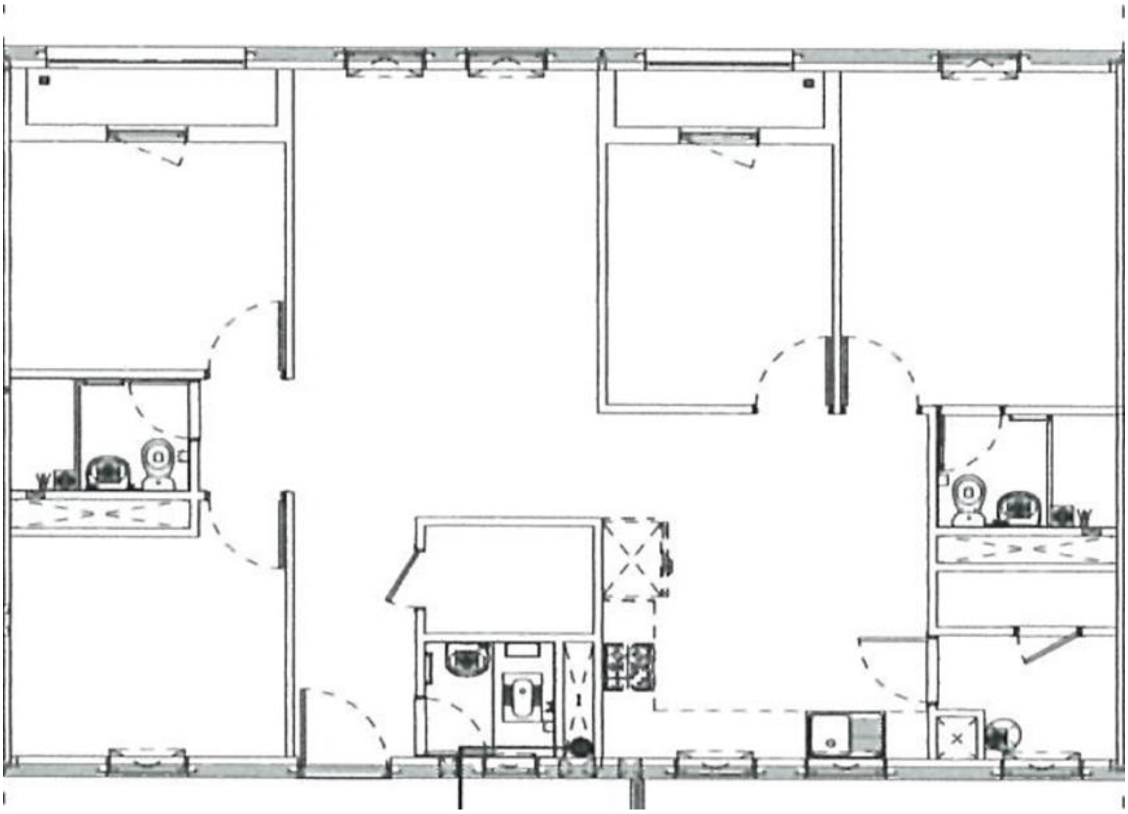

Figure. 6 Bismayah City Apartment Plan

3.4.Analysis and Design of Riser Pipes

By analyzing the riser pipe in the water supply network inside the building, it was found that the diameters of the pipes used in the network are greater than the actual need, and this caused to reduce the efficiency of the network to meet the user's requirements, as shown in Table 1, the flow velocity

Date: October 2023

inside the pipes is out of the recommended velocity limits according to the (IPC,2021) and due to the decrease in velocity the pressure value increased inside the network pipes, which causes malfunctions and damage to the parts of the network, in addition to this increase in pressure causing uncomfortable use of fixtures by the user [13].Table 2. Shows that comparing the diameters of the existing network pipes by manual and software calculations, the demand for water that can be supplied by these pipes is much greater than the existing demand for the network.

Table 1. the analysis of the existing design of the water supply network inside the buildings of the Bismayah city by using manual and the Elite (S-Pipe) calculations.

Riser Pipes	Pipe dim.	manual calculations		Elite S-Pipe	
		Velocity (ft/sec)	H.L.[a] psi/100ft	Velocity (ft/sec)	H.L. psi/100ft
1st floor	3 in	2.7	0.5	2.6	0.35
2nd floor	3 in	2.5	0.4	2.4	0.3
3rd floor	3 in	2.2	0.35	2.3	0.3
4th floor	3 in	2	0.3	2.1	0.25
5th floor	3 in	1.7	0.25	2	0.2
6th floor	2.5 in	2.5	0.55	2.5	0.4
7th floor	2.5 in	1.4	0.4	2.2	0.33
8th floor	2.5 in	1.8	0.3	1.9	0.25
9th floor	2 in	2.2	0.55	2.1	0.4
10th floor	1.5 in	2.8	1.3	2.2	0.6

a. pressure drop per100 feet psi/100f

Table 2. the analysis of the existing design of the water supply network inside the buildings of the Bismayah city by using manual and the Elite (S-Pipe) calculations.

Riser Pipes	Pipe dim.	existing network		manual calculations		Elite S-Pipe	
		Fixture Unit	Flow (gpm)	Fixture Unit	Flow (gpm)	Fixture Unit	Flow (gpm)
1st floor	3 in	160	57	806	178.5	790	176.23
2nd floor	3 in	144	53.5	806	178.5	790	176.23
3rd floor	3 in	128	50	806	178.5	790	176.23
4th floor	3 in	112	46.2	806	178.5	790	176.23
5th floor	3 in	96	42.5	806	178.5	790	176.23
6th floor	2.5 in	80	38	507	125	491	122.34
7th floor	2.5 in	64	33.2	507	125	491	122.34
8th floor	2.5 in	48	28.5	507	125	491	122.34
9th floor	2 in	32	23.7	295	84	266	78.32
10th floor	1. 5 in	16	18	129	50	100	44.05

Date: October 2023

The result of re-design by manual calculations and the Elite (S-Pipe) software for the riser pipe in water supply network inside the building as shown in Table 3. The riser pipe on the 10th floor has a diameter of (1.5) inches, a flow velocity of (2.8) ft/sec, and losses in pressure (1.3) psi/100ft, while the diameter of the pipe decreased in manual and software calculations to (1) inch and increased in velocity and pressure losses within the code limits, this decreases in diameters of the riser pipes in network done without affecting on the efficiency of the network, and thus reduce the cost resulting from using diameters larger than the actual need for the network.

Table 3. Comparing the existing design with re-design by manual and the Elite (S-Pipe) calculations.

Riser Pipes	**existing network**			**manual calculations**			**Elite S-Pipe**		
	D (in)	V(ft/sec)	H.L. (psi/100ft)	D (in)	V(ft/sec)	H.L. (psi/100ft)	D (in)	V(ft/sec)	H.L. (psi/100ft)
1st floor	3	2.7	0.5	2	5.4	2.9	2	5.7	2.5
2nd floor	3	2.5	0.4	2	4.8	2.5	2	5.4	2.3
3rd floor	3	2.2	0.35	2	4.6	2.3	2	5.1	2
4th floor	3	2	0.3	1.5	7	6.5	2	4.7	1.7
5th floor	3	1.7	0.25	1.5	6.5	6	1.5	7.8	6.2
6th floor	2.5	2.5	0.55	1.5	5.5	4.6	1.5	6.9	4.9
7th floor	2.5	1.4	0.4	1.25	6.5	7	1.5	5.9	3.8
8th floor	2.5	1.8	0.3	1.25	5.8	5.5	1.25	7.3	6.8
9th floor	2	2.2	0.55	1.25	5.2	3.7	1.25	6.3	5.1
10th floor	1.5	2.8	1.3	1	6	8.5	1	7.4	8.9

3.5.Analysis and Design of Horizontal Main Pipe

Table 4. shows the results of the analysis of the existing design of main horizontal pipes in water supply network inside the buildings of the Bismayah city by using manual and Elite (S-Pipe) software calculations according (IPC, 2021). The values of each of the flow velocity and head losses are out of the limits of the design code recommendations, also in Table 5. A comparison between the actual water demand of the network and what can be delivered from the water demand using the same diameters of the existing pipes shows that the network was designed using pipe sizes larger than what is required according to the requirements of the optimal design, which in turn leads to To the lack of efficiency of the network and the increase in the breakdowns and damage to its parts, in addition to the increased cost as a result of the use of diameters larger than what is required.

Table 4. the analysis of the existing design of the water supply network inside the buildings of the Bismayah city by using manual and the Elite (S-Pipe) calculations.

Horizontal Main Pipes	Pip dim.	manual calculations		Elite S-Pipe	
		Velocity	H.L. psi/100ft	Velocity	H.L. psi/100ft
Feed Riser 1	4 in	/[a]	/[b]	1.2	0.06
Feed Riser 1:2	4 in	1.35	0.17	1.8	0.13
Feed Riser 1:3	4 in	1.7	0.28	2.4	0.22
Feed Riser 1:4	4 in	1.9	0.35	3	0.34
Feed Riser 1:5	4 in	2.2	0.45	3.5	0.5
Feed Riser 1:6	4 in	2.7	0.65	4.3	0.66

a.The velocity value is out of design figure according (IPC, 2021).
b. The head losses value is out of design figure according (IPC, 2021).

Table 5. the analysis of the existing design of the water supply network inside the buildings of the Bismayah city by using manual and the Elite (S-Pipe) calculations.

Horizontal Main Pipes	Pipe dim	existing network		manual calculations		Elite S-Pipe	
		Fixture Unit	Flow(gpm)	Fixture Unit	Flow(gpm)	Fixture Unit	Flow(gpm)
Feed Riser 1	4 in	114	45.25	1777	310	1928	313.3
Feed Riser 1:2	4 in	228	70.6	1777	310	1928	313.3
Feed Riser 1:3	4 in	342	93.4	1777	310	1928	313.3
Feed Riser 1:4	4 in	456	115.7	1777	310	1928	313.3
Feed Riser 1:5	4 in	570	137	1777	310	1928	313.3
Feed Riser 1:6	4 in	727	165.8	1777	310	1928	313.3

The result of re-design by manual calculations and the Elite (S-Pipe) software for the main horizontal pipe in water supply network inside the building as shown in Table 6. The main horizontal pipe in the network by adopting a diameter of one (4) inch, with a flow velocity ranging from (1.35 to 2.7) ft/sec, and the amount of pressure losses ranging from (0.17 to 0.65) psi/100ft, while a pipe of graduated diameter was used from (2 to 3) inch achieved by manual and software calculations with an increase in velocity and the amount of pressure losses within the parameters of the code, and this works to reduce the cost resulting from the use of pipes with diameters larger than the actual needs of the network.

Table 6. Comparing the existing design with re-design by manual and the Elite (S-Pipe) calculations.

Horizontal Pipes	**Main**	**existing network**			**manual calculations**			**Elite S-Pipe**		
		D (in)	V (ft/sec)	H.L. (psi/100ft)	D (in)	V (ft/sec)	H.L. (psi/100ft)	D (in)	V (ft/sec)	H.L. (psi/100ft)
Feed 1	**Riser**	4	/a	/	2	4.2	1.7	2	4.734	1.767
Feed 1:2	**Riser**	4	1.35	0.17	2	6.8	4.1	2	7.188	3.814
Feed 1:3	**Riser**	4	1.7	0.28	2.5	5.8	2.8	2.5	6.081	2.158
Feed 1:4	**Riser**	4	1.9	0.35	2.5	7	3.7	2.5	7.541	3.213
Feed 1:5	**Riser**	4	2.2	0.45	3	4.5	1.8	3	6.213	1.816
Feed 1:6	**Riser**	4	2.7	0.65	3	5.5	2.5	3	7.524	2.587

Conclusion

Inappropriate design of water supply networks inside buildings reduces network efficiency and increases pipe break failure and maintenance. The results of the analysis of the water supply network inside the building showed the use of a riser pipe with a range from (3 to 1.5) inches, while with the redesign, the diameters of the pipes decreased, and they were with a range from (2 to 1) inches, with an increase in flow speed and pressure losses within the determinants of the International Plumbing Code 2021 The use of pipes with diameters larger than the required diameter increases the cost of the water supply network inside the building, and reduces head losses outside the design limitations . The results of the redesign showed the possibility of using a main horizontal pipe feeding the riser pipes with a graduated diameter of (2 to 3) inches, with a flow rate and pressure loss amount within the specifications of the International Plumbing Code 2021, instead of the existing pipe within the network with a diameter of (4) inches. The results of the manual calculations showed high efficiency, as they were close to the results of the calculations by Elite S-Pipe software.

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Date: October 2023

Estimate Raw Water Salinity for The Tigris River for a Long Time Using a Mathematical Model

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Abstract: The measurement data of the raw water quality of Tigris River were statistically analyzed to measure the salinity value in relation to the selected raw water quality parameters. The analyzed data were collected from five water treatment plants (WTPs) assembled alongside of the Tigris River in Baghdad: Al-Karkh, Al-Karama, Al-Qadisiya, Al-Dora, and Al-Wihda for the period from 2015 to 2021. The selected parameters are total dissolved solid (TDS), electrical conductivity (EC), pH and temperature. The main objective of this research is to predicate a mathematical model using SPSS software to calculate the value of salinity along the river, in addition, the effect of electrical conductivity on the salinity value was estimated. Multiple linear regression (MLR) and artificial neural network (ANN) models were used to estimate the mathematical models for calculating water salinity value in Tigris River and to present the highest effective parameter that effect on water salinity. In general, the results showed an increase in the water salinity level downstream of the Tigris River towards the south of Baghdad and the EC is the most significant effect on water salinity, and MLR and ANN analyses present a good indication of the mathematical models with highest coefficient of correlation (R^2) as (0.999 and 0.998), respectively. In addition, the regression equations proved good performance in predicting the salinity value with error percentage less than 10% for all WTPs.

5. Introduction

The Tigris River's lower reaches receiving less water due to building dams upstream is one important factor contributing to a rise in salinity value along the river. In Kut Station, discharge to the lower levels of the Tigris is reduced by 62%, and it is heavily restricted at the upstream reaches. In addition, a significant rise in salinity occurs in conjunction with a decrease in river discharge. The salinity of the Tigris River is higher than what is considered safe for human consumption in Amara and downstream [1]. The Tigris River has been used as a source of water which is essential to human civilization. The growth of salinity concentration is directly caused by the construction of large upstream dams and the use of Tharthar Lake as a storage facility, and until now, no considerable salinization has occurred in the river's upstream sections[2]. The Tigris River supplies the Tharthar Lake, which is the biggest reservoir in Iraq and redirects river flow to the Euphrates and Tigris rivers downstream. Due to the lake's rapid evaporation, the Euphrates and Tigris downstream get a significant amount of saline from the lake outflow [3]. Rapid evaporation of lake and reservoir results in large losses of water. More than 50% of Iraq's reservoir evaporative losses are currently attributable to Tharthar Lake. Tharthar Lake will probably be employed in the future for flood control in order to better conserve water supplies [4].

In 2021, a study was carried out to estimate the overall index of pollution (OIP) of eight parameters for water samples collected from five locations on the Tigris River in Baghdad city. The

Date: October 2023

OIP is one of the most reliable methods for assessing the quality of surface water. The results showed that in 2017, the Tigris River's water quality was rated as good to mildly contaminated, but it just improved to become acceptable in 2018 [5]. The decrease in the amount of pure water flowing from Turkey, where dams are being constructed to preserve water for irrigation and recreation has the most impact on the Tigris River's water quality. The most well-known dam is Aliso, which began operation in 2017. The annual precipitation rate also contributes significantly to the dilution of rivers' water, according to Iraqi meteorological data, 2017 was the driest year in the past ten years with an annual precipitation rate of 71.6 mm, and in 2018, the rate increased to 366.4 mm [6].

Water quality assessment is an integrated activity that analyzes the physical, chemical, and biological properties of water in connection to health and environment, climate change, and specific water usage [7]. There are some parameters that effect on water quality such as pH, electrical conductivity (EC), total dissolved solids (TDS), and temperature. The pH of water sample, which indicates its acidity or alkalinty, is essentially a measurement of the activity of hydrogen ions in the sample. The pH scale ranges from 0 to 14, with 7 indicating neutral. Acids have pH values less than 7, whereas alkaline have pH values between 7 and 14. Because of the natural presence of carbonates and bicarbonates, river water tend to be alkaline, which is typical of Iraqi rivers. Rainwater considered slightly acidic (pH 6.5), whereas seawater is weakly alkaline (pH 8.5) [8].

The Electrical conductivity (EC) is an important water quality parameter for identifying the amount of salts present in water, and it is a measurement of water's capacity to conduct electricity and indicates the amount of contaminants (salts). Electrical conductivity and salt concentration in milliequivalents per liter have a relationship, so, the EC at 25°C is a standard method for calculating total salt content in water. High value of EC (1000-10,000 mS/cm) indicates salty water as a result of excessive evaporation, salty irrigation returns or runoff, and caustic industrial activities. The ability to use water for agricultural irrigation is connected with salinity value, which is a measurement of the amount of salt in water. Every irrigation stream contains certain dissolved substances; these substances are often referred to as salts. In addition to effecting plant development, the salts in the water also have an indirect impact on plant growth by changing the structure, permeability, and aeration of the soil [9].The dissolved solids content of water (TDS) is the total amount of organic and inorganic substances dissolved in water, the majority of the dissolved solids in water include calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, nitrate, and silica. Combinations of these ions, such as sodium and chloride, generate salts, and salinity is another name for the dissolved solids content of water. TDS levels in surface water and groundwater may be monitored using surrogate and specific conductance. Specific conductance measures the capacity of water to conduct an electrical current. This ability is increased by the presence of dissolved ions in the water [10].

One of the most crucial factors in managing water quality is the influence of salinity that it refers to the types and amounts of dissolved salt ions present in the water. Salinity in irrigation water is determined by the concentrations of the major cations, sodium (Na^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), and potassium (K^+), as well as the major anions chloride (Cl^-), sulfate ($SO_4^{\ 2-}$), bicarbonate ($HCO_3^{\ -}$), carbonate ($CO_3^{\ 2-}$), and nitrate ($NO_3^{\ -}$)[11]. Salinity measures such as TDS measured in milligrams per liter, EC measured in micro-Siemens per centimeter, and resistivity (ohm centimeters) were taken for water samples collected from springs in the first and second potential locations. The best way to show that TDS and EC are related in a straight line is with the best-fit regression line from the equation below [12]: $TDS\ (mg/L) = 161.4 + 0.737 *(EC *10^6)$ (1) EC and TDS are the two basic parameters for estimating the salt content in water, whereas EC measures the amount of electrical current that may flow through a sample of water and TDS measures the relative weight of dissolved elements in a sample of water. Salinity intrusion is one of the climate-related hazards that affects the quality and availability of safe and usable pond water sources [13].

An artificial neural network (ANN) model was used to predict Ryznar Stability Index (RI) in 2013 for four water treatment plants on the left side of Baghdad city. The results showed that the ANN model is efficient in predicting RI with a high determination coefficient (R^2) [14] . The results of an experiment demonstrated that the ANN model, which uses polymer inclusion membranes (PIMs) with seven input variables, is particularly suitable for the prediction of cadmium (Cd) removal from aqueous solutions. Cd is one of the most dangerous heavy metals. It has been demonstrated that ANN

Date: October 2023

prediction values are more closely related to experimentally measured values. Furthermore, comparisons between multiple linear regression (MLR) and artificial neural network ANN models were made, with the results indicating that MLR had the lowest correlation coefficient R^2 of 0.787, while ANN models had values of 0.988 [15].

Over the past few years, in order to estimate some water quality parameters of the Tigris River in Iraq, a few studies have been employed to forecast these characteristics using ANN models, and they have shown a certain amount of success. Previous studies on predicting the concentration of TDS for Tigris River, estimated that the values of TDS increase with time and distance. The prediction of TDS concentration of Tigris River on five locations between Mosul and Amarah in Iraq was examined for the period from 2001 to 2011. Through using ANN models, the results showed that TDS was increased with time and distance from upstream. While, the sensitivity analysis proved that the distance and discharge have the most effect on the predicted TDS, while the time have the smallest impact [16]. Furthermore, TDS concentration for drinking water treatment plant and raw water in Tigris River in Baghdad city was evaluated. The results showed that TDS increase with distance from upstream to downstream and with time for the period from 2013 to 2017 [17]. The objective of this study is to estimate a mathematical model to predict salinity value of raw water of the Tigris River. In the present research, the basic statistical analysis of the chemical parameters of the raw water of Tigris River is carried out by developing MLR and ANN models using IBM® SPSS® Statistics 26 software (SPSS).

2. Materials and methods

2.1. Description of the Study area

The second-largest river in western Asia and the major sources of fresh water for Baghdad city is the Tigris River. The city is separated into right (Karkh) and left (Risafa) sides by the Tigris River, which flows from north to south. The Tigris has a total length of about 1900 km, of which 400 kilometres are in Turkey, 32 km are on the border with Syria, and the remaining 900 km are in Iraq [18]. In addition, it has a total drainage area of 235,000 km^2, which is shared by Turkey (17%), Syria (2%), Iran (29%), and Iraq (52%).The river travels southeast until it reaches al Qurna in southern Iraq, where it meets the. The Shatt al Arab canal, which is made up of the two rivers Tigris and Euphrates, drains into the Persian (Arabian) Gulf [3].

2.2. Data collection

The recent data used in this study were obtained from analyzing the raw water quality of five water treatment plants (WTPs) alongside of Tigris River in Baghdad such as Al-Karkh, Al-Karama, Al-Qadisiya, Al-Dora and Al-Wihda, as shown in Figure 1**.** The selected data of raw water for the period (2015-2021) are provided from the Mayoralty of Baghdad. The selected data for this research represent the averages monthly values of four parameters for raw water (Total Dissolved Salts (TDS), Electrical Conductivity (EC), and Temperature and pH). To achieve the objective of the research described above, the data were evaluated using time-series analysis and ANN and MLR mathematical models.

Date: October 2023

Figure 1. Water Treatment Plants alongside Tigris River (Google map).

2.3. Multiple linear Regression model

Regression analysis attempts to investigate the relationship between two or more variables, with the aid of an equation, referred to as a regression line. Considering that it was created using the least squares method, the line is also referred to as the best fit line. The least square technique calculates the variables of the regression equation through eliminating the sum of square errors of the dependent variables. With the use of known factors (independent variables), regression analysis determines the nature of the connection between two or more variables before estimating the unknown variable (dependent variable). The term "simple regression" refers to the study of the connection between two variables (one dependent and two independent), whereas the term "multiple linear regression" refers to the analysis of more than two variables sequentially [19]. The connection between a dependent variable and a few independent parameters is expressed mathematically by the multiple linear regression (MLR) equation. This method is based on least squares, where the model is fitted so that the sum of squared variances between predicted and observed values is reduced. MLR may be expressed using the general equation as follows [15]:

$$Y= \beta_o + \beta_1 X_1 + \ldots\ldots + \beta_n X_n + \varepsilon \tag{2}$$

Where Y stands for the dependent variable, X for the independent variables, β for the anticipated parameters, $\beta_\circ$ for Y intercept (constant) and ε for the error term.

2.4. Artificial neural network (ANN) model

A network of artificial neurons might be used to predict an output data from input data, similar to how neurons in the human brain process input signals and produce output signals. A highly parallel and distributed system known as a neural network has a tendency to store and make use of experience-based knowledge. Multilayer Perceptron (MLP) and Radial Basis Function (RBF) are the two kinds of neural network topologies that SPSS offers. The function that minimizes the prediction error of the target variable (dependent output variable) is a function of the predictor variables (independent input vectors). In the current study, data are fed into the MLP model's feed forward architecture to determine the salinity percentage of the Tigris River. Neuronal connections run from the input layer to the hidden layer, then to the output layer in a feed-forward design. A multilayer perceptron neural network may provide a prediction model for the dependent variable based on the functionality of the predictor variables. The model structure (connection weights and hidden neuron counts) were calculated using the model training approach, and the task was completed by dividing the input data into training, testing, and holdout samples. Additionally, when building the model, the set of data from holdout sample was not taken into account [20]. Through training and testing the model using past record, the mathematical relationship between the independent (chemical parameters of water quality) and the

Date: October 2023

dependent (salinity percentage) was investigated for the purpose of predicting salinity value of Tigris River.

The sum of square error function may be used to calculate the variance between observed and expected values. Because the network tries to reduce the error function during training, the prediction accuracy of ANN model was shown to be high when the error was low (IBM® SPSS® Statistics 19 User Gide). R^2, the coefficient of determination, is an alternative statistical parameter that has been studied. The range of R^2 values from 0.0 to 1.0 further illustrates that the better the ANN model matches the input data, the higher the R^2 value [21].

3. Results and Discussion

3.1. Salinity analysis for Tigris River

Some studies predicated the concentration of TDS for Tigris River in Iraq for the period from 2001 to 2017 in different locations, estimated that the values of TDS increase with time and distance. Time-series analysis is used to calculate the average value of TDS, EC, pH, and Temp. parameters of the raw water of Tigris River, during the period of study from (2015-2021). The results indicated that TDS concentration slightly increases with distance from upstream to downstream and became (555 mg/l) at Al- Dora WTP which slightly exceed the permissible limit of the Iraqi drinking water standards 500 mg/l, as show in Figure 2. While the value of EC was obviously increased, starting from 720 (μS/cm) at Al-Karkh station and ending at 917 (μS/cm) at Al-Wihda station that exceed the desirable limit of the Iraqi drinking water standards, as shown in Figure 3. These results are in agreement with previous studies that attained by [16][17]. High TDS value could be accrued, when some sedimentary rocks exposed to weathering or erosion during time, or from different sources such as industry and sewage discharge [22]. As shown in Table 1, the average value of TDS is 484.37 and EC is 874.56 and according to Table 2, salinity of Tigris River alongside the WTP is considered as slightly saline water related to EC value and none saline water related to TDS value.

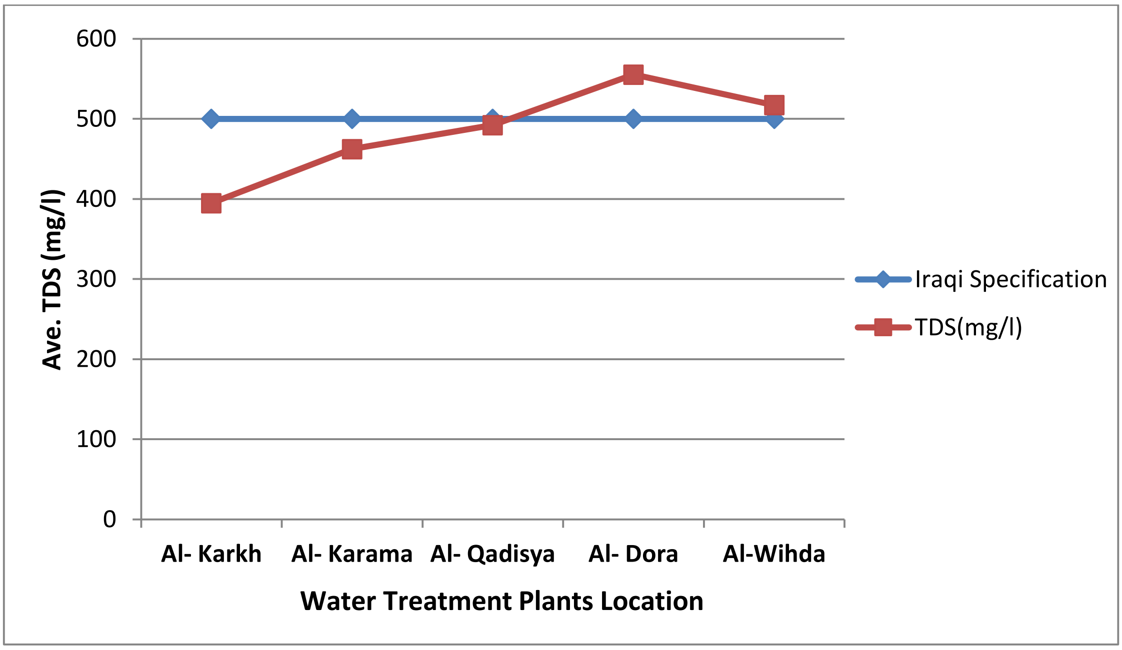


Figure 2. Average value of TDS with water treatment plants location.

Date: October 2023

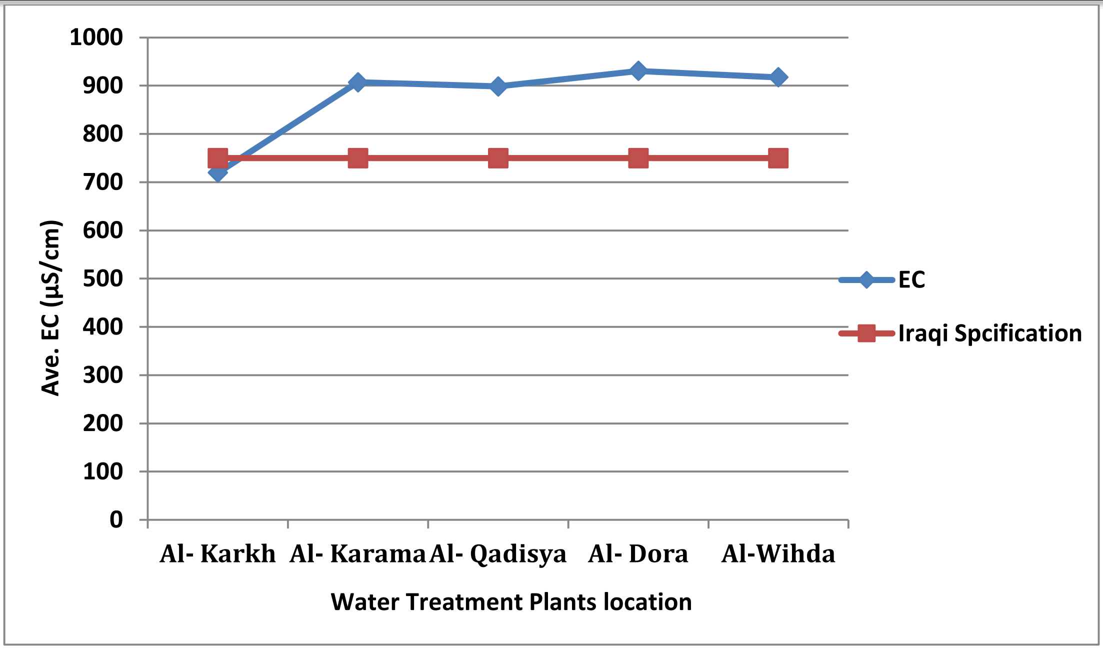


Figure 3. Average value of EC with water treatment plants location.

Table 1. Average value of annual parameters (time serious analyses) of each WTP.

[1] **WTP location**	[2] **Raw water**			
[3]	[4] TDS(mg/l)	[5] pH	[6] Temp	[7] EC(µS/cm)
[8] **Al- Karkh**	[9] 394.83	[10] 7.99	[11] 23.15	[12] 719.60
[13] **Al- Karama**	[14] 462.26	[15] 8.14	[16] 22.30	[17] 907.06
[18] **Al- Qadisya**	[19] 492.32	[20] 7.99	[21] 22.37	[22] 898.29
[23] **Al- Dora**	[24] 555.30	[25] 8.08	[26] 21.74	[27] 930.65
[28] **Al-Wihda**	[29] 517.17	[30] 7.97	[31] 22.27	[32] 917.21
[33] **Average**	[34] 484.376	[35] 8.034	[36] 22.366	[37] 874.562

Table 2. Classification of water based on salinity and according to TDS and EC values [23] .

[38] **Water classification**	[39] **EC (µS/cm)**	[40] **TDS (mg/l)**
[41] **Non-saline water**	[42] 700	[43] <500
[44] **Saline water**	[45] 700–42000	[46] 500–30,000
[47] **Slightly saline**	[48] 700–3000	[49] 500–2000
[50] **Medium saline**	[51] 3000–6000	[52] 2000–4000
[53] **Highly saline**	[54] >6000	[55] >4000
[56] **Very saline**	[57] >14000	[58] >9000
[59] **Brine**	[60] >42000	[61] >30,000

3.2. Regression model

Multiple linear regression model (MLR) is employed to estimate the mathematic model for determining salinity related to water parameters as independent variables (TDS, EC, pH and Temp) and also to find the relation between salinity and independent variables in a straight line which showed the best-fit regression line. Regression models were developed for each parameter affecting salinity value. Table 3 shows the equations of salinity predication from regression analysis of the parameters and the R square value. The highest value of R^2 of the curve fitting formula is 0.999. In addition, referring to the equations in Table 3, the negative estimated coefficients indicated that these

Date: October 2023

parameters affect the salinity value in a negative direction, and could be because the huge differences between the values of the independent variable or if the amount of one of the independent variables are too high compared to other independent variables [24].

The predicted equations were tested using the observed data of water parameters for the period from 2015 to 2021 for the five WTPs. The developed equations were used to predict salinity value using the observed parameters (TDS, EC, pH and Temp.). To determine if the predicted equations were accurate, the percentage of errors was calculated between the measured and the predicated salinity value from this equation [7]:

Diff= Predicated value – Observed value (3)

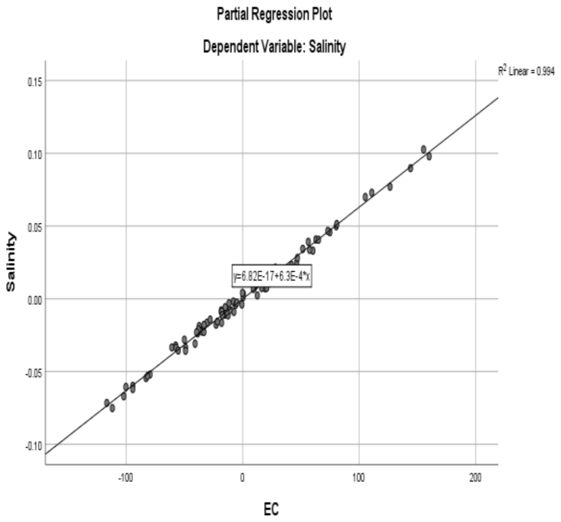
$$\text{Error \%} = \frac{\frac{\sqrt{\sum(\text{Diff})^2}}{n}}{\text{avg.Observed value}} \quad (4)$$

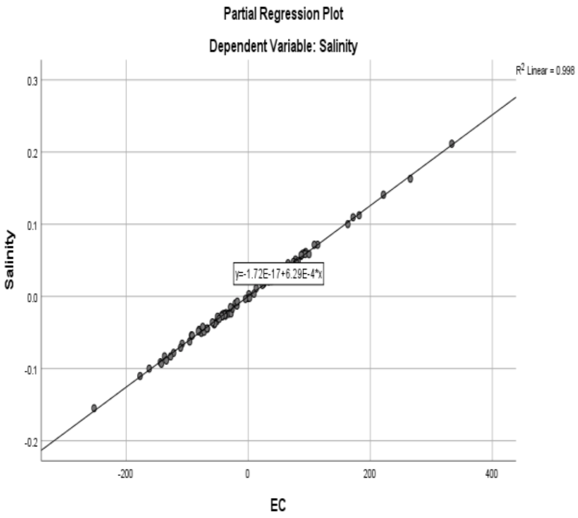
The results showed that the percentage error for salinity value at Al- Karkh, Al-Karama, Al-Qadisya, Al- Dora and Al-Wihda is equal to 6.5 %, 6.62%, 7.1%, 6.75% and 6.63 %, respectively. The error percentages for predicting salinity at each WTP are less than 10% which could be considered as minor error and the estimated equations have shown good performance in forecasting salinity value in relation to water quality parameters [7]. Figure 4 shows the relation between salinity and EC using the best fit regression line and the highest value of coefficient of determination (R^2). According to Figure 4, EC is the highest effect parameter on the salinity value through Tigris River which gives the highest value of R^2.

Table 3**.** MLR models for salinity prediction and coefficient of determination.

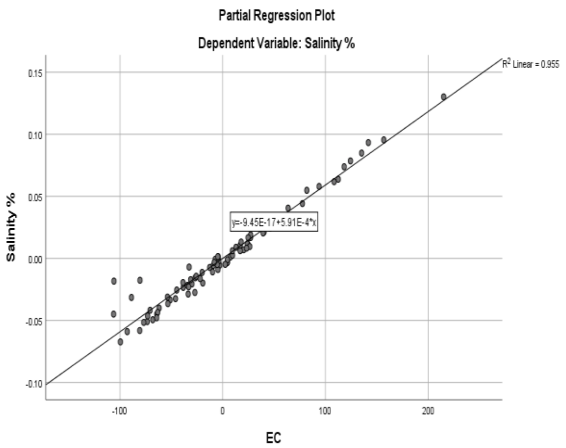
WTPs	**Equations**	**R^2**
Al- Karkh	Salinity = 0.025+5.43*10^{-6} *TDS+0.001*EC-0.005*pH-6.88*10^{-6}*Temp.	0.997
Al-Karama	Salinity = 0.005+3.73*10^{-6} *TDS+0.001*EC-0.002*pH+0*Temp.	0.999
Al- Qadisya	Salinity = -0.037+1.96*10^{-6} *TDS+0.001*EC+0.007*pH+2.44*10^{-5}Temp.	0.999
Al- Dora	Salinity = 0.014+1.07*10^{-6} *TDS+0.001*EC-0.002*pH-2.06*10^{-6}Temp.	0.999
Al-Wihda	Salinity = 0.04+9.48*10^{-7} *TDS+0.001*EC-0.006*pH-3.27*10^{-5}Temp.	0.999

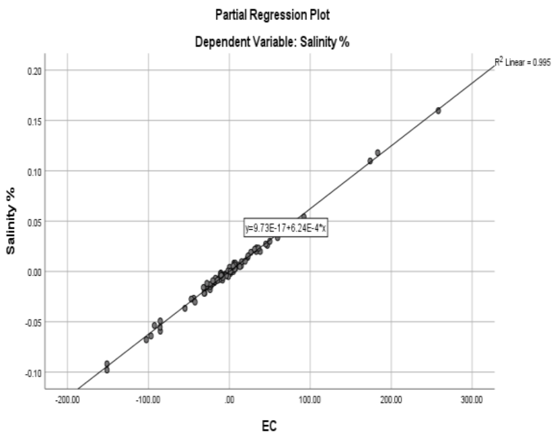
Date: October 2023





Al-Karkh **Al-Karama**





Al-Qadisya **Al-Dora**

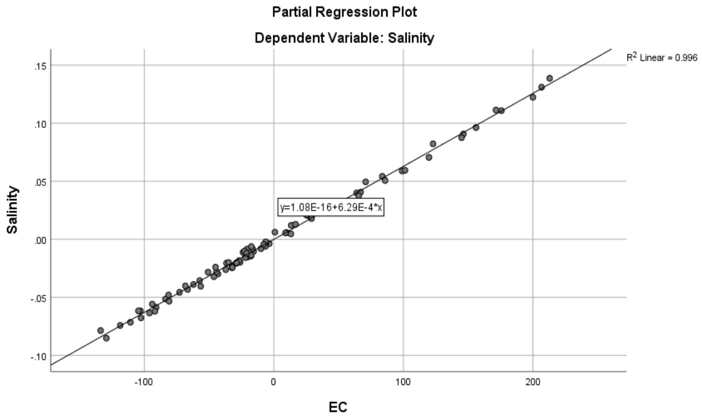


Figure 4. Relation between salinity and EC with highest determination coefficient for each WTPs.

3.3. ANN model

An ANN model was employed to predict the salinity value for the raw water at Tigris River at five WTP: Al-Karkh, Al-Karama, Al-Wathba, Al-Dora, and Al-Wihda. The model was developed through multiple tests, training, and holdout trials. The 84 experimental data were randomly divided into three

Date: October 2023

groups for training (60), testing (15), and holdout (9). The input data used for predicting salinity are (TDS, Ec, pH and Temp). Table 3 presents the equations of salinity predicators and observed value and the correlation factor R^2 for each WTP. In all cases, the equation that has higher correlation coefficient (R^2) was selected as a best fitted equation. Figure 5 shows the relationship between the observed and predicated data for each WTP with highest correlation coefficient. The best and highest correlation coefficient is 0.998 in Al- Karama, this high value could be because its placement upstream of the Tigris River in Baghdad. This result is consistent with the previous study carried by [17].

Table 4 shows the normalized importance of the independent variable which represents the parameter (TDS, EC, pH and Temp). The most important parameter that has a great effect on the prediction of salinity value is EC in all WTPs as estimated in the regression analysis, while TDS, Temperature and pH values show the least effect on salinity value.

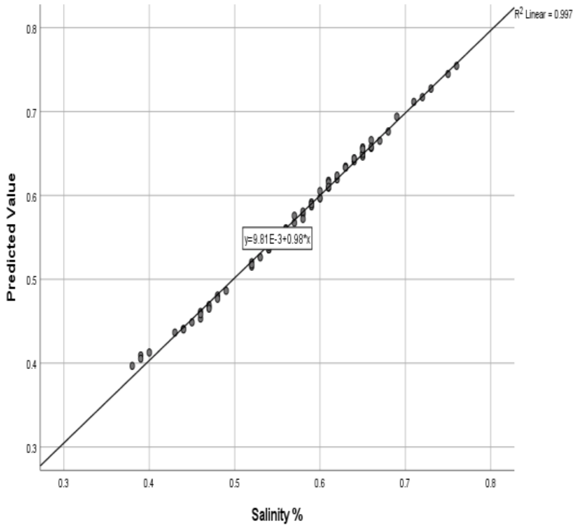
Table 4. Equations of predicted and observed value of salinity and R^2 for each WTP along Tigris River.

[62] **WTP location**	[63] **Equations**	[64] **R2**
[65] **Al-Karkh**	[66] Y=0.0059 + 0.99*X	[67] 0.995
[68] **Al-Karama**	[69] Y=0.0045 + 0.99*X	[70] 0.998
[71] **Al-Qadisya**	[72] Y=0.00066 + 0.99*X	[73] 0.992
[74] **Al-Dora**	[75] Y=0.0098 + 0.98*X	[76] 0.997
[77] **Al-Wihda**	[78] Y=0.01 + 0.98*X	[79] 0.997

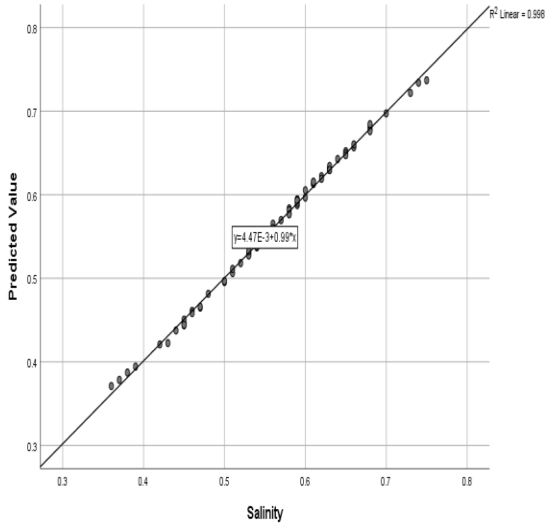
Table 5. Independent variable normalized importance.

[80] **Parameters**	[81] **Al- Karkh**	[82] **Al-Karama**	[83] **Al-Qadisya**	[84] **Al- Dora**	[85] **Al-Wihda**
[86] **TDS**	[87] 4.0	[88] 2%	[89] 12.3%	[90] 4.7%	[91] 5.5%
[92] **EC**	[93] *%100*	[94] 100%	[95] 100%	[96] *%100*	[97] 100%
[98] **pH**	[99] *1*.8%	[100] 2.4%	[101] 4.2%	[102] 1.2%	[103] 2.6%
[104] **Temp**	[105] 3.1%	[106] 1.8%	[107] 2.9%	[108] 2.9%	[109] 1.5%

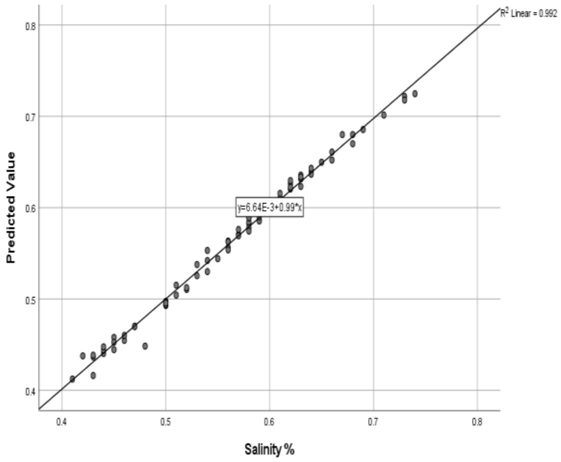
Date: October 2023



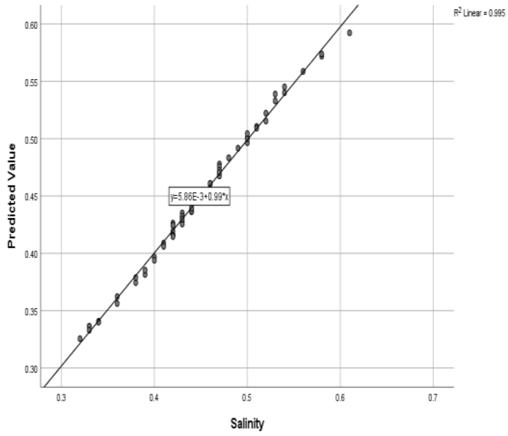
Al-Dora



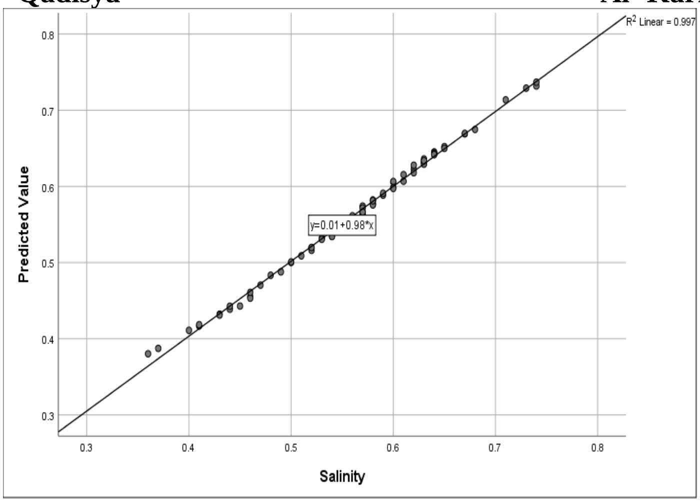
Al-Karama



Al- Qadisya



Al- Karkh



Al- Wihda

Figure 5. Relation between predicated and observed value of salinity.

4. Conclusion

Tigris River is the second-largest river in western Asia and the major sources of fresh water for Baghdad city and due to the environmental impact of climate changes, weathering of some rocks and

Date: October 2023

industrial and sewage discharging the water quality of the river are affected. Therefore it was important to measure the regional and seasonal variation of the salinity value along the river in relation to some water quality parameters such as TDS, pH, EC and Temp. The collected data for the period (2015-2021) were analyzed using time serious analysis. From the average value of TDS the salinity of raw water of Tigris River alongside the WTP is considered as none saline water while from the average value of EC it is slightly saline water. In addition, according to the time-series analysis of the parameters of raw water for the period from 2015 to 2021, TDS concentration slightly increased with distance from upstream to downstream of the Tigris River in Baghdad, while EC value was obviously increased. These results showed that salinity value increases with distance and time. A multiple linear regression was fitted to predicate salinity based on TDS, EC, pH and Temp parameters. The overall model explains 99.0% variation of salinity, and it is significantly useful in estimating mathematical model which proved good performance in predicting the salinity value with error percentage less than 10% for all WTPs. The ANN model might be employed to predict salinity value related to the observed salinity and highest value of correlation coefficient is 0.998 in Al- Karama WTP. According to the MLR and ANN analyses EC parameter has the most significant effect on predicting salinity value in both models.

Acknowledgment
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Adsorption, Isotherms, and Kinetics for Phenol Removal on Biochar Prepared from Wheat Husk

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Abstract: In this study, wheat husks were transformed into biochar (BCs). It has been used to remove phenol from the wastewater. BCs it was prepared by hydrothermal carbonization and after activation with H3PO4 Therapy. the Tube furnace were used for carbonization. many examinations were used to study the BC properties such as Fourier transform infrared (FT-IR), scanning electron microscopy (SEM), and Brunauer-Emmett-Teller (BET). in batch reactor, the operation condition were studied by many parameter in different dose, such as (pH, doses of BC and phenol). also, to determine maximum removal efficiency of phenol on biochar. From results the best operating condition were pH and contact time 4, 1 hr, the BC dose 0.5 g / L, and 50mg/L for phenol dose. with constant for others parameters such as (agitation velocity of 150 rpm, ambient temperature, and initial phenol concentration 50 mg /L). the maximum removal efficiency for phenol reach to (84%). the second order was the best adsorption kinetic. Freundlich isotherm model has introduced a fair description for sorption, so, the BC could be utilized effectively as an adsorbent.

1. Introduction

Chemicals and emerging materials are a source of great concern to scientists. especially with regard to the effects of human exposure to these substances, predominately the aquatic environment, because they remain in the environment for a long time. these are accumulated in the body when exposed to them, causing poisoning to humans and animals.

Phenol is one of these chemicals that are available in nature in [1,2] the same colors as fruits [3] and some are manufactured to be used in daily life. Phenol enters the water environment as a result of industrial, agricultural and natural waste, and sometimes it is present due to the decomposition of organic materials present in the water as a result of industrial waste [4–6]. It is an extremely lethal organic pollutant to the habitat that is impossible to remove by biological degradation [7]. As a result, various strategies for extracting phenol from wastewater have been used, including biodegradation, chemical oxidation, solvent extraction membrane filtration as well as the adsorption process. Because of its high uptake capability, cheap price, and regeneration potential the adsorption become very favored from the previously mentioned methods for phenol removal [8][9]. Bio-sorbents are efficient, selective, and have a natural affinity for pollutants. Furthermore, biosorption is commonly used due to its low-cost and natural availability.

Biochar (BC) is a charcoal-like material that contains a large amount of carbon. It is prepared by pyrolysis, i.e., resulting from the burning of organic waste in a controlled manner to reduce emissions resulting from burning and storage. differed materials used in the preparing of biochar such as agricultural waste banana peel, bark, sawdust, and others; these biological adsorbents considered very suitable for adsorption. [10]. Organic materials, such as wood chips, leaves, or dead plants, are burned in a container with very little oxygen during pyrolysis. From the literature reviews about adsorbents that prepared from friendly environmental materials, such as F.H., et al 2019 were prepared pillared clay from Iraqi clay and used as an adsorbent to remove phenol from wastewater, [11] prepared the adsorbent from tea leaves to remove dye from wastewater, addition to,

[12] prepared adsorbent from a waste of tea, that used for removal phenol from wastewater. At a low temperature (<700 ° C) [13]. Biochar has been made from a variety of plant residues and used as an adsorbent. Electrostatic contact, ionic exchange, chemical precipitation, and complexion with functional groups on the BC surface are the main adsorption mechanisms [14][14] (Liu and Zhang 2009)(M. Zhang et al. 2013)(Cao et al. 2009)(Regmi et al. 2012). The adsorbent material is subjected to several tests, such as Brunauer, Emmett and Teller (BET), scanning electron microscope (SEM),

Date: October 2023

ay Powder Diffraction (XRD) and Fourier-transform infrared spectroscopy (FTIR) , to find out the ability of biochar to adsorb pollutants, electrostatic attraction, in addition to the presence of active groups such as the free and complex carboxylate group, or the presence of phenolic carboxylate, or alcoholic carboxylate on the biochar such as -ROMe, COOMe, groups. ROH and -R- COOH [15].Surface-coordinated carboxylases (R-COOH) and alcoholic or phenolic hydroxyl groups (R-OH) are considered [16].In comparison to organic pollutants, there is a scarcity of information on the factors that influence inorganic's contaminants immobilization on BCs and the effect of BC on heavy metals retentions in soil [17].

Many researchers were studied in this field such as [9]used biochar prepared from wheat-straw via low-temperature pyrolysis at somehow 450°C, that used for removing nitrate and phosphate, Adsorptions test revealed that optimal-modified biochar(OMB) could be utilized to remove nitrate and phosphate from water.[18]was found that biochar has wide application prospects in environmental remediation, and the mechanism of biochar in the environmental application should be further investigated .[19] A review study on the environmental application of biochar. It was noted that biochar preparation methods should be further investigated, the factors contributions on preparation processes should be systematically studied. Furthermore, studied a full review about the effective of biochar in destroy various organic matter. Nonetheless, it is uneasy to compare the traits of one biochar with the others because of the wide number of various biochar's feedstocks, and their preparatory methods. In [20], the impact of preparatory methods, processes parameters, and modifying methods on the physicochemical traits of biochar was reviewed and the ways that biochar in the soil pollution remediation. The biochar application in soils like the removal ofheavy materials and persistent-organic-pollutants (POPs) and the enhancement of soil quality. The aim of this work was for the first time to prepare biochar from wheat husks, and its potential to remove phenol from aqueous solutions in a batch reactor was studied. Several variables such as pH, adsorbents, phenol concentration dose, pH, and contact time were investigated.

2. Materials and Methods

Materials

Several materials were used to prepare biochar, including:

- Wheat husk collected from Yusufia farms in Iraq was shown in Figure (1).
- Phosphoric acid (1%)
- Ethyl alcohol (100%)
- Dioniazide water

The chemical composition (mass basis) of wheat husks is as follows:
Wheat husk consists of 6% protein, 2% ash, 20% cellulose, 0.5% fat, contains moisture [7].
To prepare the pollutant: Indian phenol 99.5% purity, chemical formula C_6H_6O, which used to prepare a Stock solution of contaminated water by dissolving 83 g of phenol in 1 liter of Distilled water. 0.1M HNO_3 or 0.1M NaOH can be added to the solution to change the pH to the desired value and the solution is used.

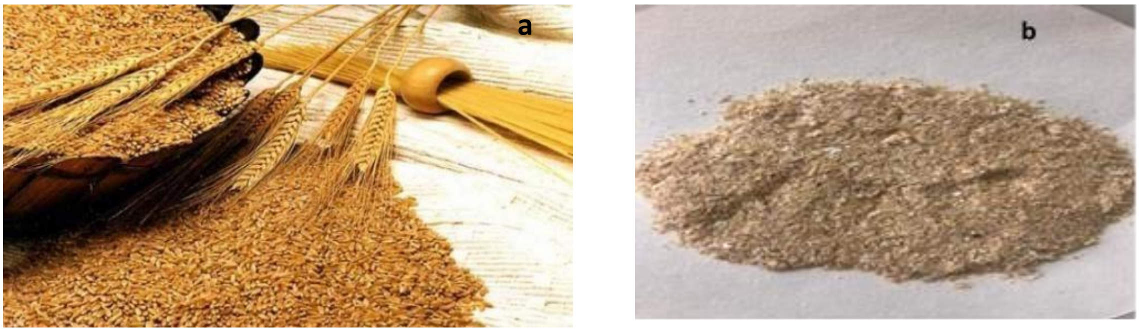


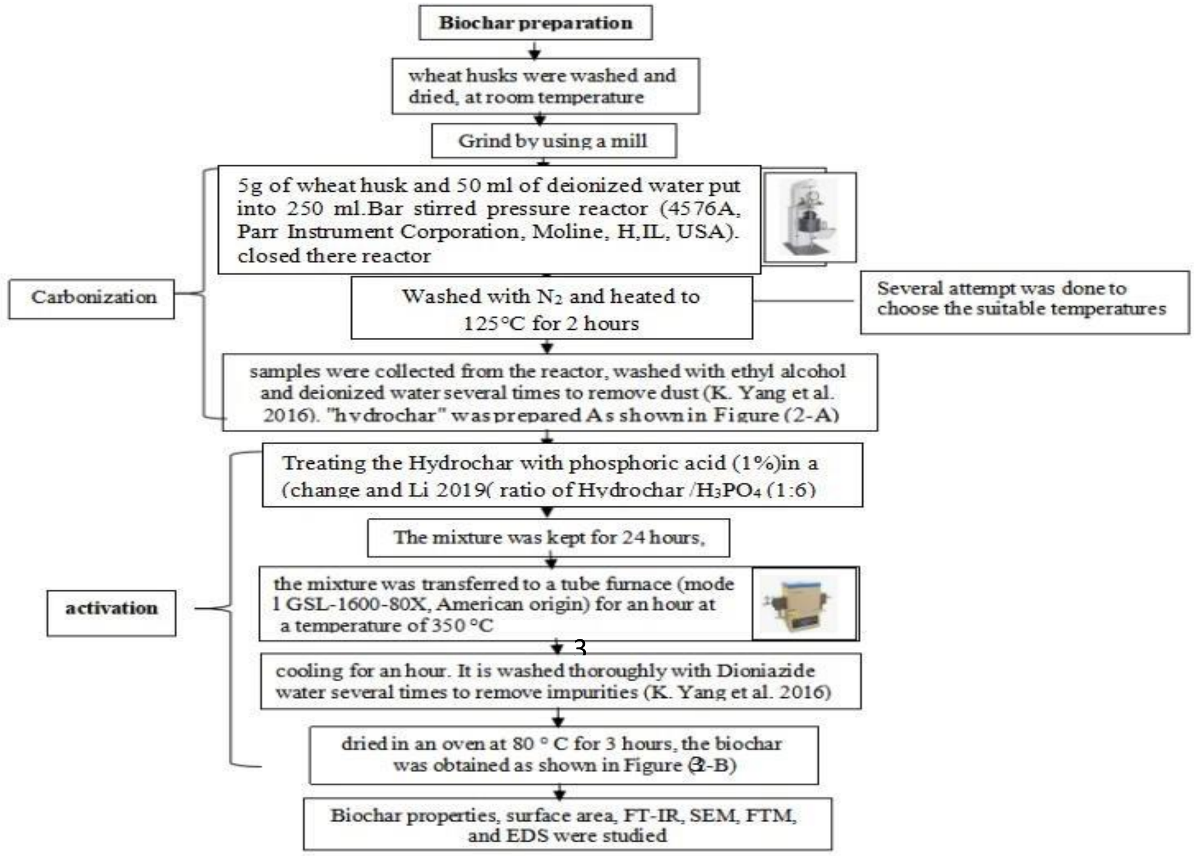
Figure 1:a.wheat husk before grinding, b. after grinding

Date: October 2023

Experimental work

The biochar was prepared as shown in Figure 2, this is a first aspect. The second aspect includes the removal of phenol using a batch reactor, Figure 3 was shown Hydrochar and biochar.

Figure 2: Biochar preparation



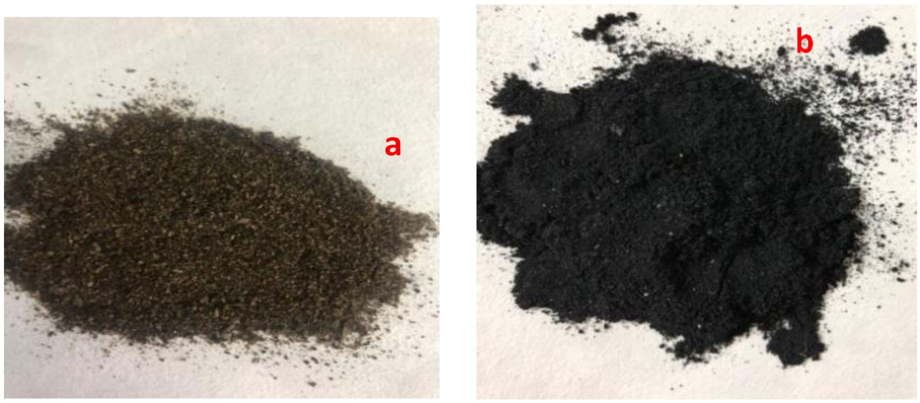


Figure 3: A. Preparation of Hydrochar, B. Preparation of biochar

The second aspect the phenol removal by adsorption on biochar in a batch reactor. to determine the operation condition many experimental were done with different parameters in variety dose, such as pH (2.5-4-7.5- and 10), phenol concentration (50-100-150 and 200), BC dose (0.1-0.4-0.5 and 0.8).

The initial phenol concentration was 500mg/L, were added in beakers that capacity 1000mL.A certain amount of absorbent (0.25 g) was distributed to each beaker. The solution in

Date: October 2023

beakers were stirred on a JAR TEST (AZTEC ENVIRONMENTAL CONTROL LTD) at 150 rpm and an initialized pH of 4 for1 h. the 10 mL samples were drawn from each beaker, then analyzed by using a spectrophotometer (UV / VIS, Model SP-3000 OPTIMA). The phenol ions were obtained by plotting the weight of the adsorb solute/unit weight (qe) versus the steady state concentration of Dissolved in solutions (M) [5].

3. Results and discussion

3.1 Characterization of prepared biochar

3.1.1. Blumenauer-Emmer-Teller (BET) analyses

To study the nature of biochar and its suitability as an adsorbent, the surface area was studied, from the results of Brunauer–Emmett–Teller (BET) for wheat Husks before and after the biochar preparation are shown in Table 1. The surface area increased after preparation. pore size also measured, the results were compared with the classification of the International Union of Pure and Applied Chemistry (IUPAC) for pore size (Å). the results of the biochar pore size are 142.8 Å, which is the appropriate size for the mesoporous adsorbent material [21].

Table.1: A surface area for wheat husks and biochar

Material	**particle size (Å)**	**particle volume(cm3/g)**	**Surface area (m2/g)**
Wheat husks	76.2	0.083	101.008
biochar	142.8	0.18334	274.589

3.1.2. Energy Dispersive Spectroscopy (EDS)

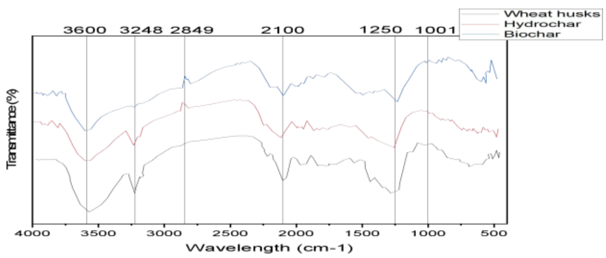
The chemical composition of wheat flakes and biochar can be calculated using Energy Dispersive Spectroscopy EDS. are shown in Tables 2

Tables. 2: Chemical composition for wheat husks and biochar

Elements	**Wheat husks**	**biochar**
K (%)	0.02	0.72
N (%)	0	5.2
C (%)	14.16	36.7
O (%)	8.97	2.58
Si (%)	0.01	0
P (%)	0.06	11.37

3.1.3. Fourier transform infrared spectroscopy FT-IR spectrum.

By Using Fourier transform infrared spectroscopy (FT-IR), the IR spectrum of wheat Husks, biochar Hydrochar and biochar with function groups are shown in Table 3 and Figures 4. From results a clear nitrogen bonding was found in Hydrochar and biochar within the range of 2849, it appears as a result of rinsing by nitrogen, the C-H bond appeared in a wide range in Hydrochar, while narrowed in biochar, but on the contrary, the C-C bond appeared narrowly in Hydrochar and widened in biochar (Al-kindi and Haidari 2020).



Date: October 2023

Figure.4:FT-IR spectra of wheat husks ,hydrochar and biochar

3.1.4. Attempts to prepare biochar.

Several experiments were conducted to manufacture biochar with different conditions, including the temperature and the concentration of phosphoric acid Until the appropriate conditions for manufacturing were reached.

Initially, thermal carbonization was performed at 250 °C, and through FTIR assay, it was found that the sample was charred due to the high temperature as in Figure 5.

It was reduced to 125°C. The activation was done by treated with phosphoric acid initially in high concentrations 40% at a temperature of 500 (as in a literature review for other materials), then washed with water at a temperature of 60°C, it was tested in FTIR assay as in Figure 5. that the sample was charred. When the temperature was reduced to 350 ° C, the sample was also charred Then the acid was diluted at 1% concentration at 400 °C and a charred sample as in Figure 5. Where the temperature was reduced to 350°C and the concentration of phosphoric acid 1% to obtain a successful result. When the sample was activated by 1% of phosphoric acid at 350° C, then washed with hot water at a temperature of 60 ° C and dried at 80 ° C for 3hr.

Table 3. The groups of the spectrum and this function

IR function	Type of bond	Functional group
3600	OH group	hydroxyl group
3248	C-H group	alkane group
2849	C-N group	Nitrogen bond
2100	C≡C	Alkyne group
1250	C-O	Alcohols
1001	C-O-C	Alcohols

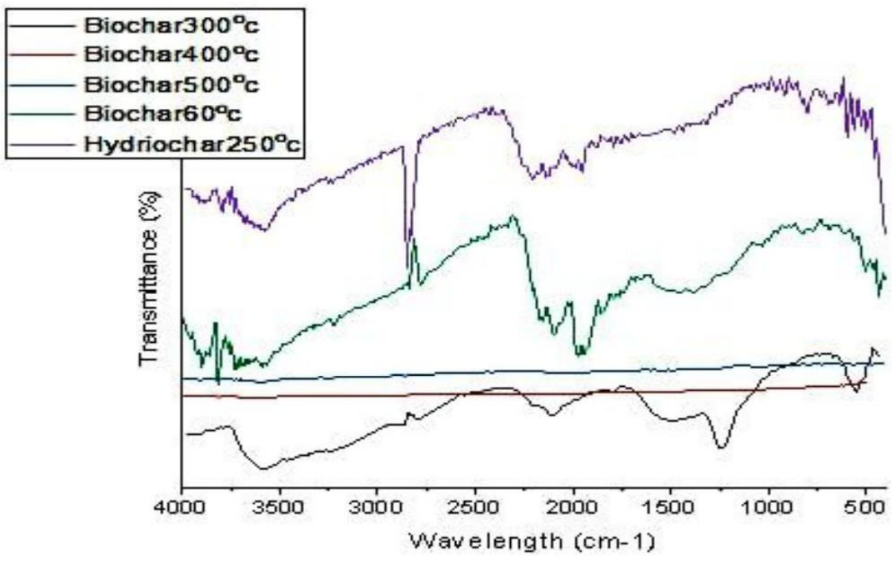


Figure 5: FT-IR spectra of attempts to prepare biochar.

Date: October 2023

3.1.5. SEM (scanning electron microscopy) analyses

The image of wheat Husks and biochar as in Figure 5(a and b) by using scanning electron microscopy (SEM) test, In Figure 6, the magnifications were 2000 and 1600 times for (a) and (b), respectively. which are shown pores and the surface roughness for biochar more and wider than wheat husks, also, in biochar the crystals area are shown in different sizes mixed with nanomaterials.

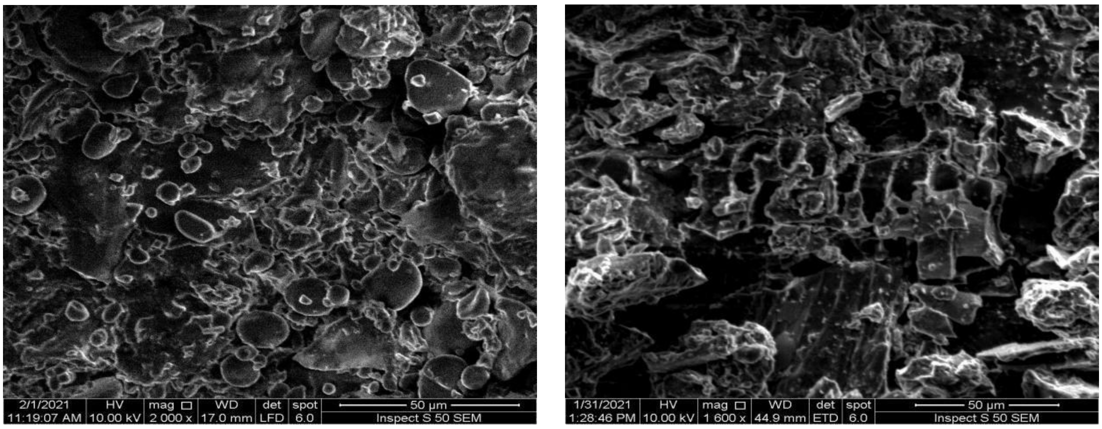


Figure 6: (a) SEM image for wheat husks, (b)image for biochar

3.2 Results of the batch reactor

3.2.1 Change in pH

Phenol adsorption on biochar was studied as a function of contact time in the initial pH range of 2.5-10 for a stable biochar dose of 0.5 g / L at the initial concentration of 200 mg / L and stirring speed of 150 rpm; the results are shown in Figure 7. Phenol absorption behavior appears to be more sensitive to pH changes. Increases in the pH of the solution up to pH 4 resulted in a general rise in phenol absorption. The contact time must be set at a fixed value called the "equilibrium time" to ensure that the final concentration of phenol reaches equilibrium. These outcomes correspond to the observations of [22][23]

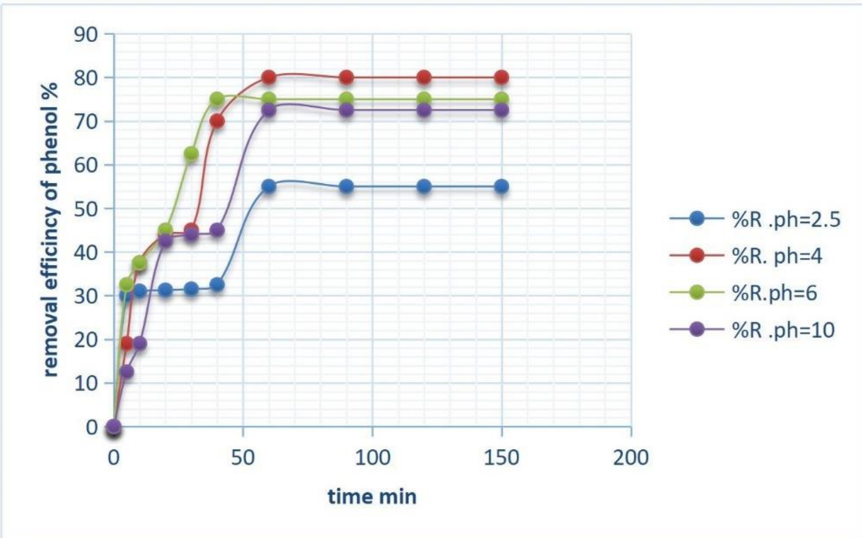


Figure 7: impact of contact-time on the sorption's efficacy of phenol onto biochar for different magnitude values of initial pH (Co= 200 mg/L, dosage= 0.5 g/ L, speed= 150 rpm).

3.2.2 Different phenol concentrations

Date: October 2023

In this study, the values of temperature, pH, and biochar dose were constant at 22°C, pH 4 and biochar equal to (0.5 g/L), and Only phenol concentration changed Systematically (50-100-150-200 mg / L). Phenol efficacy was computed by Eq. (1):

Efficiency = ((C0 -Ce) / C0)*100 (1)

hereby: 0= Initial phenol concentrations (mg / L).
 = Effluent phenol concentrations (Mg / L).
Figure 8 shows the relationship between time (min) and phenol concentration (mg/L), where removal efficiencies decrease from 84% to 54% as initial concentrations increase from 50 to 200 mg/L. It is a logical attitude the pollutant concentrations would be increasing whereas the dosage of the absorbent (i.e., binding sites) remains constant. These outcomes correspond to the observations of [22,24–26].

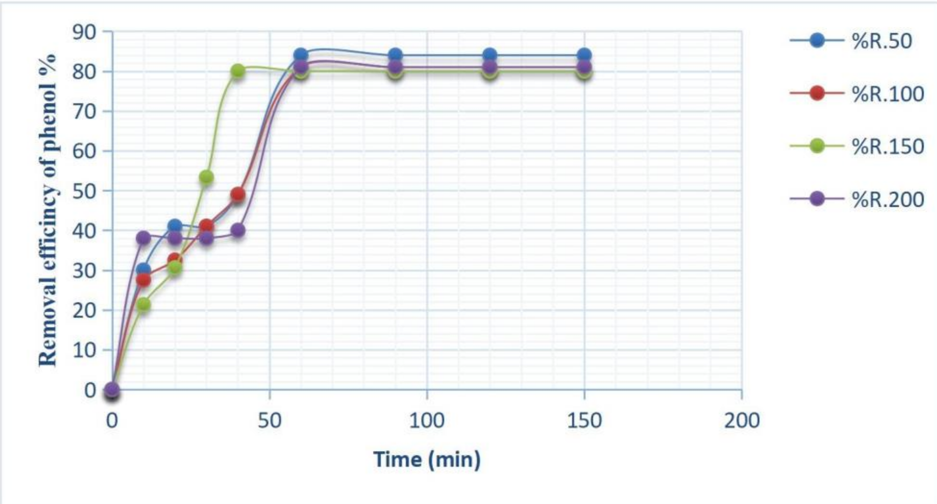


Figure 8: Impact of initialized concentrations on the removing efficacy of phenol onto biochar sorbent subject to the subsequent criteria (pH=4, agitations velocity= 150 rpm, dose=0.5 g/L).

3.2.3 Different mass of Biochar
The relationship between time and biochar dosage is shown in Figure 9. The concentration of phenol decreased over time, resulting in an obvious improvement in removal efficiency from the adsorbent material biochar, as shown in Figure 8. Different weights of the biochar adsorbent were used (from 0.1 to 0.8). The efficiency changed from 50 to 69%, respectively. This improvement could be due to the addition of a higher dose of absorbent to the solution, which has resulted in a higher number of voids. These results are consistent with the finding [13].

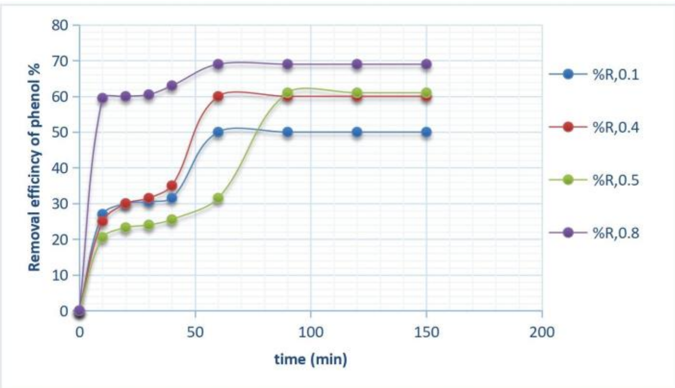


Figure 9: Effect of biochar dosage on removal efficiencies of phenol from aqueous solution under the following conditions (Co= 200 mg/L, pH= 4, speed= 150 rpm, time= 150 min).

Kinetics Expressions

The rate at which the contaminant transfers from aqueous solution to solid particles must be determined to design an appropriate adsorption treatment [27]. This rate can be estimated by applying the following kinetic models.

Pseudo first order kinetic model

It is familiar expressions as written in Eq.2 used for describing the rate of sorption for sorbate from aqueous solution (Lagergren, 1989):

$dq/dt = k_1 (q_e - q_t)$ (2)

The integration of this equation under the conditions of qt = 0 at t= 0 and qt = qe at t = t can result in the pseudo first order equation that can be written in linear form as Eq.2 or non-linear form as Eq.3:

$\ln (q_e - q_t) = \ln q_e - k_1 t$ (3)

$q_t = q_e(1 - e^{-k_1 t})$ (4)

In which and qt are the quantities of pollutant adsorbed on the solid matrix at equilibrium, and time in a respective manner in (mg/g), and k1 is the rate constant of the pseudo first order model (1/min).

Pseudo 2ndorder kinetic model

This model is supposed that the one layer of a pollutant can be attached to the surface of reactive material, the energy of sorption is not changed for each sorbent and there is no interaction between sorbet species. The model can be explained as in equation (5) [28].

$t/q_t = 1/(k_2 q_e^2) + 1/q_e t$ (5)

In which: k2 is the rate constant of the pseudo-second-order model (g/mg minute).

The initialized adsorptions rate (h) could be determined from k2and qe value by the equation (6):

$h = k_2 q_e^2$ (6)

This kinetic investigation on various pH because of the big value of R2. The results k as well as R2 for 1st, and 2nd- order were depicted in Figure 10, 11, as well as Table 4. As was noticed in the outcomes, it was discovered that the pseudo-second order was the optimal outcome because of the high R2. The results showed that the pseudo- second-order equation has fitted the test data well, with a correlations coefficient (R2) that was nearer to 1 than the first order. Table 5 lists the result of the 1st-order, and 2nd-order models the deviations from the straight-line of sorption, as in the pseudo 1st, and 2nd order model, and the adsorptions in this investigation were slow particularly in the initial period of the reaction

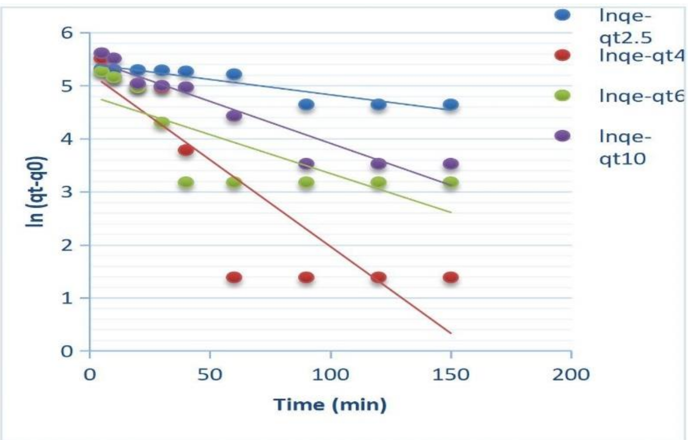


Figure 10. Linearly plotted kinetic data of the model at a different dose rate of Phenol 1storder

Date: October 2023

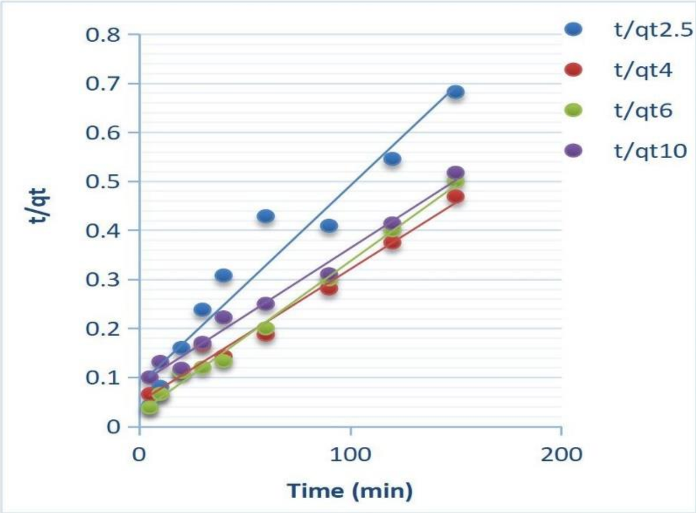


Figure 11 Linearly plotted kinetic data of the 2nd order model at a different dose rate of Phenol

Table 4. Kinetics parameters

Model	**Parameter**	**pH**			
		2.5	4	6	**10**
Pseudo-first-order	*k1* (min^{-1})	0.005	0.032	0.014	**0.015**
	qe(mg/g)	222.29	187.9	122.6	**242.98**
	R2	0.857	0.776	0.614	**0.9**
Pseudo-second-order	*k2* (g/mg min)	1.9*10-4	8.16*10-5	3.3*10-4	**4.65*10-5**
	qe(mg/g)	250	500	333.3	**500**
	h (mg/g min)	11.875	20.4	36.65	**11.625**
	R2	**0.936**	**0.983**	**0.994**	**0.985**

3.2.7 Kinetic isotherm model

The isotherm research was investigated using a fitting technology for multiple isotherm models to arrive at a suitable model for designing purposes. The constant of the Freundlich equation was calculated by the slope in the Langmuir and Freundlich adsorption models, and the linearization was performed using the equation.

$$\text{Logqe} = \text{Log K} + \frac{1}{n} \times \text{LogCe} \qquad (7)$$

In which k, n is constant, 1/n range of (0–1)

Nonetheless, the constant of Langmuir-equation was set by slope, interest linear by utilizing the equation:

$$\frac{C_e}{q_e} = \frac{1}{q_{max}} + \frac{1}{q_{max}\, b} * \frac{1}{C_e} \qquad (8)$$

A more representative Freundlich model is found to describe the absorption measurements where R2 has a value of 0.959. The outputs of this model demonstrated that the maximum amount of phenol absorbed on biochar was 500 mg / g. as in Figure (12) and Figure (13), the results were shown in Table (5).

Date: October 2023

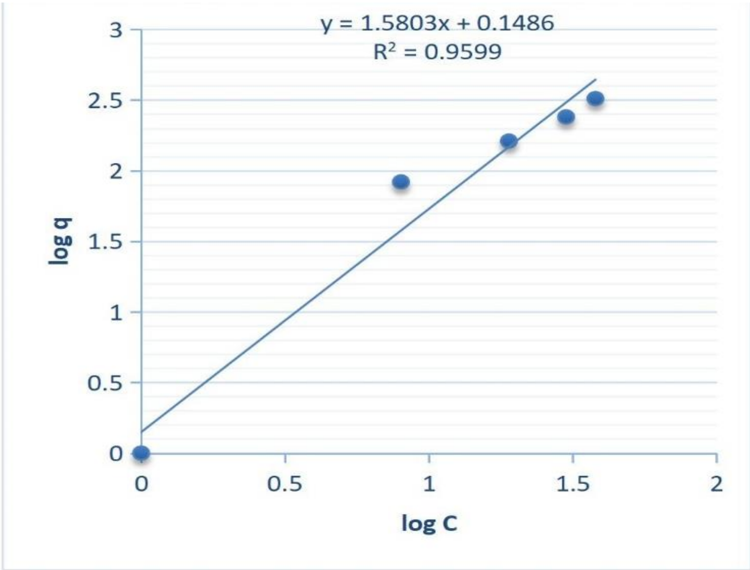


Figure 12: Freundlich mode (Ce=mg/l, and qe= mg/g) for biochar adsorbent (experimental conditions according to results of phenol dose)

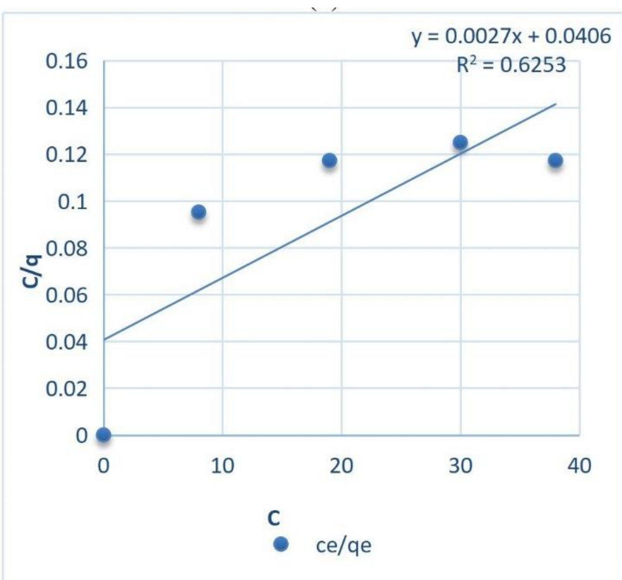


Figure 13: Langmuir mode (Ce=mg/l, and qe= mg/g) for biochar adsorbent (experimental conditions according to results of phenol dos

Isotherm model	Parameter	Value
Freundlich	KF (mg/g)(l/mg)$^{1/n}$	1.406
	1/n	0.63
	R2	0.959
Langmuir	b (L/mg)	0.05
	qmax (mg/g)	500
	R2	0.625

3 CONCLUSION

Biochar was prepared from wheat husks because it is inexpensive and available, which was discovered to be the best absorbent and a well-suited alternative. That can be used to remove phenol from wastewater using a batch reactor. The operating conditions were found as follows: pH 7, phenol Concentration 50 mg / L, absorbent material (biochar - 0.8 mg / l). Also from these results, the second order were shown the best adsorption kinetics in a batch reactor. Freundlich model gives higher R2 values than Langmuir mode. The Freundlich isotherm model were discovered to be favorable for biochar prepared from Wheat husks.

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Date: October 2023

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Date: October 2023

Evaporation Prediction Modelling Utilizing an Artificial Neural Network (ANN): Haditha Lake as a Case Study

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Abstract: Evaporation is one of the elements of the hydrological cycle whose actual quantities are difficult to measure in field conditions. Therefore, the value of evaporation rate is estimated based on calculations with empirical relationships based on climate component data. Accurate estimation of evaporation losses plays an important role in many water resource applications, such as hydrological, hydraulic, and agricultural systems management. The ability to accurately estimate and predict hydrological phenomena is considered one of the main factors in the development and management of water resources and the development of future water plans according to different climate change scenarios. Recently, several previous studies have used a state-of-the-art model called the Artificial Neural Network (ANN) model to estimate several hydrological parameters. The present work employed an ANN model to predict evaporation rate for Haditha Dam Lake on the Euphrates River in Al-Anbar Governorate, Iraq. Available daily climatic data, including temperature, solar radiation, wind speed, and relative humidity, were adopted as inputs to the artificial neural network, while evaporation was adopted as output to the proposed network. To examine model, different scenarios with different input variables were introduced by the current study. The correlation coefficient (R^2), root mean square error (RMSE), Mean Absolute Error (MAE) and Nash–Sutcliffe model efficiency coefficient (NSE) were used to evaluate the accuracy of the proposed model. The proposed models gave low values for the root mean square errors (RMSE) and high values for the correlation coefficients (R^2). The results showed that ANN is able to predict evaporation value with high level accuracy.

Introduction

Most countries located in arid or semi-arid regions, including Iraq, suffer from a scarcity of water resources used for various purposes [1]. The increase in population in these countries, in addition to climate change, has led to an increase in the drought periods that these countries suffer from, which has led to a decrease in the available water supplies, which requires that there be optimal management and optimal exploitation of water in these countries [2,3]. The volume of water revenues must be determined and compared to total water demand, as well as the amount of losses, which include both evaporation and transpiration, for rational water resource management [4–7]. The process of evaporation is one of the basic components of the phenomenon of the hydrological cycle in nature. Estimating the depth of evaporation is one of the important things needed by the decision-maker when calculating the water budget and estimating the agricultural, industrial, and environmental plans [8–11]. Several direct or indirect methods are used to calculate the amount of evaporation from water bodies such as lakes, where the pan evaporation of various types is considered one of the direct methods for calculating evaporation. Researchers from different parts of the world have also developed different equations, such as the Penman equation, the Blaney-Criddle equation, and many others equations. With the development of computers and their increase in speed, many researchers have used many other methods to estimate the amount of evaporation from water bodies. A simulation of evaporation was developed and evaluated by [12], and the performance of a hybrid model applied to the problem of forecasting the daily evaporation rate for the Talesh meteorological station in northern Iran. W. Jing et al. (2019), [13] applied AI methods to develop alternative methods for estimating ET_o from limited weather inputs. The advanced machine learning models was used to estimate monthly evaporation loss at two plants in Iraq [14], were the monthly climate parameters was the inputs for the simulate the monthly depth of evaporation.

This research aims to use an artificial neural network to estimate the daily evaporation from Haditha Dam Lake based on daily meteorological data that is easily measured and has high accuracy, namely the temperature and relative humidity of the air. In order to give accurate values of the daily

Date: October 2023

evaporation depth that can help the decision-maker during planning for sustainable and integrated management of water resources.

Figure 1. Haditha Lake and Dam on the Euphrates River.

2. Materials and methods

2.1.Artificial Neural Network (ANN)

A large number of straightforward components working in tandem make up an artificial neural network (ANN) [20,21]. Channels of communication (connections) between these elements often carry numerical data (weight). The only data used by the units to function is their own internal data and inputs received through connections. An ambition to create artificial systems capable of carrying out complex calculations akin to those the human brain frequently does serve as a major source of motivation for the area of ANN [22,23].

An ANN ought to include a structured learning rule that modifies the weights of the connections based on input/output data [24,25]. To put it another way, an ANN learns given instances (of well-known input/output sequences) and demonstrates significant representational power outside of the training set. Since the calculations of the components are essentially independent of one another, ANN typically has a high potential for parallelism [26]. In real-world applications, ANN is particularly helpful for categorization and function interpolation method issues, which are tolerant of some errors and contain a large amount of training information accessible [27,28]. Figure 2 shows the architecture of artificial neural network method.

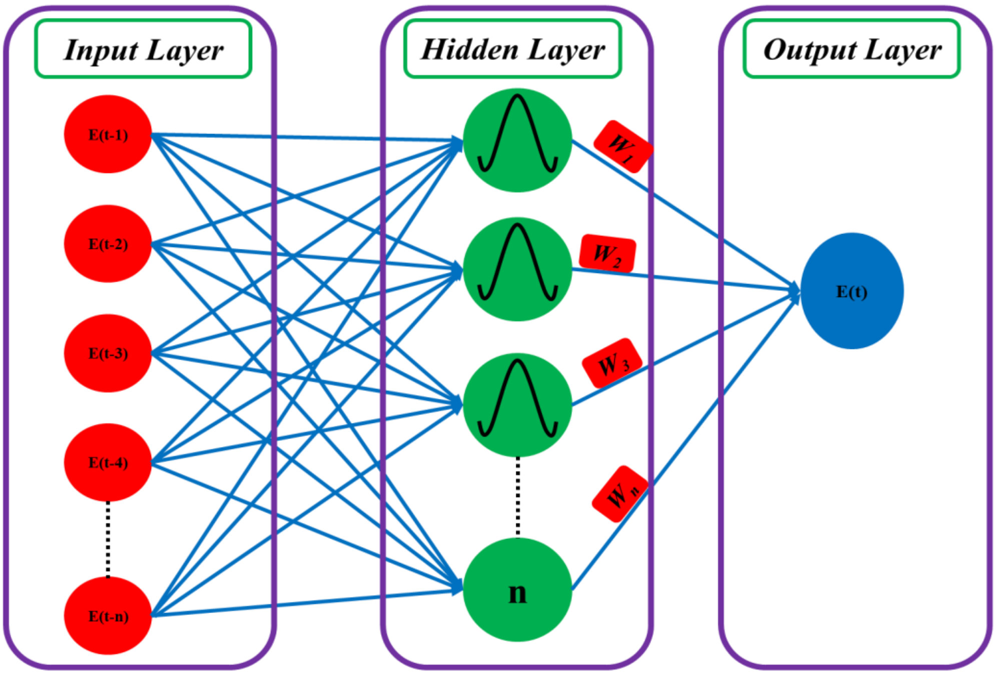

Figure 2. The architecture of ANN model.

Date: October 2023

3.Results and Discussion

Artificial Neural Network (ANN) method has been employed to predict the evaporation rate. Four different architecture models were generated to examine the performance of the predictive model with different input variables. The table shows the level of accuracy of the evaporation prediction. It could be observed that the worst model is Model-4 according to RMSE = 0.86, MAE = 0.69 and NASH = 0.81. On the other hand, the ANN method provided excellent prediction results with considering the structure of the second model.

Table 1. The evaluation performance indicators for the ANN model.

Model	RMSE	MAE	NASH
Model 1	0.44	0.34	0.86
Model 2	0.41	0.29	0.94
Model 3	0.86	0.62	0.83
Model 4	0.86	0.69	0.81

- Figure 3 shows a comparison between the performance of models based on the correlation coefficient indicator. The results indicated that model 1 and model 4 provided acceptable prediction accuracy. However, model 2 achieved a high correlation level between predicted and actual evaporation data. It could be concluded that the ANN method with model 2 is a more reliable predictive method compared to the other models.

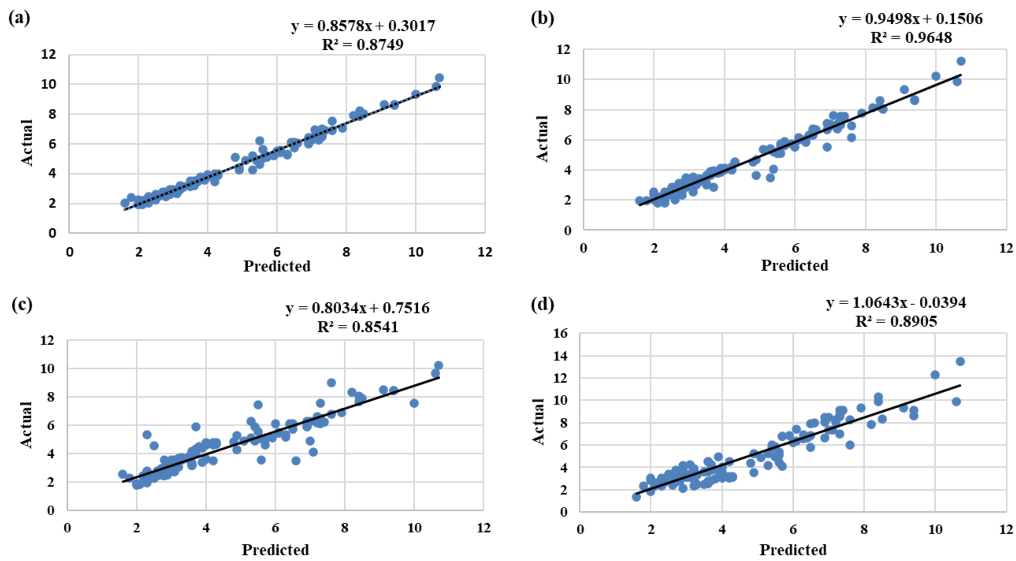

Figure 3. The correlation coefficient indicator for all models using ANN (a) Model-1, (b) Model-2, (c) Model-3, and (d) Model-4.

4.Conclusion

The study found that the artificial neural network model developed in this study had good accuracy and predictability of Haditha Lake's daily evaporation values based on meteorological station data inputs. The study recommends the use of climatic data collected from all meteorological stations in Al-Anbar Governorate to test the artificial neural network model that was worked on in this study for the purpose of developing an effective model that can be used with high accuracy to estimate the daily evaporation depth in Al-Anbar Governorate.

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Date: October 2023

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Date: October 2023

Vertical and Lateral Variation of Ecological Risk Index of Heavy Metals in the Euphrates River Sediments between Heet and Fallujah, Iraq.

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Abstract: The heavy metals (HMs) contamination of river sediments and their ecological risks is a global environmental problem that has attracted the attention of researchers and those interested in environmental protection. The study aims to investigate the ecological hazards of some HMs in sediments of Euphrates River between the cities of Heet and Fallujah, Iraq and their lateral and vertical variations. At three depths—0-30, 30-60, and 60-90 cm—samples of sediment were collected from five sites. Atomic Absorption Flame Emission Spectrophotometer (ASC.7000) was used to measure concentration of Cd, Cr, Cu, Ni, Pb, and Zn. The ecological risk index (ErI) values of metals in Euphrates River sediment in the study area take the following descending order: Cd > Ni > Cu > Cr > Pb > Zn. The ErI levels were low for Cr, Cu, Ni, Pb and Zn and considerable ecological risk for Cd. The obtained results did not show a common lateral variation pattern of the ecological risk of the measured metals. There is a high level of risk for the measured metals at the downstream sampling sites except for the risk from Cd on the contrary. The potential ecological risk of Cd, Cr, Pb and Zn showed a similar vertical variation pattern which in turn reflects a common source or origin for these metals, while copper and nickel showed a different common distribution pattern.

Introduction

Pollution of water systems with heavy metals resulting from industrial activities and social-economic development has evolved a global environmental problem that has obtained wide attention due to the high toxicity of these metals and their non-dissolution and stability [1-2]. Interest in sediment pollution has increased because it represents an important evidence of environmental change caused by human activities [3]. River sediments represent a large reservoir of heavy metals liberated into the aquatic environment by human activities [4]. Sources of heavy metals in river sediments include rock weathering, soil erosion, agricultural runoff, wastewater treatment and atmospheric sedimentation [5]. Heavy metals in river sediments may enter the food chain and pose a threat to human health [6]. Heavy metals do not remain in river sediments permanently, but through mobilization processes, they may be absorbed or dissolved and released into the water column, which has a detrimental effect on quality of water [7]. Heavy metal pollution may emerge from river hydrological processes such weathering, erosion, and transport conditions, depending on differences in particle size distribution, mineral composition, and organic matter content [8]. The method presented by Hakansen [9] was employed in assessing the potential ecological hazards of heavy metals in sediments and soils. Al-Heety [10] introduced a new method for assessing the potential ecological risks (ErI) of soil and sediment pollution with heavy metals. This method was used in the current study to assess the ErI of heavy metals in the sediments of the Euphrates River. The Hakanson method has been used to assess the potential ecological hazards of heavy metals in the sediments of many rivers and water streams, e.g., Xihe River/China[2], Fengshan River/Taiwan[11], Strzyza Stream and Warta River /Poland [4, 12], Munzur Stream/Turkey[13]. While the spatial variation (vertical and horizontal) of heavy metal concentrations in river sediments have been studied by many authors (e.g. [4, 11, 12, 14,15), Vertical

Date: October 2023

and horizontal variation of potential ecological hazards resulting from heavy metal pollution of river sediments has not been investigated.

The study aims to assess the potential ecological risks resulting from the pollution of the sediments of the Euphrates River between the cities of Heet and Fallujah, western Iraq, and to identify the extent of their variation, both laterally and vertically.

To our knowledge, this work is the first effort to assess the (ErI) of heavy metals in sediments of the Euphrates River and their vertical and horizontal variation.

Materials and Methods

Sampling Sites Location

The study area is located in Anbar province, between the cities of Heet and Fallujah (Figure 1). Sediment samples of the Euphrates River between Heet and Fallujah cities were collected from five locations and at three depths using an auger tube device.

2.2. Sample Preparation and Analysis

After being thoroughly dried, the samples were placed in an oven set at 70 degrees Celsius for 24 hours. For digestion, the samples were homogenized after being crushed in an agate ceramic mortar and sieved through a 150 m steel sieve [16-17]. Nitric acid and hydrochloric acid were combined in a 3:1 ratio to create a mixture of digesting sediments. Following that, 10ml of the ready-made lemon mixture was added to 1 gram of the dry sample, and the sample was whisked. The mixture was then heated to 190°C in the microwave for 15 minutes, nearly drying it out. Then the mixture was cooled and washed several times with de-ionized water until all of the sample was removed. To acquire a 50 ml solution, the mixture was then filtered using filter paper (Whiteman, 42 mm) and the amount was filled up with distilled water. [17]. The digested samples are analyzed using the Atomic Absorption Flame Emission Spectrophotometer (ASC.7000) at the Central Water Laboratory/ Anbar Water Directorate to measure the concentrations of Cd, Cr, Cu, Ni, Pb, and Zn.

2.3. Potential Ecological Risk Assessment Methodology

To assess the potential ecological risks of heavy metals in the sediments of the Euphrates River for the part extending between the cities of Heet and Fallujah, the method presented by Al-Heety [10] was employed. The following two steps are obeyed to assess the ecological risk index (ErI):

I. Calculation the geo-accumulation index (Igeo) using the following equation [18]:

$$I_{geo} = \log_2\left(\frac{C_n}{1.5\,B_n}\right) \quad (1)$$

Where Cn is the metal concentration that is actually measured, heavy metal geochemical background levels represented by Bn and a factor of 1.5 added to account for any changes in the background levels brought on by geological activity. The sediment quality guidelines (SQGs) of United States.

Date: October 2023

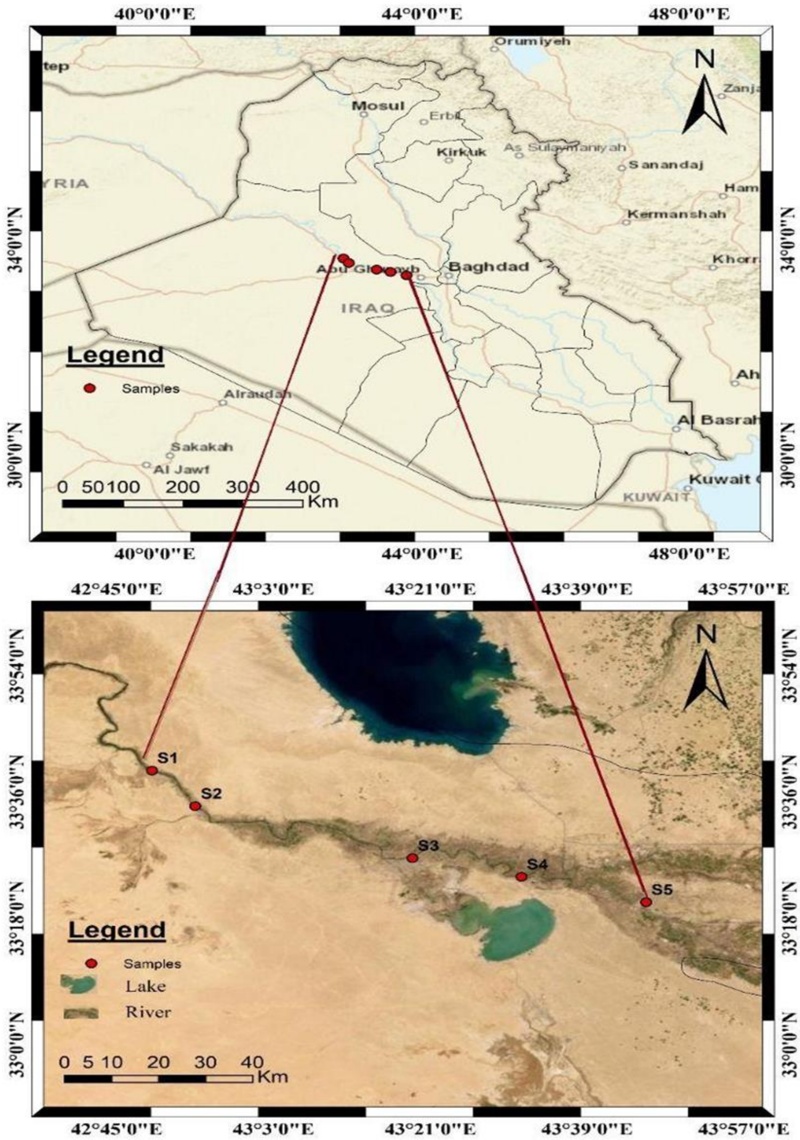


Figure 1. Location map showing sampling regions in Anbar governorate. S1 (Heet) and S5(Fallujah), [15].

States Environmental Protection Agency (USEPA) is used as a background values for Cd (0.6), Cr (25), Cu (16), Ni (16), Pb (40) and Zn (110) [19].

II. Calculation of ErI of Cd, Cr, Cu, Ni, Pb, and Zn using the following equations:

$$Log_2 E_r^{Cd} = 5.486 + I_{geo} \quad (2)$$

$$Log_2 E_r^{Cr} = 1.58 + I_{geo} \quad (3)$$

$$Log_2 E_r^{Cu} = 2.901 + I_{geo} \quad (4)$$

$$Log_2 E_r^{Ni} = 2.901 + I_{geo} \quad (5)$$

$$Log_2 E_r^{pb} = 2.901 + I_{geo} \quad (6)$$

$$Log_2 E_r^{Zn} = 0.58 + I_{geo} \quad (7)$$

To describe the level of potential ecological risks, the ErI values were categorized into five classes [9], ErI < 40 (low potential ecological risk), 40 ≤ ErI < 80 (moderate potential ecological risk), 80 ≤

Date: October 2023

ErI < 160 (considerable potential ecological risk), 160 ≤ ErI < 320 (high potential ecological risk), and 320 ≤ ErI (very high potential ecological risk).

3. Results and Discussion

Results of concentrations and Igeo of the measured metals are listed in (Tables 1 and 2). The Igeo values for the measured metals were employed to assess the ecological risk (ErI) for these metals using the equations introduced by Al-Heety [10]. Results of the descriptive statistics ErI for the measured metals in the sediment samples collected from five sampling sites and three depths from Euphrates River between Heet and Fallujah cities are listed in (Tables 3-6).

Table 1. Concentration of heavy metals (mg/kg) in Euphrates River sediments in the study area.

Metal	Sampling Site														
	S1			S2			S3			S4			S5		
	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
Cd	2.89	3.25	3.07	1.18	1.90	1.47	1.16	1.16	1.13	1.21	1.51	1.70	1.95	1.84	1.57
Cr	30.48	33.67	37.38	47.98	47.12	50.14	46.26	40.48	39.96	39.79	52.56	50.66	57.30	59.89	57.47
Cu	18.32	18.93	22.24	17.66	17.60	20.19	19.53	23.87	25.21	21.16	25.50	28.39	35.99	40.81	37.80
Ni	62.06	65.50	72.27	104.05	85.48	95.62	117.76	120.09	138.29	118.74	131.71	137.37	146.96	158.94	161.77
Pb	12.13	15.13	14.80	8.79	10.79	10.45	9.78	9.45	9.12	10.45	12.46	14.80	17.14	16.82	15.13
Zn	42.68	75.85	69.33	46.04	62.92	47.48	49.25	48.72	48.33	57.73	57.44	62.91	72.48	70.35	69.81

D1: depth 0-30cm, D2: depth 30-60cm, D3: depth 60-90cm.

Table 2. Geo-accumulation index (Igeo) values of the heavy metals in Euphrates River sediments in the study area.

Metal	Sampling Site														
	S1			S2			S3			S4			S5		
	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
Cd	1.68	1.85	1.77	0.39	1.08	0.70	0.37	0.36	0.32	0.42	0.74	0.90	1.12	1.03	1.77
Cr	-0.30	-0.156	-0.005	0.35	0.33	0.42	0.30	0.11	0.09	0.08	0.48	0.43	0.59	0.67	0.61
Cu	-0.39	-0.34	-0.11	-0.44	-0.45	-0.25	-0.30	-0.01	0.07	-0.18	0.08	0.24	0.58	0.76	0.65
Ni	1.37	1.45	1.59	2.11	1.83	1.99	2.29	2.32	2.52	2.30	2.45	2.51	2.61	2.72	2.75
Pb	-2.30	-1.99	-2.02	-2.77	-2.48	-2.52	-2.61	-2.66	-2.71	-2.52	-2.27	-2.02	-1.81	-1.83	-1.99
Zn	-1.95	-1.12	-1.25	-1.84	-1.39	-1.80	-1.74	-1.76	-1.77	-1.51	-1.52	-1.39	-1.23	-1.23	-1.24

D1: depth 0-30cm, D2: depth 30-60cm, D3: depth 60-90cm.

Table 3. Descriptive statistics of the ecological risk index (ErI) of the heavy metals in Euphrates River sediments in the study area.

Metal	Mean	Minimum	Maximum	Std.Dev.	Coef.Var.
Cd	90.25	56.18	162.01	105.83	39.38
Cr	3.64	2.43	4.77	2.34	20.02
Cu	7.74	5.47	12.69	7.22	30.60
Ni	35.45	19.41	50.31	30.90	28.60
Pb	1.55	1.09	2.13	1.04	23.34
Zn	0.52	0.38	0.68	0.30	19.14

Date: October 2023

Table 4. Descriptive statistics of the ecological risk index (ErI) of the heavy metals in Euphrates River sediments collected from depth range (0-30cm) in the study area.

6. Metal	7. Mean	8. Minimum	9. Maximum	10. Std.Dev.	11. Coef.Var.
12. Cd	13. 83.67	14. 57.96	15. 144.10	16. 37.63	17. 44.98
18. Cr	19. 3.52	20. 2.43	21. 4.51	22. 0.77	23. 22.02
24. Cu	25. 7.01	26. 5.50	27. 11.19	28. 2.37	29. 33.84
30. Ni	31. 34.20	32. 19.41	33. 45.72	34. 9.59	35. 28.05
36. Pb	37. 1.44	38. 1.09	39. 2.13	40. 0.41	41. 28.38
42. Zn	43. 0.48	44. 0.38	45. 0.65	46. 0.10	47. 22.58

Table 5. Descriptive statistics of the ecological risk index (ErI) of the heavy metals in Euphrates River sediments collected from depth range (30-60cm) in the study area.

Metal	Mean	Minimum	Maximum	Std.Dev.	Coef.Var.
Cd	96.18	57.60	162.01	39.66	41.23
Cr	3.72	2.68	4.77	0.81	21.86
Cu	7.88	5.47	12.69	2.87	36.50
Ni	34.49	20.38	49.45	11.48	33.29
Pb	1.60	1.17	2.09	0.38	23.71
Zn	0.56	0.44	0.68	0.09	16.48

Table 6. Descriptive statistics of the ecological risk index (ErI) of the heavy metals in Euphrates River sediments collected from depth range (60-90cm) in the study area.

Metal	Mean	Minimum	Maximum	Std.Dev.	Coef.Var.
Cd	90.91	56.18	153.06	36.53	40.18
Cr	3.67	2.81	4.58	0.75	20.50
Cu	8.32	6.28	11.76	2.14	25.79
Ni	37.65	22.48	50.31	11.26	29.90
Pb	1.59	1.13	1.88	0.35	22.14
Zn	0.53	0.43	0.63	0.10	18.88

The obtained results showed that the ErI values of the metals measured in the sediments of the Euphrates River in the study area takes the following descending order: Cd > Ni > Cu > Cr > Pb > Zn. Due to the Hakanson classification, the mean values of ErI indicate that the level of risk resulted from Cr, Cu, Ni, Pb and Zn in the sediments of the Euphrates River is low, while the risk of cadmium was classified as a considerable risk. The coefficient of variance (CV) values for the ecological risk values of Cd, Cu and Ni indicate a higher level of dispersion around the mean value and this reflects the difference in the concentrations of these metals across the sampling sites, while the CV values of Cr, Pb and Zn indicate a lower level of dispersion, which in turn reflects little change in the concentrations of these elements among the sampling sites.

3.1. Lateral Variation of Potential Ecological Risk (ErI)

Figure (2) shows the lateral variation of ErI values of Cd, Cr, Cu, Ni, Pb, and Zn in sediments of the Euphrates River within the study area.

Date: October 2023

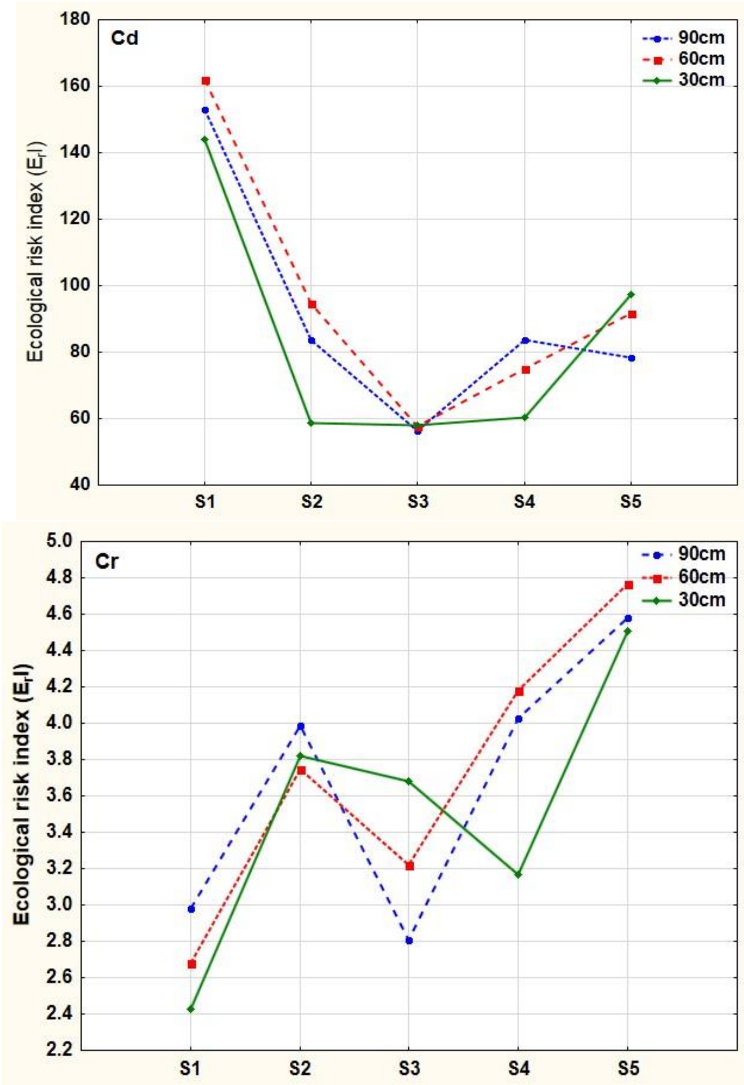
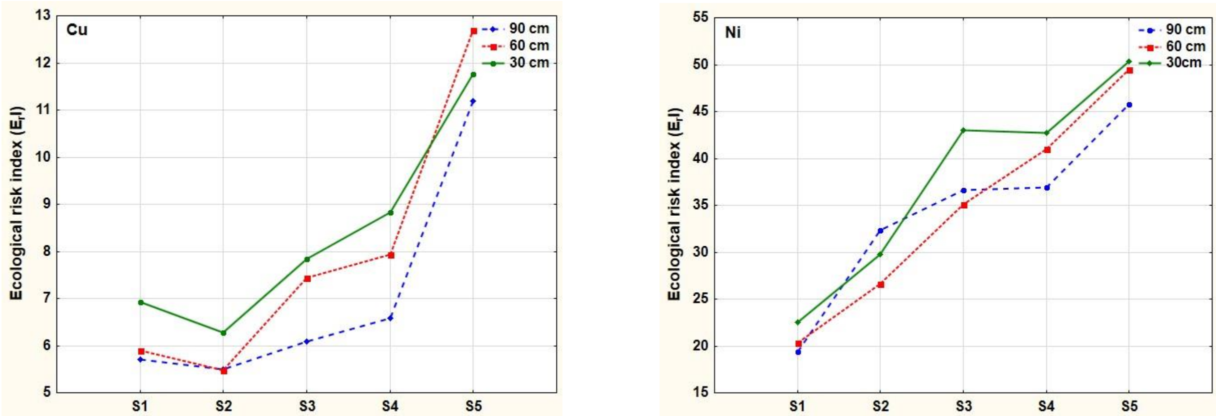
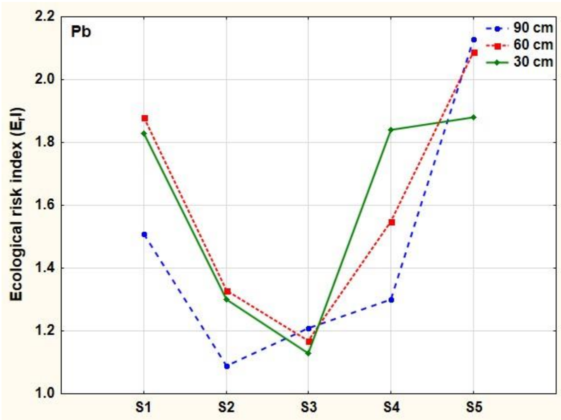
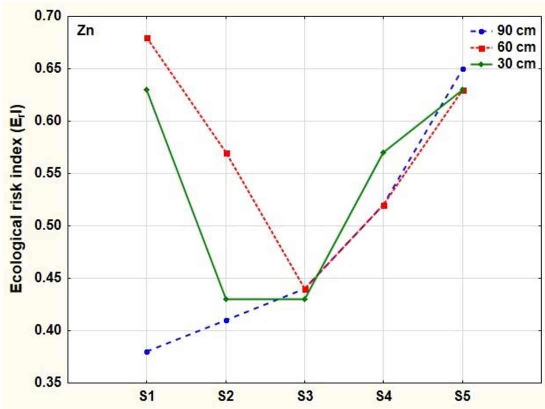


Figure 2. Lateral variation of ErI of heavy metals in Euphrates River sediments in the study area



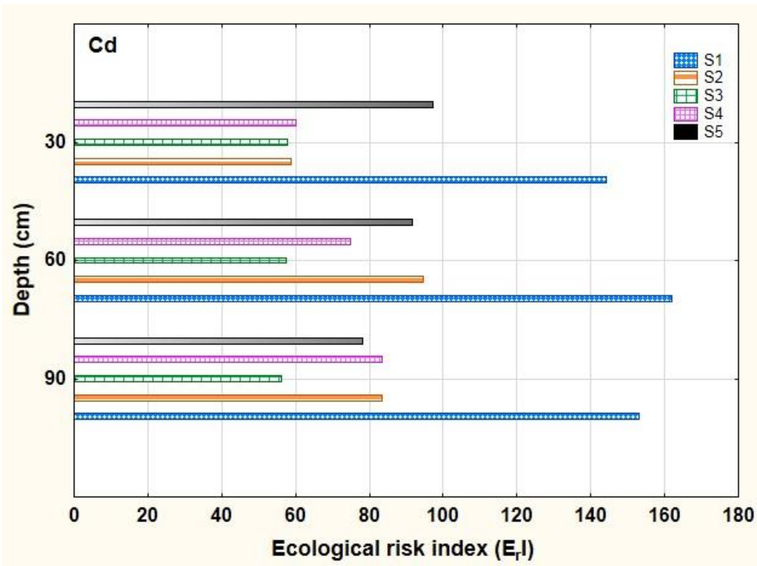




The results of the study showed various patterns of lateral variation of ErI of the metals measured within one depth and among the three depths. The results of covariance analysis (ANOVA) indicated that there are significant differences (at $p \leq 0.05$) in the ErI values between the different sampling sites for all measured metals except for Zn, which indicated insignificant differences. The significant differences between the ErI values indicate a change in the concentrations of metals between the sampling sites, which in turn reflects the presence of local sources of these metals, which may be human sources. The highest ErI of Cd was reported in the sediments of the S1 (Heet), and the lowest risk was recorded in S3 (Ramadi) and for the three depths, then the risk returned to an increase. In general, the ErI values of Cr, Cu and Ni in Euphrates River sediments in the study area increase in the stations located downstream (Ramadi, Khalidiya and Fallujah) , and in turn reflects the increase in the concentrations of these metals due to human activities. The lateral variation pattern of the ErI for Pb showed an increase in the two sampling sites upstream (S1) and downstream (S5) compared to the reported ErI in the sites between them. The lateral variation pattern of the risk for Zn is almost identical to that of Pb. The similarity in the lateral distribution pattern of the potential ecological risk of heavy metals in the sediments of the Euphrates River in the study area may reflect a common source or origin for these metals.

3.2. Vertical Variation of Potential Ecological Risk (ErI)

Figure 3 shows the vertical variation of the ErI from Cd, Cr, Cu, Ni, Pb, and Zn in sediments of Euphrates River within the study area. The obtained findings exhibited that the ErI of Cd, Cr, Pb, and Zn generally increase with depth, and this reflects an increase in the concentration of these metals in the deep sediments compared to their concentrations in the surface sediments. The vertical distribution pattern of ErI for Cr is similar to that of Cd, indicating the common origin or source of both.



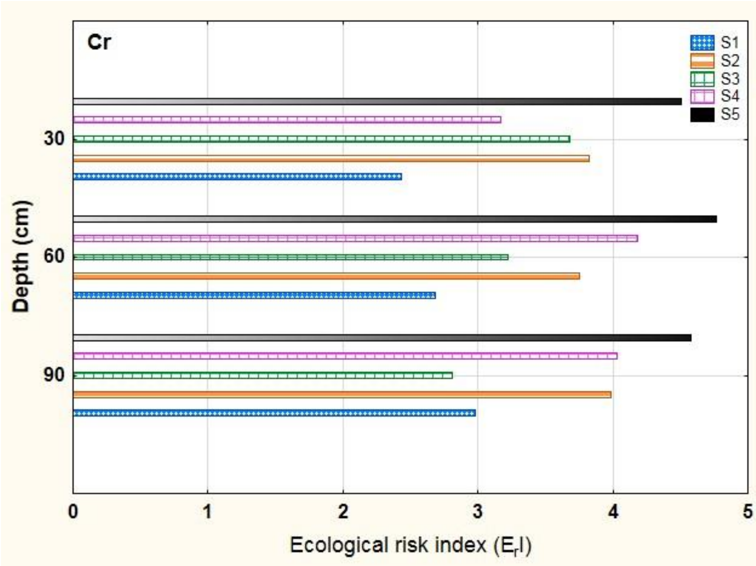


Figure 3. Vertical variation of ErI of heavy metals in Euphrates River sediments in the study area.

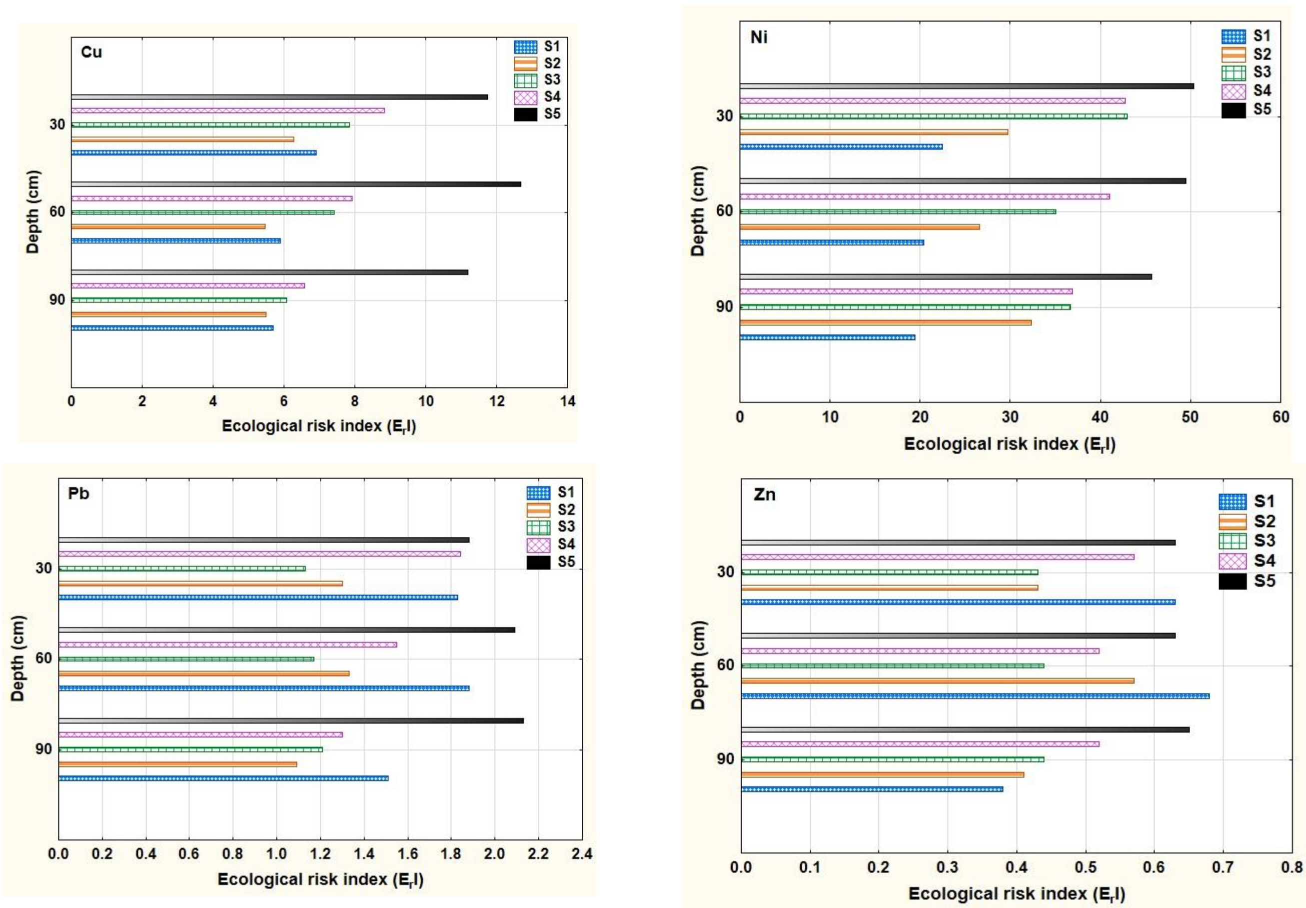


Figure 3. Continued.

The vertical distribution pattern of ErI for Cu and Ni showed that the risk increased with depth and this may reflect a higher contamination level in the deep sediments compared to the surface sediments.

4. Conclusion

The findings exhibited that the Cr, Cu, Ni, Pb and Zn pose low potential ecological risk in the Euphrates River sediments between the cities of Heet and Fallujah, while Cd generates considerable potential ecological risk. The obtained results did not show a common lateral variation pattern of the ecological risk of the measured metals. There is a high level of risk for the measured metals at the downstream sampling sites except for the risk from Cd on the contrary. The ErI of Cd, Cr, Pb and Zn showed a similar vertical variation pattern which in turn reflects a common source or origin for these metals, while Cu and Ni showed a different common distribution pattern.

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Date: October 2023

Irrigation With Saline Water for Quinoa Crop (*Chenopodium Quinoa*willd) Depending on Growth Stages and its Effect on Plant Yield and Salt Accumulation

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Abstract: The study aimed to determine the success of the use of saline water during certain stages of the growth of the quinoa (*Chenopodium quinoa* Willd) plant and to provide a portion of fresh water without affecting the yield significantly. A field experiment was carried out with a Randomized Complete Block Design, in which Euphrates River (fresh water) (R) , and saline groundwater (S) were used, its electrical conductivity was 1.6 and 5.1 dSm^{-1} respectively.Growth stages were divided into four stages: germination and emergence - vegetative growth - flowering - yield formation. Five treatments were used for irrigation: treatment T1, irrigation with river water for the four stages (RRRR), treatment T2: irrigation with river water for the first and second stage, and saline water for the third and fourth stage (RRSS) ,and treatment T3: irrigation with river water for the first and third stage and saline water for the second and fourth stage (RSRS),while treatment T 4: irrigation with river water for the first stage and saline water for the other three stages (RSSS). and treatment T5: irrigation with saline water for all stages (SSSS). Plant growth and yield were followed, as well as the amount of salt accumulation in the soil before planting and after harvest.

Introduction

Irrigation is still the determining factor for agricultural expansion in order to maintain a balance between the increase in population growth and the need for food production. Because of the limited available freshwater resources in Iraq and the Arab world, the use of marginal (low-quality) water has become one of the important means to face the water deficit and climate change, as a number of studies indicated [1]. that the water that is globally classified as water unsuitable for irrigation has been used successfully to grow crops without damaging soil permeability and increasing salt accumulation in the soil in the short or long term [2]. However, the use that includes appropriate management methods would preserve the productivity of the land, the productivity of the crop, and the environment [3]. There are numerous examples of the successful use of saline water in crop irrigation, for example, the United States of America [4-13]. The previous examples included the reuse of agricultural drainage water or saline groundwater in irrigating grain crops, fiber, horticultural crops, and vegetable crops. Varied management depended on climatic conditions, soil conditions and crop type. But the examples mentioned about Iraq were limited to certain conditions and included the use of saline groundwater for the production of horticultural crops and vegetable crops in desert areas and in sandy soils. The management used must prevent the large accumulation of salts and alkalinity in the layer in the root zones, as well as in controlling the salt balance in the soil systems [14]. Also, the type of crop, water quality, and soil characteristics determine which method of management is required to maintain productivity, as the response of the crop A complex mechanism that depends on the osmotic stress and the structural stress [5], which are affected by the nature of growth, the efficiency of the root system, the physiological ability to adapt, and the mechanism of crop tolerance [15-17], and the presence of differences in the bearing capacity. Plants to salinity at growth stages [18]. In this regard, researchers [19] indicated that germination, seedling emergence and its early development are among the most important stages for obtaining good growth and production. The management used must prevent the large accumulation of salts and alkalinity in the root zones layer, as well as in controlling the salt balance in the soil systems [15]. Also, the type of crop, water quality, and soil characteristics determine which method of management is required to maintain productivity, as the response of the crop a complex mechanism that depends on the osmotic stress and the structural stress [5], which are affected by the nature of growth, the efficiency of the root system, the physiological ability to adapt, and the mechanism of crop tolerance [15-17] and the presence of differences in the plants tolerant capacity to salinity at growth [18]. In this regard, researchers [19]. indicated that germination, seedling emergence and its early development are among the most important stages for obtaining good growth

Date: October 2023

and production. The study aimed to determine the possibility of using saline water during certain stages of the growth of the quinoa plant and to compensate for part of the water needs of the plant through. Determine which stage or stages of growth are tolerant and sensitive to salinity. The amount of savings in fresh water. The amount of salt accumulation in the soil as a result of the use of saline water.

Material and Method

A field experiment was conducted at the site of the fodder research station affiliated to the Haditha Agricultural Division - Ministry of Agriculture, 240 km northwest of Baghdad, located at latitude 34 º 35⁻ north and longitude 22º 42⁻ west, on 1 Feb , 2022. The soil was classified according to the modern classification [20], for the great group of fine-loamy, mixed turifluvents, the site is exploited for the establishment of agricultural experiments related to forage All agricultural operations were carried out to prepare the land from plowing, leveling and smoothing, then its area was divided into 5x5m, apart and 1.5m was left between the plots and 2m between sectors to prevent the horizontal movement of water and salts between adjacent plots. Guard plots were also used for the experimental site. The quinoa Regalona genotype was planted on lines of 25 cm distance between one plant and another and on lines of distance between them 75 cm so that the number of plants was 45000 plants / ha. All grafting, thinning, weed control and fertilization were carried out by adding 300 kg urea/ha (in two portion), 400 kg NP/ha (27:27:0) and 250 kg potassium nitrate/ha.

2.1.Experimental scheme and design

Two types of water were used in the irrigation process: the water of the Euphrates River (EC = 1.6 dSm-1, SAR = 1.2) and saline well water (EC = 5.1 dS m^{-1}, SAR 11.8). Divided into four main stages . The first stage (25 days): begins with germination and includes emergence and development of the seedling. The second stage (33 days): vegetative growth. The third stage (14 days): flowering. The fourth stage (41 days) yield formation and maturity. Irrigation treatments included five treatments for river water and saline water by excluding saline water from one or more stages of plant growth, as follows (Fig. 1) First Treatment (RRRR): Irrigation with river water for the four stages of plant growth. Second Treatment (RRSS): Irrigation with river water for the first and second stage and brackish water for the third and fourth stage. Third Treatment (RSRS): Irrigation with river water for the first and third stage and saline water for the second and fourth stage. Fourth Treatment (RSSS) Irrigation with river water for the first stage and brackish water for the remaining three stages. Fifth Treatment (SSSS): Irrigation with saline water throughout the growing season.

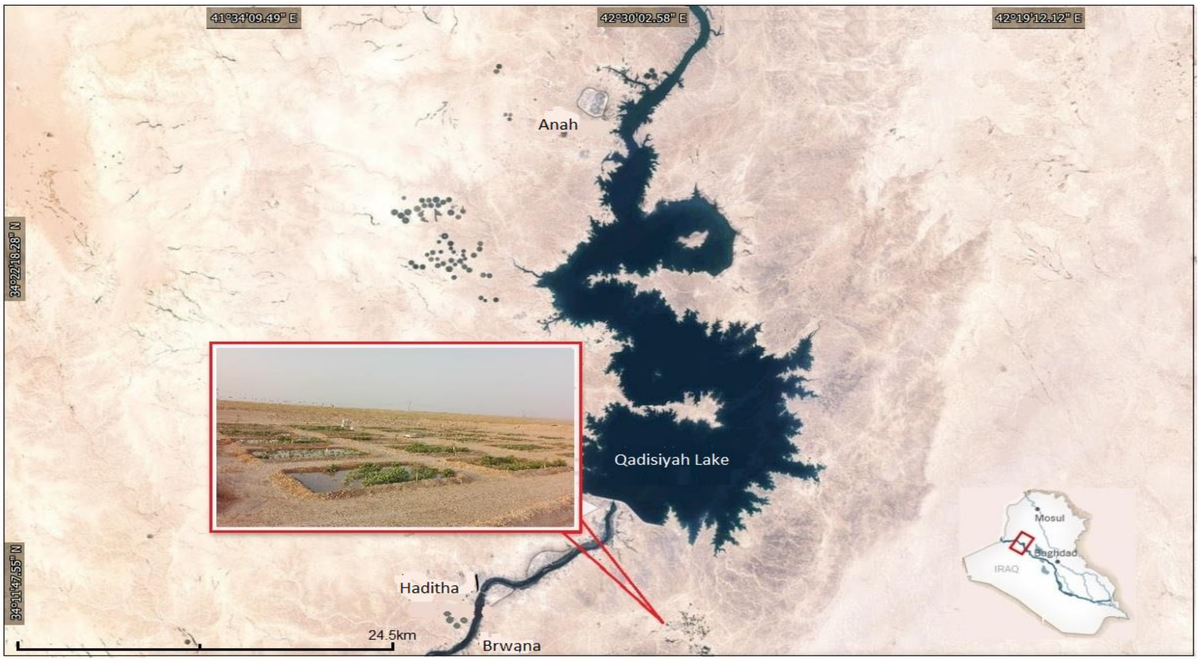

Figure 1 The location of the study area captured by the LANDAST-Copernicus US Dept. satellite image. Of state Geographer. (2018)

Date: October 2023

Randomized Complete Block Design with three replications was used. The irrigation method was carried out by using pumps, a network of pipes, and meters to calculate the amount of water delivered to each plot. The river water was stored in over ground tanks and the saline water was pumped directly from a well dug and cased at a depth of 30 m to ensure a good water yield throughout the irrigation time, which lasts for several hours. The irrigation schedule and the amount of water in each irrigation depended on a moisture depletion that approached 65-80% of the ready water for the 0-40 cm layer to treat river water, as the available water reached a volumetric moisture content of 0.23 cm3 / cm3 (moisture content at KPa33 = 0.36 and at KPa 1500 = 0.13 cm3/cm. The irrigation schedule and the amount of water in each irrigation depended on a moisture depletion that approached to 65-80% of the available water for the 0-40 cm layer to water river treatment, as the ready water reached a volumetric moisture content of 0.23 cm3 / cm3 (moisture content at KPa33 = 0.36 and at KPa 1500 = 0.13 cm3/cm.

2.2.Soil properties monitoring and plant yield:

Basic physical and chemical soil properties (Table 1) were determined using the standard method [21]. The soil particle size analysis was estimated by hydrometer method, the content of carbonates by acidic neutralization, organic matter by Walkey and Black method, and chlorides by titration with silver nitrate. While the sodium adsorption ratio (SAR) was estimated by measuring the concentration of sodium (flame meter), calcium and magnesium by titratio with (EDTA-NA). The amount of salt accumulation in the soil was estimated for depths 0-20, 20-40 and 40-60 cm and at three time periods before planting, during the growing season (after about 45 days) and after harvest (the plants were harvested on May 16, 2022 for a growing season that lasted 113 days). Cobs and their weights and grain weights were calculated.

Table 1. Some soil chemical and physical properties

parameters	unit	value
clay	gm kg^{-1}	366
silt		326
sand	gm kg^{-1}	308
texture	Clay loam	Clay loam
EC	dSm^{-1}	4.2
pH	-	7.84
O.M	gm kg^{-1}	6.8
CO_3	gm kg^{-1}	285
HCO_3	gm kg^{-1}	432
SO_4	gm kg^{-1}	376
SAR		4.8

Results and discussion

[1] 3.1.Plant yield and water use efficiency:

The effect of using saline water during certain stages of quinoa crop growth on grain yield is shown in Table 2. The use of saline water throughout the growing season (all growth stages) in the SSSS treatment led to a significant reduction in yield of more than 30%, but the use of saline water during two stages or three stages of plant growth that cause a limited and insignificant reduction in yield As the amount of reduction in the yield depended on the amount of saline water used, and this reduction increased with the increase in the saline water used. Researchers [22,23]. indicated that the amount of reduction in the yield depended on the concentration of dissolved salts, the type of crop, and its tolerance to salinity at stages Its different development and the prevailing weather conditions, and that the salts have.

Date: October 2023

Table2. Yield of quinoa irrigated with saline water depending on growth stages.

Treatments No.	Irrigation treatments	Plant yield (Ton / hac.) grains	Cobs
T1	RRRR	9.2833 a	7.2410 a
T2	RRSS	8.4700 a	6.5610 a
T3	RSRS	7.3500a	5.7330 a
T4	RSSS	7.4500 a	5.8110 a
T5	SSSS	6.4333 b	5.0180 b

+ The different letters in one column indicate that there are significant differences (LSD) at $p<0.05$
R++ = river water and S = saline water for the plant growth stage
Table 3. The amount of fresh and saline water used in irrigation treatments during the growing season of quinoa (Regelona)
R+ = irrigation with river water and S irrigation with saline water for each stage of plant growth.
Table 3. The amount of fresh and saline water used in irrigation treatments during the growing season of quinoa (Regelona)

Treatment No.	Irrigation treatment's +	Irrigation water quantity (mm)		Total
		Irrigation water	Saline water	
T1	RRRR	353		535
T2	RRSS	465	68	533
T3	RSRS	375	154	529
T4	RSSS	345	185	530
T5	SSSS	-	325	525

Table 4. Soil surface salinity for the layer 0-20 and 0-60 cm before planting and after harvesting of quinoa (Regelona) irrigated with saline water depending on the growth stages.

		Electrical conductivity(dSm-1)++ 0-20 cm	
Treatment No.	Irrigation treatment+	before planting	**after harvest**
T1	RRRR	4.0a	**5.8b**
T2	RRSS	4.7a	**4.8ab**
T3	RSRS	3.4a	**7.7b**
T4	RSSS	3.5a	**9.4ab**
T5	SSSS	4.6a	**11.9a**
		0-60	
T1	RRRR	3.9a	**4.4cd**
T2	RRSS	4.7a	**6.7cd**
T3	RSRS	3.4a	**6.9bc**
T4	RSSS	3.5a	**8.8ab**
T5	SSSS	4.6a	**10.6a**

Date: October 2023

General and specific effects on the crop, its development, the yield and the growth medium [2]. As the amount of reduction in the yield depended on the amount of saline water used, and this reduction increased with the increase in the saline water used. Researchers [22-24]. indicated that the amount of reduction in the yield depended on the concentration of dissolved salts, the type of crop, and its tolerance to salinity at stages Its different development and the prevailing weather conditions, and that the salts have general and specific effects on the crop, its development, the yield and the growth medium [2]. What distinguishes the results in Table 2 is the difference in the response of the quinoa crop to saline water during the different stages of plant growth, as it appears that the germination stage and seedling development, which lasted for 25 days, was the most sensitive stage to salinity. In a previous study, [25]. Indicated that both stages of germination, seedling formation, and flowering are sensitive to salinity, and that exclusion of saline water during them preserved the yield of quinoa from significant reduction [26]. stated that the effect of salts is critical during germination as long as it affects the plant density and thus the yield. The same researcher mentioned that the development of the seedling is more important than the germination and that this has a great impact on the yield and other researchers confirmed. that the stage of germination, emergence and early seedling growth are the most sensitive stages to salinity and that the loss of plant density during this period cannot be compensated and will cause a loss in the crop.

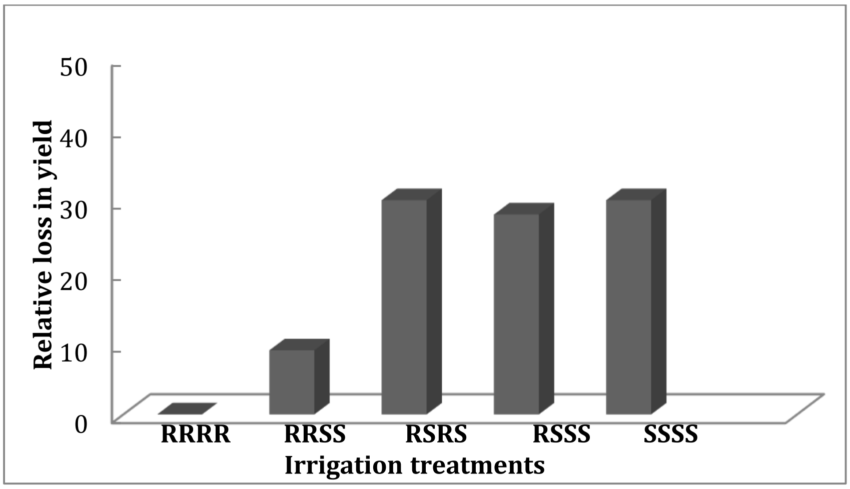

Figure 2. Relative loss in grain yield when irrigated with river water (R) Saline water (s) at each growth stage .

Table 3 shows the amount of fresh and saline water used during the growing season. The water requirement of the crop was approximately 350 mm in 18 irrigations, and part of this water was saline water, the lowest percentage of which was 12% of the total water requirement in the treatment T2 (RRSS) (Fig. 3) and then increased to reach 29 in treatment T3 (RSRS) and 35% in treatment T4 (RSSS). The convergence of the use of saline water in treatment 3 T and T4 explained the convergence of plant yield (Table 2) or loss in grain yield (Fig. 2). The results of plant yield agree with the results of water use efficiency (Fig. 4), as this efficiency reached 1.35, 1.23, 1.08, 1.10, and 0.69.

Date: October 2023

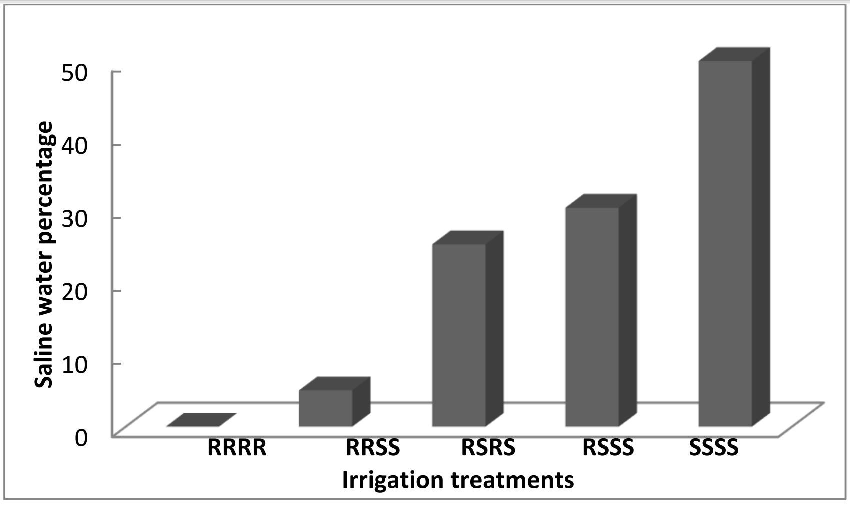

Figure 3 Percentage of saline water consumed of the total water requirement along the growing season

Table 3 shows the amount of fresh and saline water used during the growing season. The water requirement of the crop was approximately 350 mm in 18 irrigations(T2), and part of it was saline water, the lowest percentage of which was 12% of the total water requirement in treatment T2 (RRSS) (Fig. 3) Then it increased to reach 29 in treatment (RSRS) T3 and 35% in treatment T4 (RSSS). The convergence of saline water use in treatment T 3 and T4 explained the convergence of plant yield (Table 2) or the loss of grain yield (Fig. 2). The results of plant yield agree with the results of water use efficiency (Fig. 4), as this efficiency reached to 1.35, 1.23, 1.08, 1.10, and 0.69, indicate that the partial use of saline water during the stages that are relatively tolerant to salinity such as the stage of vegetative growth and crop formation and its exclusion during the stage of emergence and seedling formation leads to a limited and insignificant reduction in the water use efficiency .

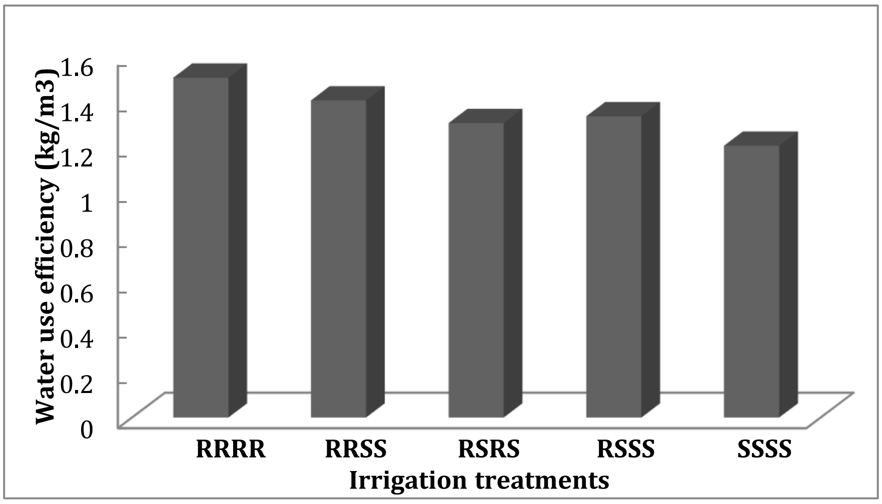

Figure 4.Water use efficiency (kg/m3) for Quinoa crop irrigated by river water(R) and saline water (S)

The second irrigation treatments (RRSS) and the third (RSRS), which adopted the use of saline water during stages of plant growth and fresh water during other stages, are in fact a type of water management that included periodic irrigation of fresh and saline water. The periodic irrigation strategy was used successfully in irrigating crops such as wheat, cotton, cannabis, sugar beet and watermelon [4, 5]. As the increase in the concentration of salts in the root zone when irrigating with saline water will decrease as a result of irrigation with good quality water.

3.2.salt accumulation in the soil:

Soil salinity before planting in the 0-20 cm layer ranged from 3.0 - 4.6 dSm^{-1} (Table 4). Although there were no significant differences between these values, they are within the suggested limits of the

Date: October 2023

value for the quinoa crop inhibition threshold (5 dSm^{-1}) [18]. the increase of soil salinity that approached 2-3 units of electrical conductivity leads to a reduction in yield of 24-36% (assuming that the relationship between the relative yield and electrical conductivity is a direct relationship and that one unit of electrical conductivity leads to a reduction of 12%, the use of Euphrates River water or saline water during the quinoa season, which approached 530 mm, caused salt accumulation in the 0-20 cm layer. The amount of this accumulation varied according to the water quality or the number of irrigations of saline water, as the highest accumulation was in the treatment T5 (SSSS) using saline water for all growth stages, which increased significantly from the salinity of treatment T1 (RRRR) using river water for all growth stages. The rate of salt accumulation in the soil as a result of the use of saline water in different irrigation treatments (Table 4) depended on the amount of salts added with the irrigation water (incoming salts) and the rate at which the salts were removed as a result of plant absorption or leaching (outgoing salts). This accumulation increased with the increase in the percentage of saline water used in irrigation. The concentration of salts in the 0-60 cm layer of soil (Table 4) was more harmony with the percentage of saline water used in irrigation (Fig. 3), where the treatment (SSSS) T5 showed preventing large accumulation salts and at the same time maintain a reasonable yield of quinoa (Table 1) [11]. showed in the long-term studying the effects of using saline water on soil salinity, the ultimate goal remains to control soil salinity and reduce its impact on plant growth and not remove this salinity. Figure 5 shows the relative salts accumulation in layer 0-60 cm at the end of the growing season for the saline water irrigation treatments compared with river water irrigation. In general, the salt accumulation increased by about 50 in the T2 and T3 treatments, 100 in the T4 treatment, and 140% in the T5 treatment. The increasing percentage in these treatments, T2 and T3, represents a limited and non-significant increase in soil salinity (note Table 4). It can be dealt with in the future by planting crops that are more tolerant of salinity or using a leaching fraction [2].

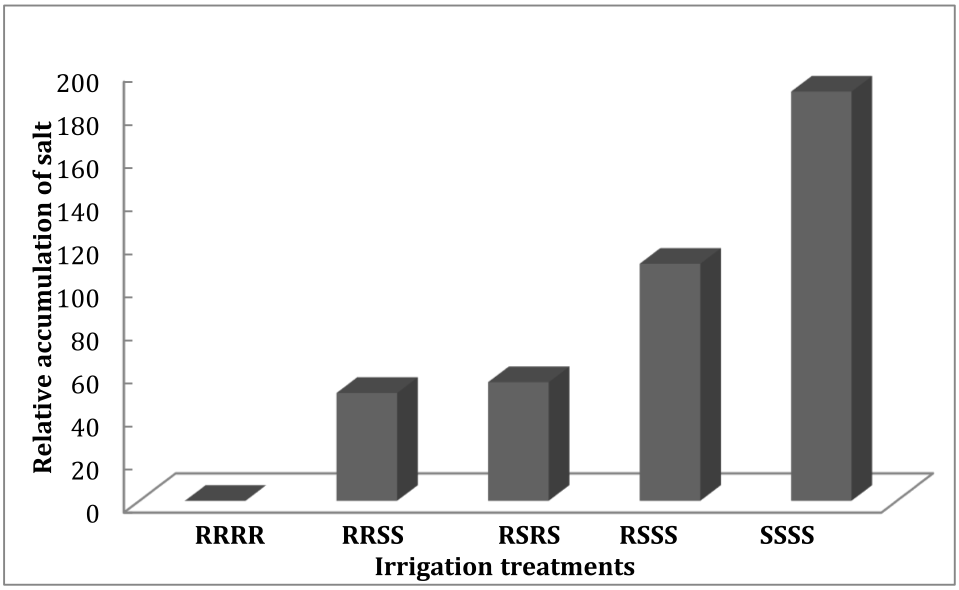

Figure 5. Relative accumulation of salt in the (0-0.60m) layer at the end of growing season when irrigating with saline water, depending on growing stages (R = river water , s= saline water)

Date: October 2023

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Date: October 2023

Flow Coefficient Determination in Catchment Based on Analysis of Temperature and Wind Speed Data Using the Fuzzy SMRGT Method

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Abstract: In engineering hydrology, calculating the flow coefficient is a crucial step. The flow coefficient calculation is necessary for directing the rational profiteering of water resources, improving the overall efficiency of water resource utilization, and minimizing the effect of catastrophic events. By precisely determining the flow coefficient, which is the most influential factor in flood flow, the current issues will be mitigated substantially. Various techniques are available in the existing literature for modelling flow coefficient. Most of them, however, rely on black-box approaches that are not generalizable. Therefore, this paper applied an intelligent model based on a fuzzy logic system called the Simple Membership Function and Fuzzy Rules Generation Technique (SMRGT). The new technique considers the physical cause-effect relationship and is intended to aid individuals who struggle to choose the number, form, and logic of membership functions and fuzzy rules in any fuzzy set. The study area's temperature and wind speed data were incorporated into the SMRGT model's input variables. The output was the flow coefficient. The prediction made by the model was validated against observational data. The comparison relies on numerous statistics and errors. The results indicated that the SMRGT model predicts the flow coefficient extraordinarily well and is an excellent method for generating membership functions and fuzzy rules.

48. Introduction

The primary focus of hydrology, hydraulics, and other water-related earth sciences is on uncertain natural phenomena. There is a close relationship between precipitation, overflow, drought, storm, solar irradiance, and other phenomena and daily economic and social interactions. To control catastrophic consequences, it is crucial to anticipate future occurrences and magnitudes of these phenomena with some degree of certainty. The publication of a seminal paper by Lotfi A. Zadeh [1] is widely regarded as a turning point in developing the contemporary notion of uncertainty. Zadeh introduced in his paper a theory whose objects, fuzzy sets, are sets with indefinite boundaries. A fuzzy set determines membership by degree rather than by affirmation or denial. Zadeh's pioneering study challenged probability theory as the only source of uncertainty and the basis of probability theory, which is Aristotelian two-valued logic. There are many literature used fuzzy logic in hydrology and hydraulic applications; for example, [2] applied fuzzy logic to optimize water distribution, while [3] used it to simulate infiltration and water movement in the unsaturated zone. [4] Investigated fuzzy rule-based hydraulic control systems. [5] used fuzzy logic for disaster monitoring and damage assessment. [6] used a fuzzy algorithm to compute solar irradiation from sunshine duration and proposed that his model be implemented in several stations in western Turkey at countless latitudes. Figure 1 shows the general sections of any fuzzy system.

Date: October 2023

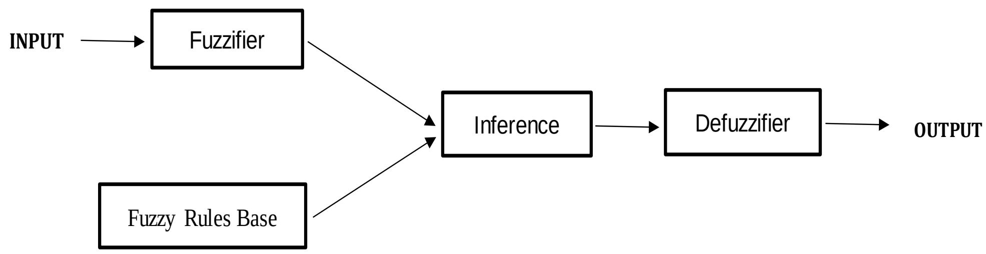

Figure1. Nonlinear plotting of the fuzzy logic system.

The evaluation of the flow coefficient is among the most challenging aspects and a significant source of uncertainty in numerous water-related projects. This paper modelled the flow coefficient for Aksu River Basin using a new fuzzy method named SMRGT (Simple Membership function and fuzzy Rules Generation Technique), which was first presented by Toprak in 2009 [7]. Hydrological prediction research relies heavily on the ability to predict flow coefficients, as this evidence can inform flood and drought mitigation plans, basin scheduling, and hydroelectric power generation [8, 9]. For the most effective distribution of basin water resources and strategic regional development planning, knowing how to establish a flow coefficient prediction model with higher forecast accuracy is crucial. In light of the fact that the rainfall flow process is impacted by numerous factors, including topography, precipitation patterns, soil characteristics, land usage, and climate change, procedure-driven models necessitate a large amount of modelling data, and a lack of data will affect the model's excellence.

In the fuzzy SMRGT method, the laws of physics are reflected in the model as expert opinion. In addition, the use of available data allows a better result to be obtained. Also, it can be thought that incorporating the laws of physics as an expert opinion in fuzzy logic may bring some idealizations. There may be some idealizations, depending on considering the laws of physics. However, these idealizations are very small compared to other methods. For these reasons, the fuzzy logic method was preferred. The absence of such a study in the literature also contributed to this preference.

The SMRGT technique has been used in several other studies, albeit in different contexts. The first application of the fuzzy SMRGT method was by [7] to model the flow discharge in open canals. After that, [10] used it to calculate water distribution system leakage. Automatic fuzzy model generation using the SMRGT technique (abbreviated as SFM (SMRGT Fuzzy Modeler)) was developed by [11]. Using the fuzzy least square regression (FLSR) technique, [12] could apply it to time series data, creating an equation for making projections in the future. It was used by [13] to assess the surface profile of the water in open channels when subjected to varying hydraulic conditions. [14] used it to create a seismic classification of buildings' floors. [15] attempted to predict the river's flow using MLR, ANN, M5 Decision Tree (M5T), ANFIS, SMRGT, and Mamdani - fuzzy Logic (M-FL).

49. Materials and Methods

Aksu River Basin coordinates 36–38 degrees north latitude and 30–31 degrees east longitude, surrounded by the Mediterranean Region's geographical boundaries. This region is the focal point of this study. The length of the Aksu River is approximately 370 km (230 miles), and it has a total width at its mouth of 100 meters (330 feet). Based on ArcGIS measurements, the basin drains an area of approximately 7505 km^2. The average annual temperature and wind speed data from 1990 to 2020 were utilized for the dataset. The data was obtained from the Turkish state meteorological service.

The SMRGT method was presented to assist those who have problems determining the shape, number, and logic of MFs and FRs, as the two most important aspects of a data-based fuzzy model (FM) are the generation of membership functions (MFs) and fuzzy rules (FRs). The most notable advantage of this method is that the model can easily and quickly establish both the FRs and the MFs. Nonetheless, it can be established even in the absence of data, as it is based entirely on the actions of experts. The proposed method is based on the following algorithm and procedure, both of which are described below.

Date: October 2023

- As a first step, the dependent and independent variables of the SMRGT method are identified. Two independent variables (temperature (°C) and wind speed (m/s)) are used as inputs, while the dependent variable (flow coefficient) is the output. The created fuzzy model is shown in Figure 2.

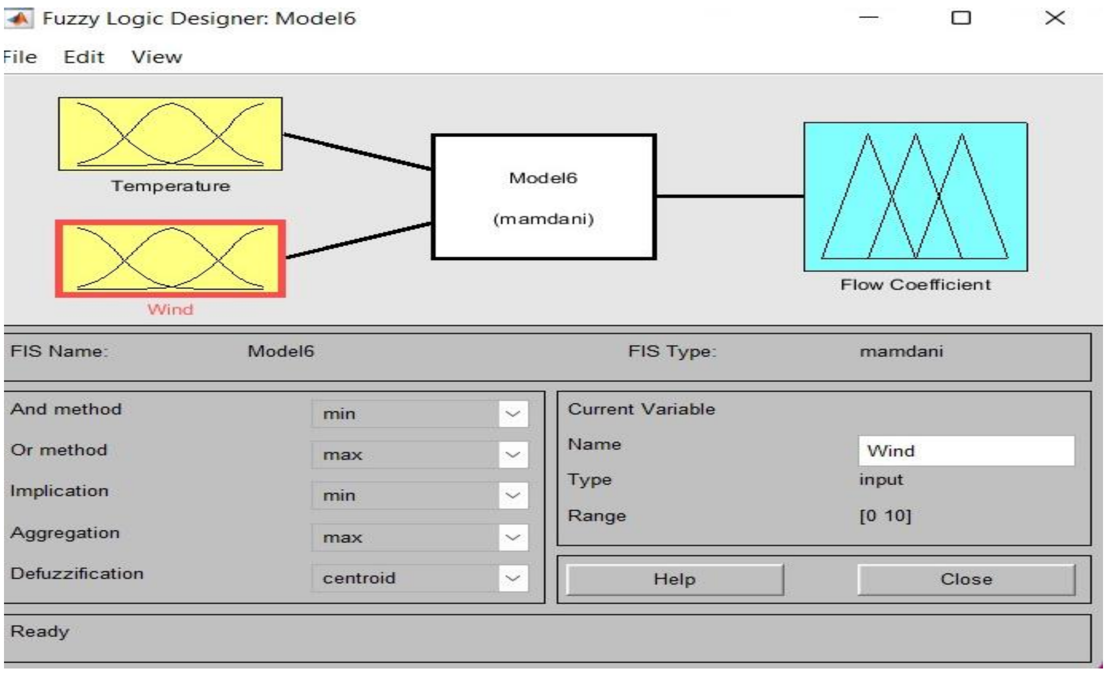

Figure 2. Fuzzy system of the model.

- Maximum and minimum upper bounds, and then fuzzy clusters (very very low (VVL, very low (VL), low (L), medium (M), high (H), very high (VH), very very high (VVH)) were established accordingly. Temperature limits were (0-50) °C, and wind speed limits were (0-10) m/s.
- The forms of the membership functions were settled upon (triangle and trapezoidal). Triangular membership functions are favoured over other types in the academic literature and this study.
- Determining the unit width, core, and key values for each triangle membership function is the last step in determining membership functions. The key values were assigned according to expert experience. These key values are the input of the SMRGT model; Figures 3 and 4 show the boundaries of each MFs for the inputs variable, which they highlighted in bold.

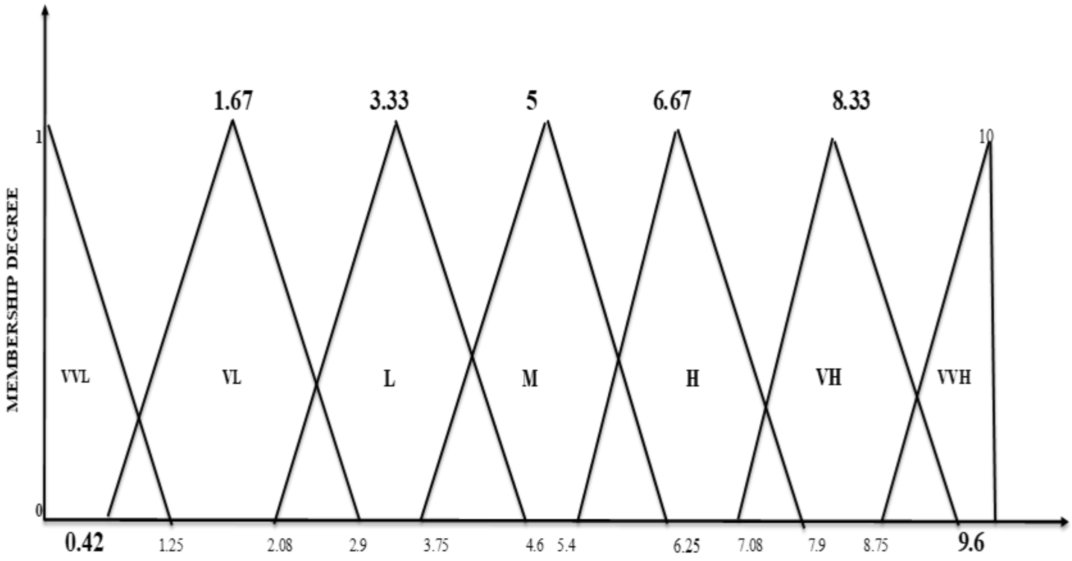

Figure 3. The key values of the wind MFs.

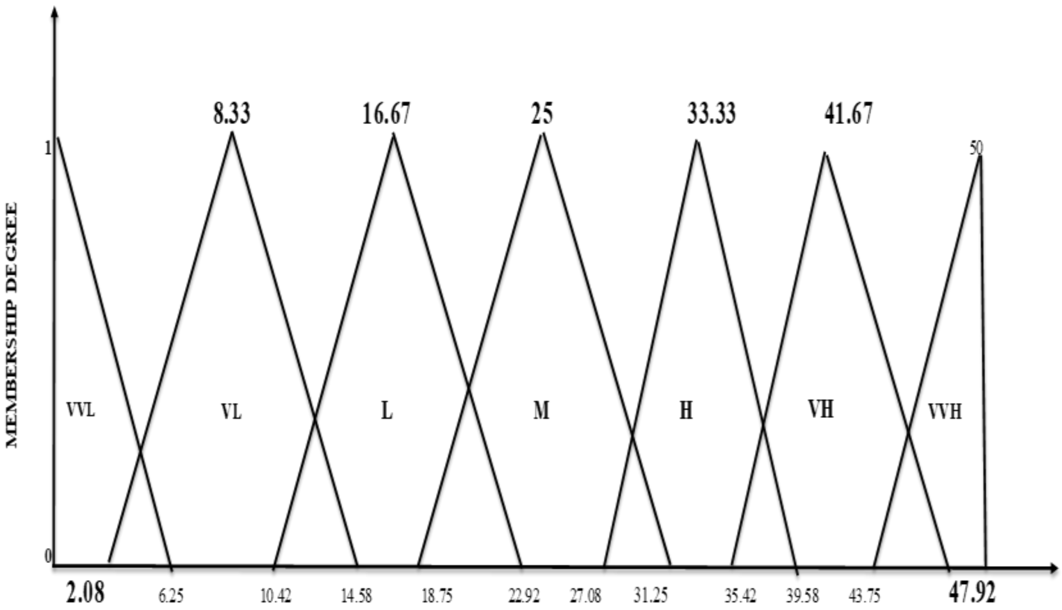

Figure 4. The key values of the temperature MFs.

- For each parameter, fuzzy rules are formulated during the training phase, and the process of obtaining the results begins. As can be seen in Figure 5, the fuzzy rules base is established by factoring in physical conditions such as "IF," "and," and "THEN." The membership function of each fuzzy set and the number of fuzzy sets in the independent variables determine the total number of fuzzy rules.
- Generated MFs are built the same as input MFs. The smallest output key value is the first MF centre value. Key values peak is the last MF's centre value. When output FRs match MFs, model performance improves. Figure 6 shows the membership functions of the output.
- Then, a table containing the number of FRs and the output's key values is generated. The table depicts the construction of fuzzy rules for a fuzzy model with inputs of five MFs and one output of 49 MFs.

Date: October 2023

- The fuzzy SMRGT model is run using MATLAB software, which is the most suitable package program for this study. Input and output files prepared and added to the program with (.dat) extension. Then the program with the (.fis) extension is loaded. The (.m) extension file is prepared for running the prepared program. Model results can be obtained by running this file with the (.m) extension. Preparing the program with this procedure will reduce the trial and error process.

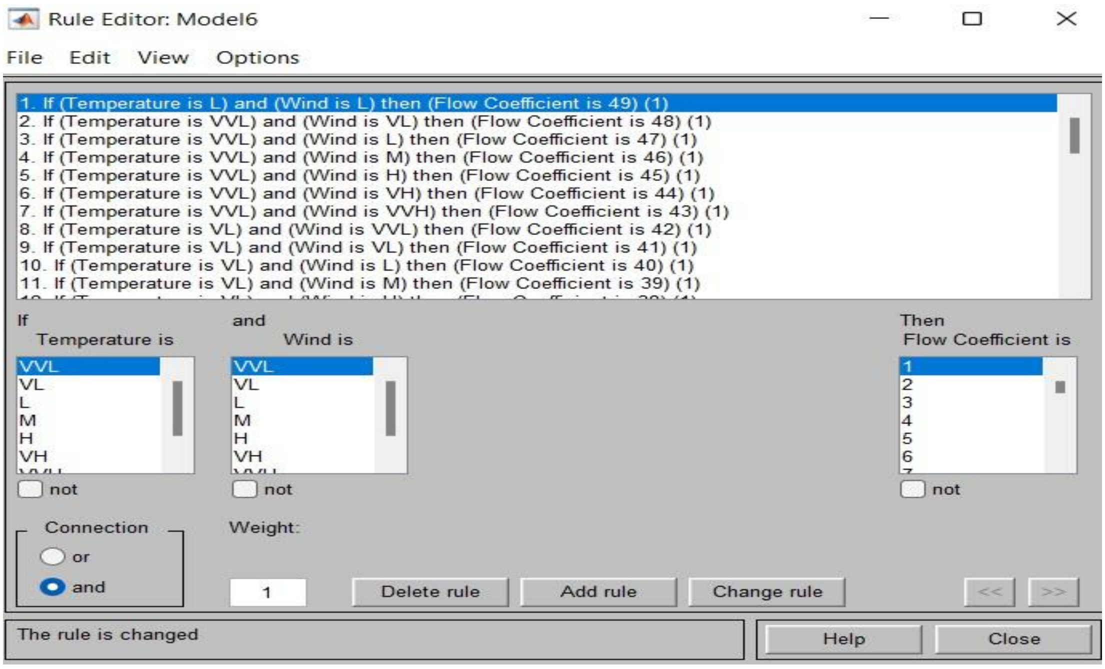

Figure 5. MATLAB view of the generated fuzzy rules.

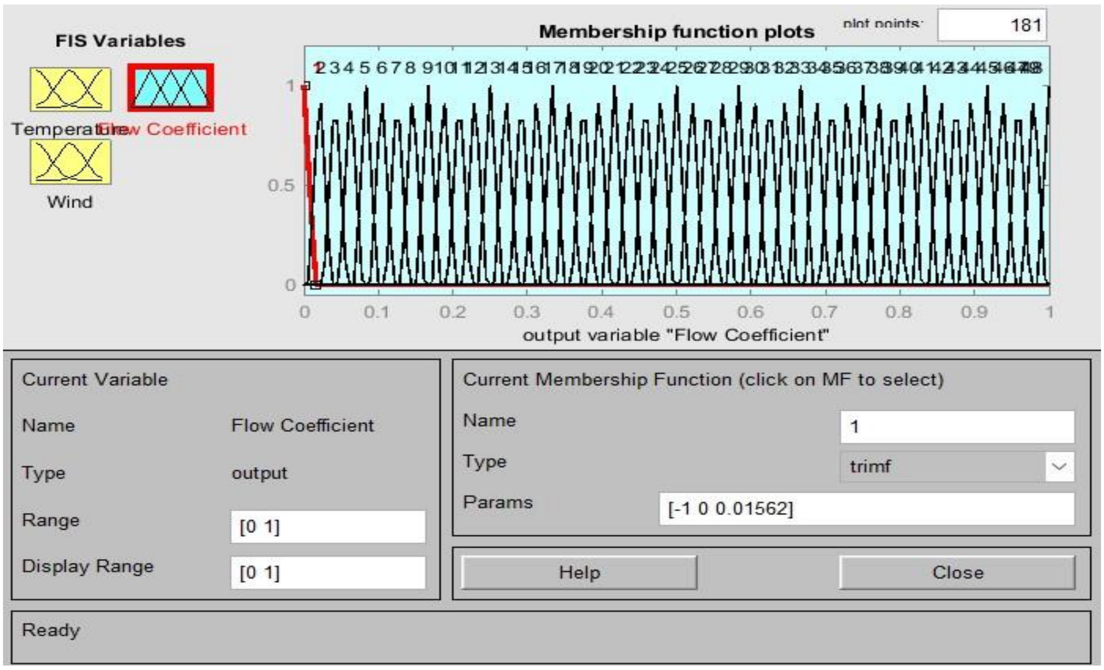

Figure 6. MFs of the output (flow coefficient).

Results and Discussion

In this research, the flow coefficient for Aksu River Basin was modelled using the fuzzy logic theory. The flow coefficient was considered depending on the temperature and wind speed data as the input variable. The Turkish State Meteorological Service obtained the dataset from 1990 to 2020. Seven membership functions were set for each input variable, and 49 fuzzy rules were generated. MATLAB software was chosen as a package program to run the model.

As a result, figures 7 and 8 display the maximum and minimum values of the flow coefficient based on temperature and wind speed. When the temperature is at the minimum limit (2.08 °C), and the wind speed is (0.417 m/s), it is evident that the flow coefficient is (0.98). Likewise, when the temperature is at the maximum limit (47.9 °C), and the wind speed is (9.58 m/s), the flow coefficient is (0.003). These examples indicate that the model is mathematically and physically functioning properly. Also, the correlation between the output and inputs is negative. Assuming that all precipitation reaches the ground, the flow will be very high when the weather is cold and the wind speed is low.

Figure 7. Graphical view of the rules (maximum value of output).

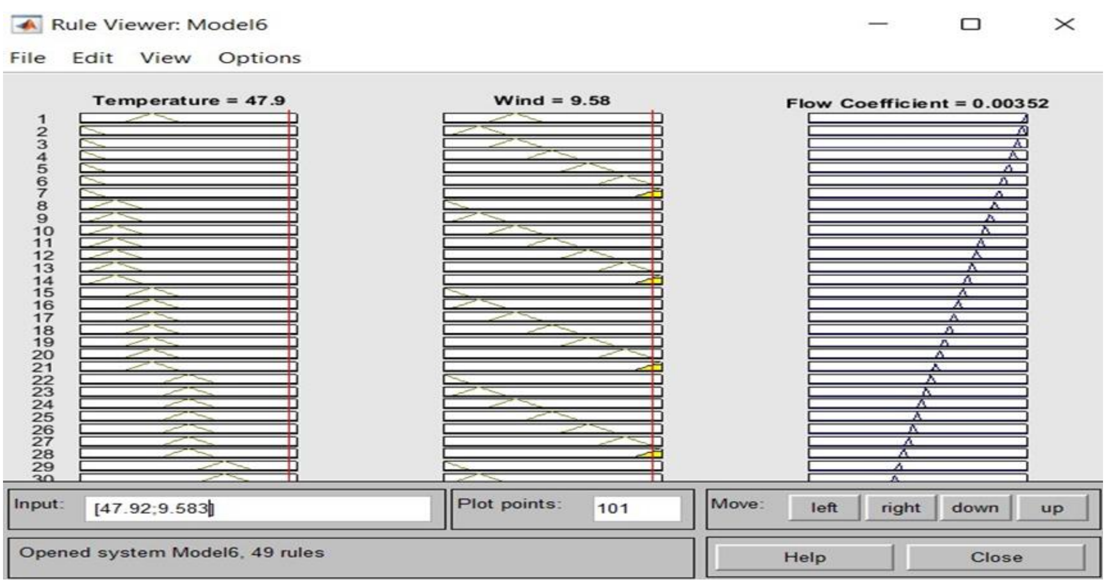

Figure 8. Graphical view of the rules (minimum value of output).

Date: October 2023

In this study, a small subprogram is prepared to run model files with the (.fis) extension. This subprogram runs all MATLAB files with the extension 'fis' and allows the loaded files and program to run automatically. It keeps the user from manually applying and makes the program run very easily. The model results are compared to the available data. In order to test the model's prediction accuracy, statistical parameters such as minimum (Xmin), mean (Xm), maximum (Xmax), standard deviation (σ), coefficient of variation (Cvx), coefficient of skewness (Csx), correlation coefficient (r), also Mean Absolute Relative Error (MARE), Mean Square Error (MSE), Mean Absolute Error (MAE), and Root Mean Square Error (RMSE) were used. The results of the statistical comparison are shown in Table 1. The low error rates and high correlation coefficient point to the possibility of mathematically representing the statistical relationship between the model and the data.

Table 1. Statistical comparison of the model and data

Statistical Parameters and Errors	Data		Model
Max.	1.00		1.00
Min.	0.00		0.00
Mean	0.50		0.50
Standard Deviation	0.30		0.29
Skewness	0.0000		0.0016
Coefficient of Variance (C_V)	0.616		0.589
Correlation Coefficient (r)		0.99	
Mean Square Error		0.05%	
Mean Absolute Error		2%	
Mean Absolute Relative Error		6.88%	
Root Mean Square Error		2.36%	

In addition, graphical representations of the comparison were created using a scatter diagram and a series graph (see Figures 9 and 10). The scatter plot reveals that the regression line intersects the horizontal axis at an angle of approximately 45 degrees. In other words, the model does not produce forecasts that differ significantly from the collected data. The scatter plot shows a high correlation between the actual and estimated data. A three-dimensional representation of the interplay between dependent and independent variables is shown in figure 11. Table 2 displays key output values, the total number of fuzzy rules, and the creation of a fuzzy model.

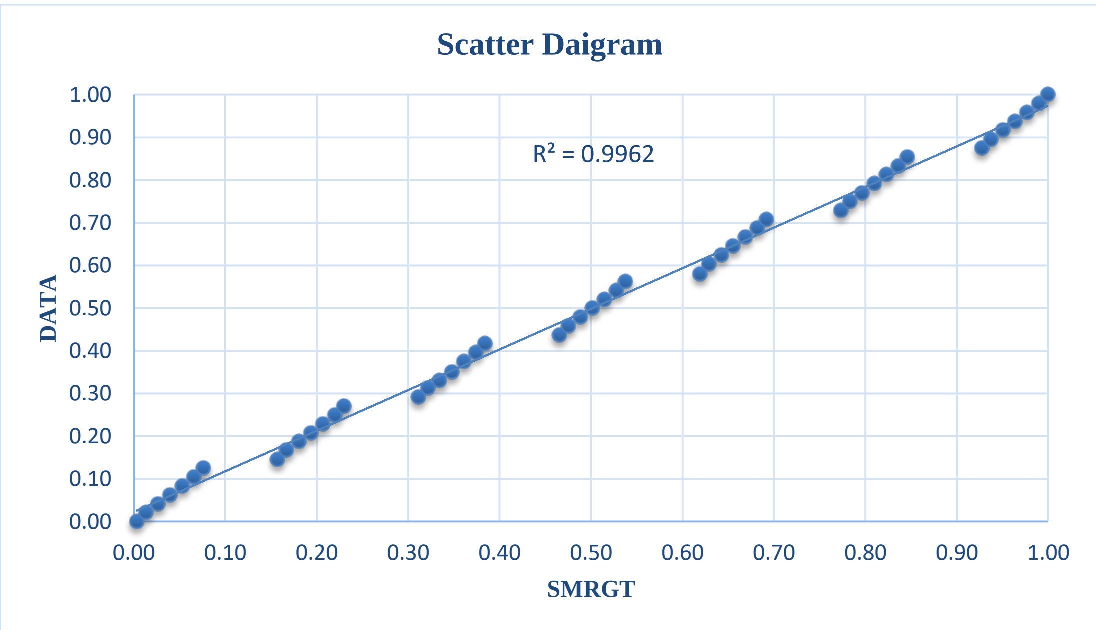

Figure 9. The scatter plot of the SMRGT and Data.

Date: October 2023

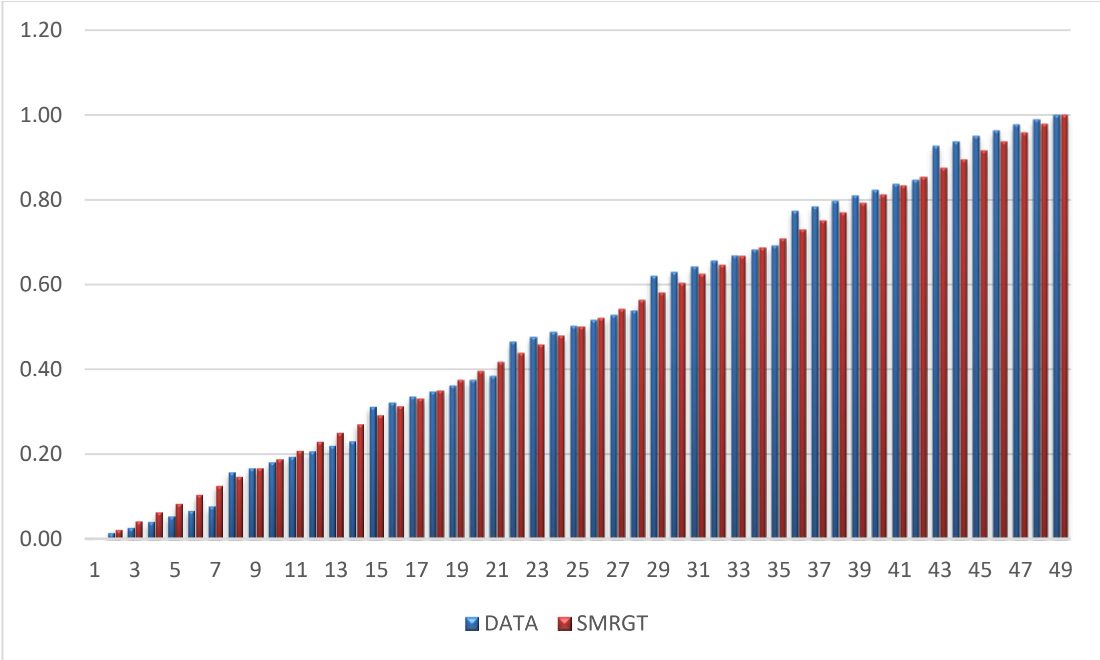

Figure 10. The series graph of the results.

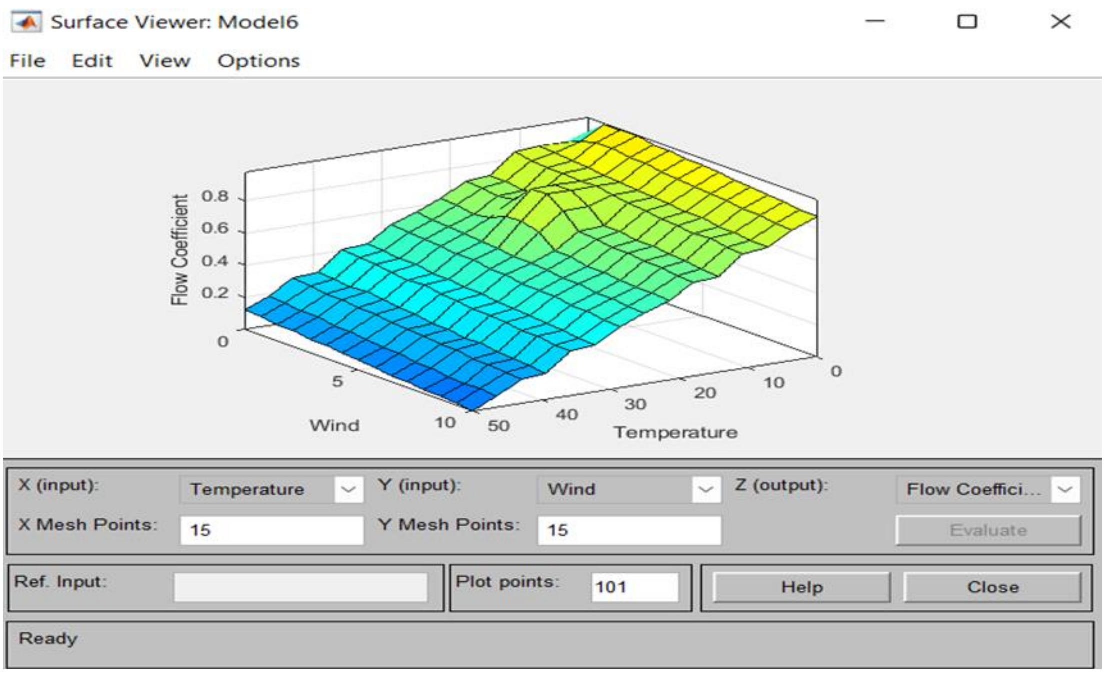

Figure 11. Variation of output as a function of inputs.

Date: October 2023

Table 2. Generated fuzzy set.

Rules No	Temperature °C		Wind m/s		Flow Coefficient (data)	Flow Coefficient (model)	MARE
	Numerical	Verbal	Numerical	Verbal			
1	50	VVH	10	VVH	0.00	0.00	0.000
2	50	VVH	8.33	VH	0.01	0.02	1.168
3	50	VVH	6.67	H	0.03	0.04	1.186
4	50	VVH	5	M	0.04	0.06	1.180
5	50	VVH	3.33	L	0.05	0.08	1.165
6	50	VVH	1.67	VL	0.07	0.10	1.176
7	50	VVH	0	VVL	0.08	0.13	1.320
8	41.67	VH	10	VVH	0.16	0.15	0.149
9	41.67	VH	8.33	VH	0.17	0.17	0.002
10	41.67	VH	6.67	H	0.18	0.19	0.081
11	41.67	VH	5	M	0.19	0.21	0.152
12	41.67	VH	3.33	L	0.21	0.23	0.219
13	41.67	VH	1.67	VL	0.22	0.25	0.279
14	41.67	VH	0	VVL	0.23	0.27	0.356
15	33.33	H	10	VVH	0.31	0.29	0.130
16	33.33	H	8.33	VH	0.32	0.31	0.056
17	33.33	H	6.67	H	0.33	0.33	0.027
18	33.33	H	5	M	0.35	0.35	0.014
19	33.33	H	3.33	L	0.36	0.38	0.080
20	33.33	H	1.67	VL	0.37	0.40	0.119
21	33.33	H	0	VVL	0.38	0.42	0.174
22	25	M	10	VVH	0.47	0.44	0.122
23	25	M	8.33	VH	0.48	0.46	0.074
24	25	M	6.67	H	0.49	0.48	0.039
25	25	M	5	M	0.50	0.50	0.007
26	25	M	3.33	L	0.51	0.52	0.023
27	25	M	1.67	VL	0.53	0.54	0.052
28	25	M	0	VVL	0.54	0.56	0.093
29	16.67	L	10	VVH	0.62	0.58	0.130
30	16.67	L	8.33	VH	0.63	0.60	0.082
31	16.67	L	6.67	H	0.64	0.63	0.055
32	16.67	L	5	M	0.66	0.65	0.031
33	16.67	L	3.33	L	0.67	0.67	0.006
34	16.67	L	1.67	VL	0.68	0.69	0.017
35	16.67	L	0	VVL	0.69	0.71	0.047
36	8.33	VL	10	VVH	0.77	0.73	0.117
37	8.33	VL	8.33	VH	0.78	0.75	0.087
38	8.33	VL	6.67	H	0.80	0.77	0.068
39	8.33	VL	5	M	0.81	0.79	0.046
40	8.33	VL	3.33	L	0.82	0.81	0.026
41	8.33	VL	1.67	VL	0.84	0.83	0.008
42	8.33	VL	0	VVL	0.85	0.85	0.019
43	0	VVL	10	VVH	0.93	0.88	0.115
44	0	VVL	8.33	VH	0.94	0.90	0.092
45	0	VVL	6.67	H	0.95	0.92	0.073
46	0	VVL	5	M	0.96	0.94	0.055
47	0	VVL	3.33	L	0.98	0.96	0.040
48	0	VVL	1.67	VL	0.99	0.98	0.023
49	0	VVL	0	VVL	1.00	1.00	0.000

Date: October 2023

Conclusion

Prediction techniques based on statistics, probability, and stochastic or classical approaches, for instance, artificial neural networks and genetic algorithms, have become increasingly popular in recent years. Most of the approaches, however, are opaque. Models run using black box techniques include a few disadvantages that should be aware of. Therefore, it is recommended to use generalizable modelling techniques. The flow coefficient was estimated using the fuzzy SMRGT technique in this research. The effectiveness of the suggested method was evaluated using six statistical criteria, a correlation coefficient, and four different kinds of errors. The model's success in estimating the flow coefficient rate is demonstrated by the following: low error rates, the similarity between the data and the model's estimation, high determination and correlation coefficients between the data and the model's estimation, and unbiasedness and linearity in the scatter plot. It is concluded that the fuzzy SMRGT method is among the most practical and accurate techniques for determining the flow coefficient. It is simple to determine the total number of variables, fuzzy sets, and membership functions. In addition, the SMRGT method considers the event's physical cause-effect relationship, making it applicable to any basin or region. Also, it does not require expensive package programs and allows the expert experience to reflect in the model.

Moreover, when calculating the flow coefficient, the study area's climate, land use, and soil characteristics must all be considered instead of depending on values created by humans in tables. Studying the correlation between precipitation and flow is a crucial hydrological phenomenon to investigate using fuzzy logic due to the uncertainties in the data.

Complex systems that a simple mathematical model cannot adequately represent are prime candidates for implementation using fuzzy logic. Moreover, it has been demonstrated to greatly simplify the modelling of nonlinear processes when applied on a large scale. When an adequate and straightforward mathematical model already exists for a system or conventional modelling theory yields satisfactory results, fuzzy logic is not recommended.

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Date: October 2023

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Improving the Discharge Capacity of the Al Butera River

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Abstract. In the province of Maysan, the Al Butera River is one of the most significant tributaries of the Tigris River. It has a length of 48.8 km and reaches the Central Marshes in the south of Maysan from downstream of Al Butera Regulator. Villages and farmland suffer significant. The purpose of this project is to examine and enhance the Al Butera River, which has suffered harm from sedimentation and bank encroachment, particularly during the flooding in April 2019.. Using the available cross-sections and hydraulic data from numerous Ministry of Water Resources .Iraq sectors, a one-dimensional hydraulic model simulating the flow in the Al Butera River was created using the HEC-RAS 5.0.7 software. The fieldwork was conducted to fill in any gaps in the data that were there regarding the river. Fieldwork includes doing an inspection and measuring outflow. Using calibration and verification with a low root mean square error, the simulation demonstrated that Manning's coefficient is 0.026. Additionally, the Al Butera River has a current capacity of 170 m^3/s with the current flood escapes, while its developed capacity for short-term development by raising the banks level is 250 m^3/s. However, the river's long-term development through cross-section alteration with bank-level maintenance is 400 m^3/s and does not allow for flood escape. Because there are pavements and populated areas nearby, raising the banks of the Al Butera River by around 2 m would be necessary to develop it to handle the design discharge of 700 m^3/s.

1. Introduction

Al Butera River branches from the Tigris River in the north Amamarh Barrage in Maysan province. The Tigris River is Iraq's principal river. Shown in Figure 1. Three reasons changed the flow hydrograph of Al Tigris River. These reasons are the construction of dams, acclimation, and increased water demand. These reasons reduce the discharge of the Tigris River and its branches including the Al Butera River. On the other hand, the cross sections of Al Butera have become lacking in the discharges incoming during the flood season, due to the sediments and damage to embankments surrounding the reach. With the floods caused by the filling of the natural channel with sediments, the Al Butera basin needs to maintain continuity. For these reasons, it's very important to study the capacity of reach under this condition and make modifications to cross sections or raise embankments or both cases for the short or long term.

Numerous studies have been conducted on the Tigris River concerning sediment, Manning's coefficient, and water quantity models, based on the cross-sectional data requirements, observer water levels, and field discharge during the various flood, dry, and wet seasons times. Generally, this study's objective is to evaluate and adjust the Butera River's flood to use all of its available capacity. In the research region, the Al Butera River's capacity to carry flood discharges has been decreased by sedimentation, a lack of maintenance, and the numerous meanders that have formed in the river's main channel over the years. In the Maysan province, this increases the risk of flooding. To determine the risk of flooding and come up with the best potential solution, hydraulic analysis is required. This section of the report will discuss some earlier studies on the Tigris River and its branches as well as other escapes that used the HEC-RAS software.

The Shatt Al Hilla is a tributary of the Euphrates River on the left bank. The 303 m^3/s design discharge. The hydraulic characteristics of the flood bed, the water surface profiles of the Q25, Q50,

Date: October 2023

Q100, and Q500 flood recurring floods, and a one-dimensional floodplain analysis of the Tigris River were all discovered with the aid of the HEC-RAS software. The use of a prospective regulator that the research area has suggested. The results were made known.[2].

HEC-RAS software was used to research the hydraulic characteristics of the Kumayt flood escape (river). Using AsSanna'f Marsh as a flood relief channel, this escape directs water from the Tigris River to Al Huwayza Marsh. The Manning's n coefficient used in the model had a range of 0.03 to 0.045. If the final portion of the river is altered, the river's discharge capacity will rise to 250 m^3/s. and it gained 569 m^3/s in capacity. [3].

The Al-Husa'chi River's 25 km of developed discharge capacity. It is an Al Kahlaa River tributary. It feeds Al-Huwayza Marsh. To simulate the flow of the river, a one-dimensional steady-state hydraulic model was built using the HEC-RAC software and geometrical information collected from survey work. Upstream and downstream, Manning's n was discovered to fluctuate between 0.025 and 0.045, respectively. Additionally, they found that the river had a capacity of 20 to 35 m^3/s and a design discharge of 85.5 m^3/s. [4].

HEC-RAS software was used to develop a one-dimensional steady-state model of the Al Musharah River's hydraulics. According to the study, Manning's coefficient progressively varies upstream and downstream between 0.038 and 0.06. The river's current maximum capacity, which was found to be approximately 20 m^3/s, was also examined in the study. Future marsh and agricultural developments should have a design discharge of 40.5 m^3/s. [5].

Examined the Al Khummus Regulator, the Central Marsh's entrance near the mouth of the Al Butera River. The regulator's intended discharge is 270 m^3/s at a 6.27 m above mean sea level. The regulator is made up of numerous structures, including two crests. The first crest measures 65 meters in length and has a level of 5.8. The other crests measure 27 meters in length and have a level of 3.5 m.a.m.s.l. with an invert level of 0.9 m.a.m.s.l. [6].

13816 m^3 of deposition sediment, or around 4.1 cm/year, was trapped annually in the Al Butera River flow of 80.2 m^3/s, according to three-dimensional models of sediment movement that were successfully developed upstream of the Al Butera regulator. [11].

The Euphrates River's hydraulics were modeled in one dimension.. The findings show that under the current circumstances, the Euphrates River can flow at a maximum rate of 300 m^3/s. The capacity, however, may rise to 800 m3/s in the short term and 1.300 m^3/s in the long run following the improvements. [17].

A flood analysis for the Tigris River has been completed using HEC-RAS. Floods affect Turkey. This study focused on the floodplain between the ancient Ten-Eyed Bridge and the Diyarbakr-Silvan Highway. There are three historical bridges among them. The study path also passes by several residences, buildings, and medical facilities on the Dicle University campus, as well as the UNESCO-designated Hevsel Gardens. This research was done to look at flood plains and create a flood hazard map that can show high-risk locations. [19].

The Al Kahlaa River's flow was examined.and its branches' capacity in Amarah City Utilizing the HEC-RAS software, a one-dimensional hydraulic model was put into practice. According to the strategic study, they used data from cross-sections every 100 meters between cross-sections with Manning's n = 0.022. Al Zuber, Um Atos, and Al Hachi rivers make up the three branches that make up the 450 m^3/s design discharge. [21].

The Manning's n coefficients for Shatt Al-Daghara, Shatt Al-Diwaniya, and the Diversion canal are 0.022, 0.023, and 0.018, respectively. This study evaluated and developed the (Hilla - Diwaniya - Daghara) river control system using a one-dimensional hydraulic model software simulation of the flow within the study area. The current condition's findings revealed that the Diversion Canal's, Shatt Al- Hilla's, Shatt Al- Daghara's, and Shatt Al-respective Diwaniya's current capacities are 200, 50, 60, and 22 m^3/s. It should be noted that the station's Shatt Al-cross Daghara regulator rejected the A discharge that was greater than 5 m^3/s (64 000 km). The Shatt Al-Hilla, Shatt Al-Daghara, Shatt Al-Diwaniya, and the Diversion Canal can each discharge up to 303, 75, 96.2, and 45.5 m^3/s, respectively, according to the outcomes of the applied upgrades. However, by modifying the cross sections between stations (13 000 - 31 000 km), raising bank levels, and eliminating the cross regulator at the station, Shatt AlDaghara's current capacity increased from 50 to 75 m^3/s (64 000 km) [24].

Date: October 2023

2.Materials and methods

The Al Butera River has a length of 44.6 km and runs from the Al Butera Regulator shown in Figure 1, which can release 700 m^3/s, to the Al Khummus Regulator. Al Khummus Reqlator has a maximum water level of 6.27 m.a.m.s.l. with a designed discharge of 270 m^3/s.

The primary branches of the Al Butera River are Al Kafka, Um Alganais, Um Al Fageel, Al Hadaam, Al Margina, and Al Fahadi. As shown in Figures 1 and 2, they are also employed as flood escapes that release water into the Central Marshes.

[16] 2.1 General Characteristics of the Al Butera River.

The Al Butera River's primary features include:

- Along the reach, the water's top width of cross-sections varies between 110 and 800 m.
- Two growing lands make up the reach; the first island is located between stations 2+250 and 12+750, while the second island is at station 31+250. And narrow cross-sections between stations 32+500 to 41+200.
- The river reaches between Al Butera and Al Khummus Regulators were cross-sectioned at an interval of almost 250 m.

The river bed levels ranged from 3.54 m.a.m.s.l. at station 4+750 and 0.31 m.a.m.s.l at station 41+250.

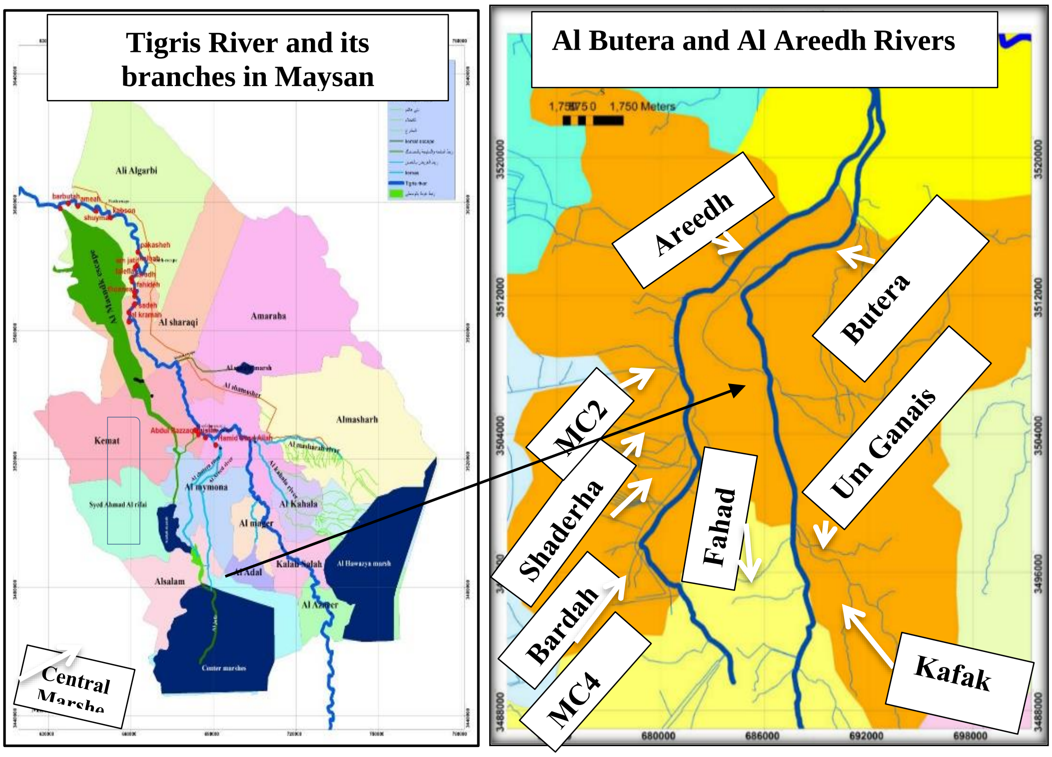

Figure 1. Tigris and its main branches Rivers. Al Butera and Al Areedh Rivers in Maysan Province

[17] 2.2 Hydrological data.

For the period from 2004 to 2021, MoWR.Iraq. Provided hydrological daily data for the Al Butera River in Maysan province Villages, structures, and agricultural land were affected by the flood on both sides of the Tigris River and its tributaries,as presented in Tables 1 and 2 examples of data.

Table 1. Average monthly discharges (m^3/s) of the Al Butera River provided by [Maysan province, Directorate of Water Resources in Maysan] from 2012 to 2020

Month	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
	Average Months discharges *(m^3/s)*								
Jan	23	26	40	23	21	24	17	34	32
Feb	24	28	28	17	30	20	22	118	34
Mar	24	46	31	16	43	29	21	85	49
Apr	18	22	40	23	36	31	24	207	30
May	27	32	38	22	37	61	18	161	48
Jun	21	19	31	16	35	36	14	48	39
July	26	17	31	12	26	24	14	47	37
Aug	27	24	31	13	25	16	15	44	38
Sep	21	32	30	15	25	16	15	48	40
Oct	22	28	21	14	21	16	13	39	38
Nov	18	36	16	28	13	9	23	33	30
Dec	28	29	21	20	21	16	47	59	26

Table 2. Discharges distributions of the Al Butera River 2019, provided by the Directorate of Water Resources in Maysan [MoWR] Iraq during 2019

March –day								April								
24	25	25	27	28	29	30	31	1	2	3	4	5	6	7	8	9
125	130	134	136	130	134	134	132	140	160	190	180	182	190	208	210	211

2.2.1.Consumption of Water in Al Butera River.

The consumption of water along the Al Butera River by lateral canals starting from downstream Al Butera regulator is computed according to Eq. (1) since there are no accurate records or documentation about the consumptions.The consumption is found from 0.86 to 3.24 m^3/s per 5 *km* for the different discharges, using the equation of consumption for each km as $Consumption = ((Qu – 0.5* Qd)/ L)$ (1) Where:Qu: discharge upstream, Q: discharge downstream, *m3/s*. L: length of reach, km. The discharges which were used for the calibration, and verification of the model are 50, 93, 117,121,144,187and 192 m^3/s.

2.2.2.Hydrological data.

Recorded water levels in the Al Butera River,the recorded water levels for Al Butera Rivers are available in the Directorate of Water Resources in Maysan province. Which is recorded automatically by monitoring every 15 minutes every day. It's recorded downstream of the Al Butera regulator from 2004 to 2021. As shown in Table 3

Date: October 2023

Table 3. Daily water level (W.L.) of Al Butera River downstream the regulator in April of 2011, 2015, and 2019, [Directorate of Water Resources in Maysan 2022].

[18] 2.3 Survey data.

	2011					2015				2019	
day	W.L.	Day	W.L.	Day	W.L.	Day	W.L.	Day	W.L.	Day	W.L.
1	6.1	16	6.5	1	5.5	16	5.9	1	7.0	16	8.1
2	6.1	17	6.4	2	5.6	17	5.9	2	7.2	17	8.1
3	6.15	18	6.4	3	5.6	18	5.9	3	7.5	18	8.1
4	6.15	19	6.4	4	5.6	19	5.9	4	7.6	19	8.0
5	6.15	20	6.5	5	5.6	20	6.1	5	7.6	20	8.1
6	6.3	21	6.5	6	5.6	21	5.9	6	7.6	21	8.0
7	6.4	22	6.5	7	5.6	22	5.9	7	7.8	22	8.0
8	6.25	23	6.5	8	5.7	23	5.8	8	7.8	23	8.0
9	6.25	24	6.5	9	5.7	24	5.8	9	7.9	24	8
10	6.25	25	6.5	10	5.7	25	5.9	10	7.9	25	7.9
11	6.25	26	6.3	11	5.7	26	5.9	11	7.9	26	7.9
12	6.25	27	6.2	12	5.7	27	5.8	12	8	27	7.9

Many sectors of MoWR provided the surveyed cross-sections of the Al Butera River between the downstream Al Butera Regulator till Al Khummus Regulator. It consists of 172 cross-sections with an interval of 250 m in 2005 and 2019, as shown in Figure 2.

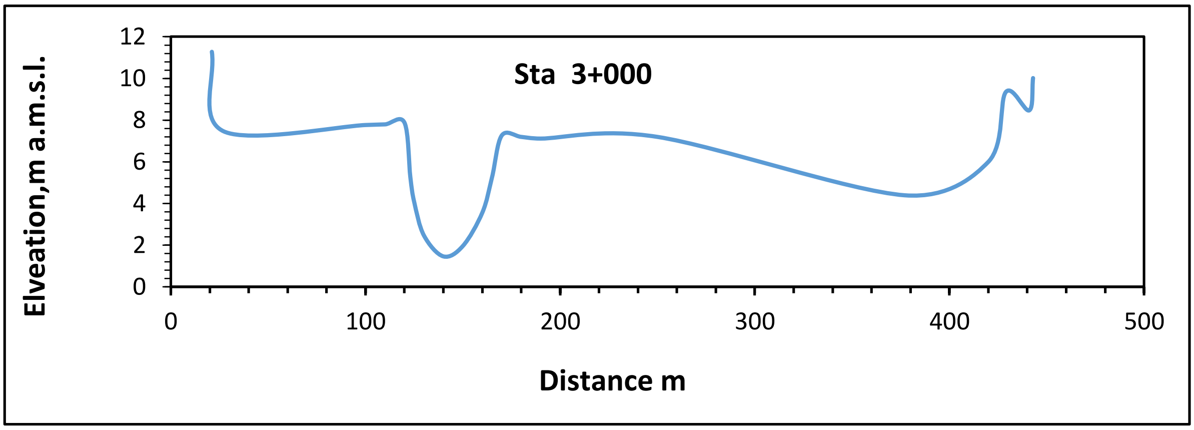

Figure 2. Cross–section of Al Butera River

[19] 2.4 The fieldwork.

The conducted fieldwork to cover unavailable or missing data concerning river.

The fieldwork consists of a survey and discharge measurement and was achieved in the period from 14 April to 12 Dec 2022. The below devices were used in the survey work as shown in Figure 3.

[20] 2.4.1. Alpine quest software:

Alpine Quest software was used to check the length of rivers and the distance of cross-sections.

[21] 2.4.2. GPS (Global positioning system). differential devices:

benchmark which was based on the surveying of the cross-sections of Al Butera Rivers checked by using the GPS *(*Global positioning system) Differential Device and which was corrected about 10 cm and adopted in this study which used transformation done on the Pol service reference,through a period of about 20 days from 27/4/2022 to 4/5/2022.

Date: October 2023

[22] 2.4.3. Level device.

The data which was collected by many sectors of the Water Resources Ministry has a significant lack of data on all of the right banks of the Al Butera River. Through a period of about 20 days from 27/4/2022 to 5/6/2022.

[23] 2.4.4. The discharge measurement M9 device.

Some of the Al Butera cross-sections River were checked by an M9 device such as the cross sections near, Al-Salam Bridge (C.S 15), Al- Haddam, and Al- Maimuna Bridge (C.S 18). As well as the cross-sections of Al Khummus River and Al Butera River, for Investigations were carried out in the fieldwork through the period of about 7 days from 14/4/2022 to 5/6/2022 as presented in table 4.

Table 4. Al Butera and Al Khummus cross-sections were checked and investigated during the period 14/4 to 5/6/2022.

River name **C.S**	Number of C.S for investigation or check								Date
AlKhummus (created**)**	0.1	0.2	0.3	0.4	0.5	0.55	0.6	0.7	14-16/4/2022
Al Butera (check)	15	18							14/4 5/6/022

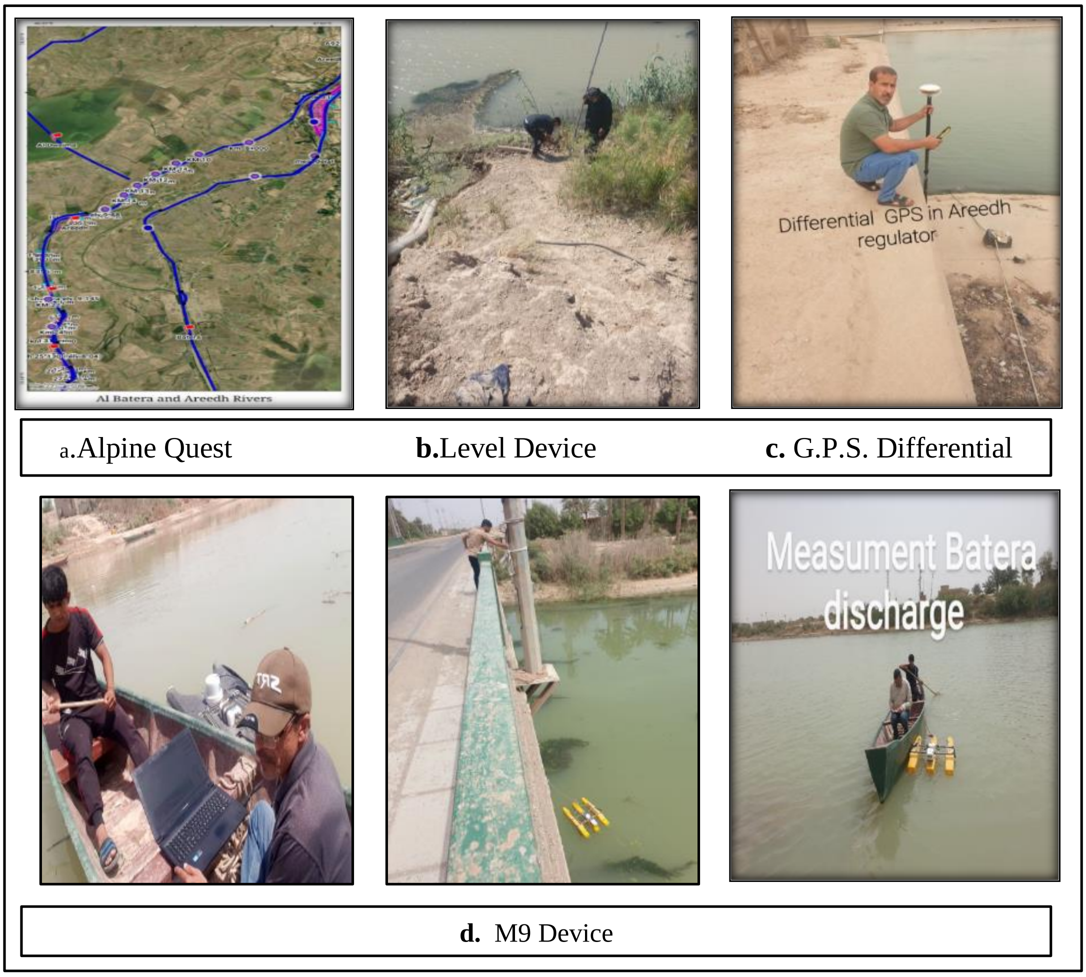

Figure 3. The devices and the fieldwork within the Butera River

2.5 Implementation of a one-dimensional hydraulic model.

A one-dimensional steady-state gradually varying flow of the study area was implemented with various situations using the HEC-RAS 5.0.7 Software. The software provided by the Army Corps of Engineers of the United States is utilized to study the river system.

Date: October 2023

[24] 2.5.1. River System Flow Diagram,

Collecting the cross-sections and hydrological data of Al Butera River then checking the data and modeling a hydraulic one-dimensional model to model the flow by the calibration and verification to find the proper Manning's coefficient. Then the discharge capacity and development of the discharge capacity for the short and long term will be found. Between the downstream of the Al Butera regulator to station 48+800 km

[25] 2.5.2. Boundary conditions,

The discharge downstream of the AL Butera regulator is a boundary condition that exists upstream while the downstream boundary condition is the water level upstream of the Al Khummus regulator which is presented by the regulator rating curve. shown in Fig 4.

[26] 2.5.3. Data of Hydraulic Structure in the River System.

Al Khummus head Regulator is input as inline structure data in the window of HEC- RAS.

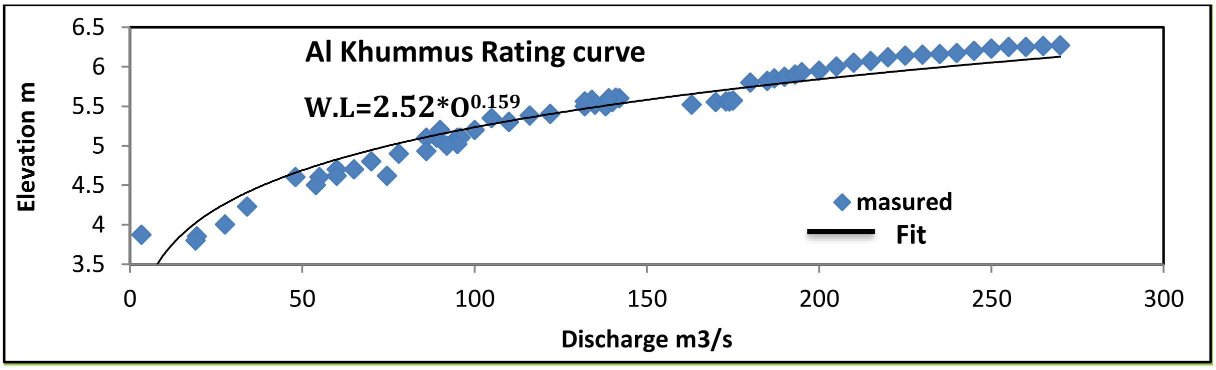

Figure 4. The rating curve at the upstream of Khummus Regulator, Directorate of Projects of Maysan Marshes and Wetland in 2022.

3. Results and Discussion

50. The outcomes and analysis of the HEC-RAS ' simulation of the examined reach of the Al Butera flow capacity. The analysis takes into account the existing conditions and any necessary modifications as determined by the strategic research before the calibration and verification of Manning's n of the rivers are presented.

[27] 3.1. Calibration and Verification.

Manning's coefficient (*n)* can vary along the river depending on the condition of the channel and flood plain.

These conditions are surface roughness, vegetation, stage and discharge, and channel irregularity. Te. Chow,1959, calibration is required to get the right values for the Manning coefficient to evaluate and contrast the computed observed water surfaces, the Root Mean Square Error, (RMSE), was used in an equation. RMSE= ($\sqrt[2]{\frac{\sum_i^N (Si-Oi)^2}{N}}$ … (1) Where:

N= the number of data Si = Simulated water surface elevation, *m* And Oi = observed water surface elevation, *m.* The range of these examined values varies between 0.020 and 0.028 and increased at the step of 0.002, many recorded discharges between 93 to 192m^3/s were used in the analysis in Al Butera River. The water level elevation was obtained with different values of Manning's coefficient (n) the result calibration is presented in Figure 5 and Table 5

Date: October 2023

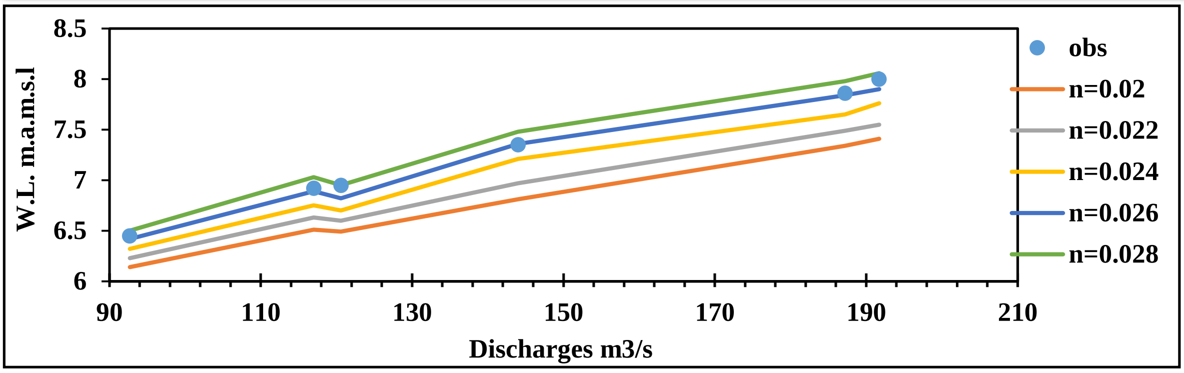

Figure 5.The calibration of Al Butera River under different Manning's coefficients and discharges

Table 5. Comparison between the observed and simulated water levels for different Manning's coefficients and different discharges in Al Butera River.

		Water level *m.a.m.s.l.*				
Q ***m³/s***	Observed	Simulated with Mannings coefficient				
		0.02	0.022	0.024	**0.026**	0.028
93	6.45	6.14	6.23	6.32	**6.42**	6.50
117	6.92	6.51	6.63	6.75	**6.89**	7.03
121	6.95	6.49	6.60	6.70	**6.82**	6.95
144	7.35	6.81	6.97	7.21	**7.36**	7.48
187	7.86	7.34	7.49	7.65	**7.84**	7.98
192	8.00	7.41	7.55	7.76	**7.90**	8.06
RMSE		0.48	0.35	0.20	**0.07**	0.09
Mannings coefficient((n)					**0.026**	

The verification of the observed and simulated discharges profile of Al Butera River with the upstream discharge of 44 m^3/s is presented in Table 6. It is clear, that there is a very good agreement between the observed and simulated water levels with the Root Mean Square Error is 0.012

Table 6. Verification along Al Butera River with n=0.026 at the discharge of 44 m 3/s

Station ***km***	**Discharge,** ***m³/s***	**Water level,*m.a.m.s.l.***	
		Observed	**Simulated**
1+250	50.00	5.60	5.61
1+500	50.00	5.60	5.61
1+750	50,.00	5.59	5.61
2+150	49.50	5.59	5.61
2+250	49.50	5.59	5.60
2+500	49.50	5.58	5.59
5+000	46.00	5.48	5.47
9+250	43.00	5.34	5.33
9+936	42.00	5.33	5.31
25+000	31.00	4.97	4.96
RMSE		0.01	

[28] 3.2. The current capacity of the Al Butera River.

The Al Butera River and branches located along the reach serve as the irrigation system and feed marshes.

3.2.1. Case One with flood escapes into the Central Marshes.

Different discharges downstream of the head regulator of the Al Butera River are used in the range of 80 to 190 m^3/s. The maximum current capacity is 170 m3/s as shown in Figure 6.

Date: October 2023

[29] 3.2.2. Case Two without flood escapes into the Central Marshes.
According to current river conditions, the maximum current capacity is 130 m^3/s, as shown in Figure

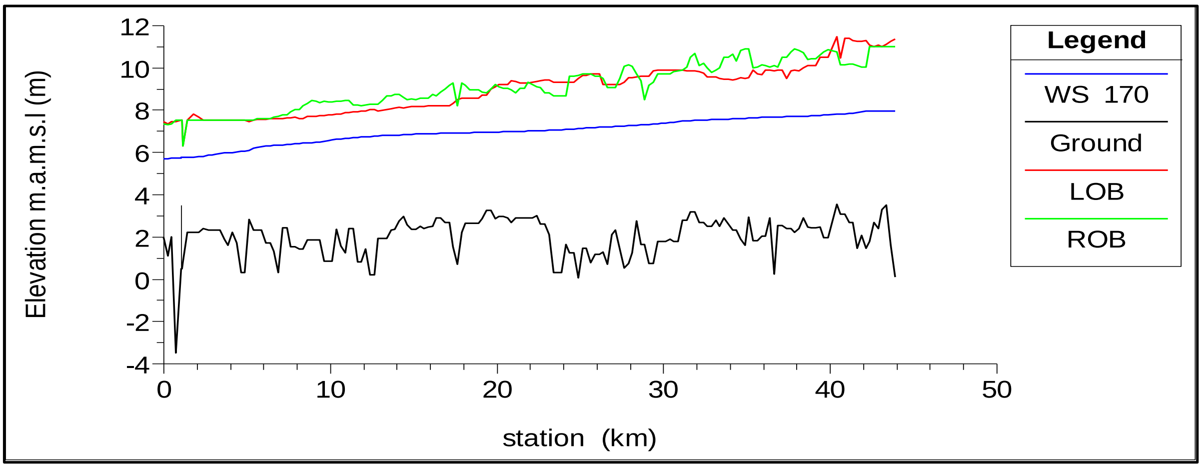

Figure 6. Water level verification along Al Butera River under the current condition for the maximum possible discharge of 170 m^3/s with flood escape.

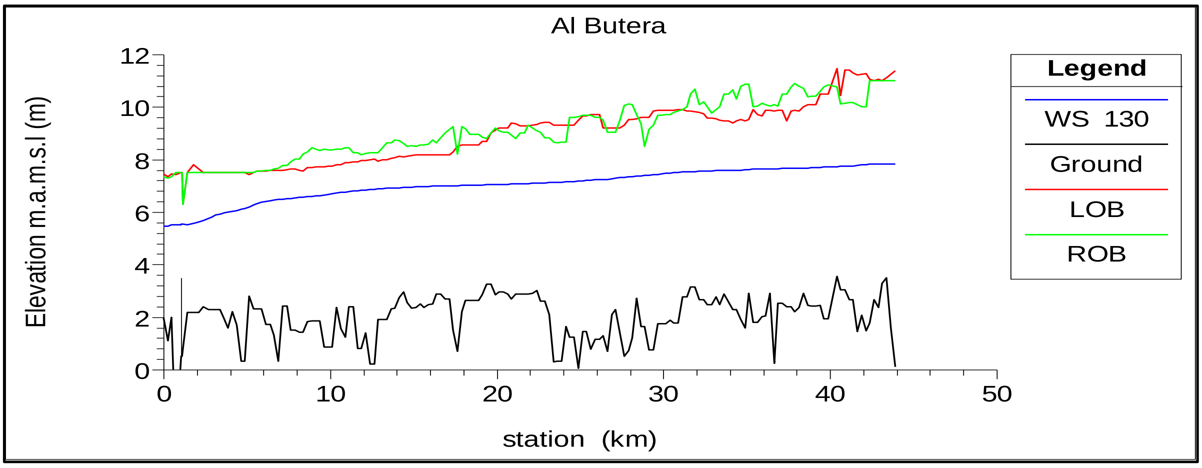

Figure 7. Water level verification along Al Butera River under the current condition for the maximum possible discharge of 130 m^3/s without flood escape.

[30] 3.3. Development of the discharge capacity of the Al Butera River.
To increase the current discharge capacity of Al Butera River, the maintenance of the river banks and (or) modifying the cross-sections are needed. The locations of the cross sections that need developments are presented in Tables 7 and 8.

Table 7. Islands and narrow cross-sections in Al Butera River

Station *km*	**Type of problem**	**Number of C.S**	**Remark**
2+250 to 12+750	islands	42	Difficult to be removed
31+250	islands	1	Modification
25+000 to 44+500	Narrow	75	Modification

Date: October 2023

Table 8. Development of the discharge capacity of Al Butera River for short and long term

Development	Modification Station	No of C.S.	LOB Station maintenance	ROB Station maintenance	Bed Width m or Remark	Q m^3/s	Raising of the bank,cm
Short-term	-		26+750 to 41+500	37+700 to 41+500	with consumption	230	30
			25+00 to 42+500	28+750 to 42+750		300	30 to 80
			25+500 to 41+750	37+000 to 41+750	without consumption	200	45
			25+000 to 42+000	31+000 to 42+000		225	60
Long-term	25+000 to 44+500	75			100	275	
			9+250 to 11+500	14+750 to 15+000. 19+750 to 20+500		400	25
			25+500 to 43+200	32+000 to 43+200			55

[31] 3.3.1. Short-term development of Al Butera River.

The level of banks in many sections is increased between 30 to 80 cm for the maximum discharge of 300 m^3/s and with flood escapes**.** While the level of banks in many sections will be raised with no more than 60 cm in height, for the maximum discharge of 225 m^3/s and without flood escapes

[32] 3.3.2. Long-term development of Al Butera River.

The modification is needed in 75 cross-sections in different locations along the river. The capacity of the river will increase to 275 m^3/s. The modification of 75 cross sections and raising the levels of banks between 25 to 55 cm. This action will increase the discharge capacity of Al Butera River to 400 m^3/s as shown in Figure 8.

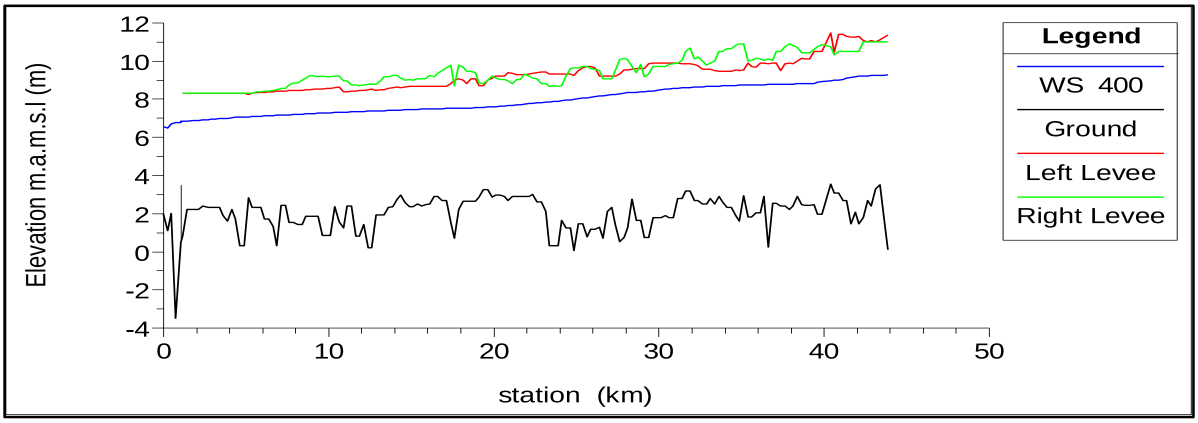

Figure 8. The water surface profile along the Al Butera River with a maximum discharge of 400 m^3/s in case of long-term development and without flood escapes

4. Conclusion

According to the results of the simulation for the Al Butera River with the existing and developing situation conclusions are listed below: Using the available field measurements data and the simulation of Al Butera River using HEC-RAS software, the calibration and verification revealed that Manning's n coefficient is 0.026. Under the current conditions, the result of the simulation gives that the maximum allowable discharge in the Al Butera River is 170 m^3/s. The short-term development by raising the bank levels will increase the discharge in the river to 300 m^3/s. But in the case of long-term development and with the modification of many cross-sections and the maintenance of the bank will increase the discharge to 400 m^3/s. To develop the river to carry the design discharge of 700 m^3/s, the required modification in the cross section and raising the left and right banks by about 2 *m*., and this is not practical, due to the presence of pavements and populated area.

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Water Balance for the Euphrates Aquifer, South of Haditha District, Al-Anbar Governorate

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Abstract. Groundwater balance calculation was carried for the Euphrates aquifer extended in the southern parts of Haditha district within Al-Anbar Governorate, where the Euphrates aquifer in this area is considered as unconfined with a flow direction towards the Euphrates River. The yearly recharge quantity for the Western Desert catchment-basin (1664.19 $\times 10^6$ m^3/year); whilst the ground-water quantity that intervenes study area (1155926.53 m^3/ year), as regenerated storativity. The quantity of consumed ground-water in the area through the present study (423567.36 m^3/year) for both industrial and domestic uses. Therefore, the quantity of the ground-water storage change (ΔS) you will be (732359.17 m^3/year). It is obviously that there is an increase in the continual storativity and the regenerated storage is sufficient to cover the water requirement.

1. Introduction

Water balance is an important tool in hydrological and hydrogeological studies because it is a flexible method that deals with its factors. Water balance or water budget indicates the mass balance in water input and output for a system over a certain period. The general expression describing the water balance of a watertight catchment over a given period means that water balance is quantitative term used to characterize the balance between the renewable water quantity and the consuming water to one discharge besin, meaning that it must preserve the water amount of the input and the output discharge basin [1].

The water balance in arid areas can be based on the relationship between rainfall and evapotranspiration. The precipitation is regarded as the major source in evaluation of water balance in the desert areas that lead to recharge of aquifers from these waters, and the precipitation that represents a part of the natural hydrological cycle and its importance, especially in desert areas [1]. Study area located in the north portion of the Western Desert of Iraq; It is lies about 158 km Western of Al- Ramadi city between longitude (42º 16′ - 42º 25′) E and latitude (34º 1′ - 34º 6′) N, where it covers an area of about (150 km^2) (figure 1). Several geological, hydrological, hydrogeological, hydrochemical, and geochemical studies has been done in this area [2,3.4.5]. Some studies used other methods to calculate the water budget, including: [6] analyzing the climatic parameters, [7] Lerner's methods, and [8] used the SWAT model to know the hydrological condition.

The studied area is considered as one of the most known areas in Al- Anbar Governorate, possessing different economic activities such as industrial, agriculture and livestock breeding for pastoral purposes. The studied area is considered a promising region for extraction of primary building materials such as gravel, sand and gypsum. The groundwater is mainly used for industrial purposes because of the existence of several factories for the production of washed sand and gravel, in addition to the agricultural activities where there are many farms which are supplied by groundwater from drilled wells in the area. The aim of this study is to calculate the groundwater balance in the Euphrates aquifer.

Date: October 2023

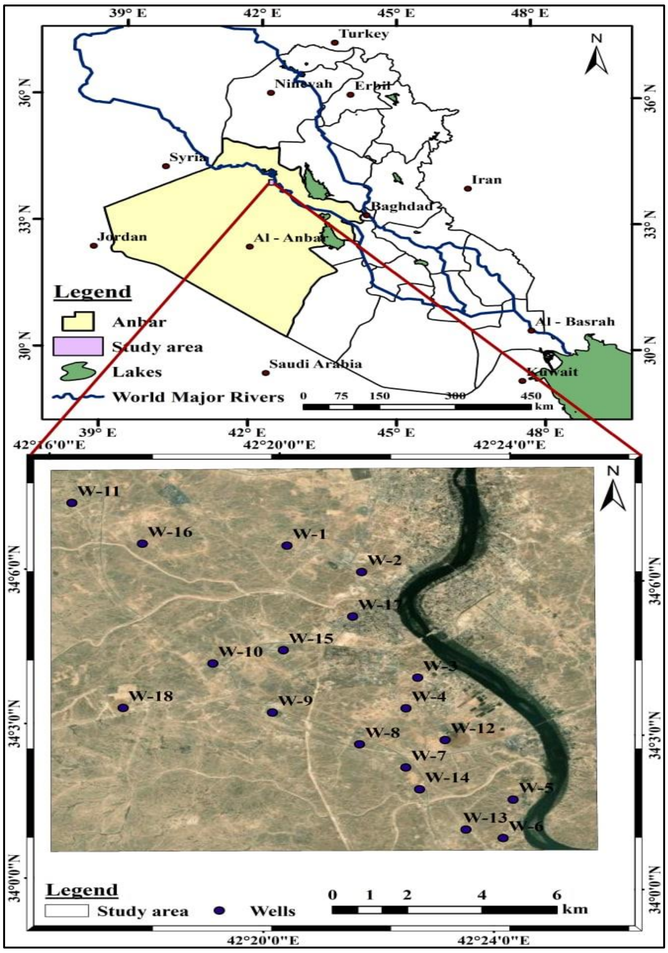

Figure. 1. Location of the study area

2. Materials and Methods

The inventory of wells was achieved in October 2022 through the reconnaissance field tours, where it includes wells in the villages, factories and farms. For each well, the discharge rate and the hours of discharging water were measured, to account the quantity of ground-water consumption of the aquifer.

3. Results and Discussion

Considering the change within surplus and deficit that represent the change in groundwater storage ($\pm\Delta S$) as the difference between input subsurface flow and output subsurface flow [9] the equation of water balance can be expressed as:

$\pm\Delta S$ = Input– Output -------------------------------- (1).

i.e.

$\pm\Delta S = Q_{in} - Q_{out}$

Where: -

$\pm\Delta S$ = Change in groundwater storage "increase or decrease", in m^3 /year,

Q_{in} = subsurface inflow, in m^3 /year, and

Q_{out} = subsurface outflow, in m^3 /year.

In the case of unbalance, the change in decrease or increase represents the change in surface and groundwater storage ($\pm\Delta S$).

Date: October 2023

Input of subsurface inflow (Q_{in})

The annual recharge amount for the basin (Q_{in}) is calculated by using the yearly recharge amount from the value of precipitation on the Euphrates Formation outcrops. Since the rocks are exposed with no soil cover, soil moisture value can be neglected and considered zero.

The previous studies indicated that the rates of surface runoff (SR) in the western desert do not exceed 5% of the yearly rainfall (P) in each [2,3,10]. Limits (SR %) at only 5% of rainfall may find its way to recharge the groundwater, assuming SR= 5% (i.e.5.4mm) from rainfall, where the water surplus (WS): WS = 52.9mm according to equation (2) [11] as follows:

WS = SR+GR -------------------------(2)

52.9= 5.4+GR

GR = 47.5 mm

Amount of the recharge at basin (Area (A) = 150 km^2), the amount of (Qin) to the whole basin is:

$Q_{.in}$ = A × GR ------------------------------------- (3). [12]

$= 150 \times 10^6 \times 47.5 \times 10^{-3}$

$= 71 \times 10^5$ m^3 / year.

Subsurface inflow value in the studied area, can be determined through (Darcy's) equation [13] [12], as follows:

Q = T×I×L -- (4).

Where:

Q: discharge (Inflow or Outflow) in m^3 /day;

T: transmissivity, in m^2 /day;

I: hydraulic gradient, in (dimensionless); and

L_w: width of the flow front in the studied area, in (meter).

The depth and static water level for six selected wells were measured (Table 1). Pumping test was carried out on the six wells using six observation wells for monitoring and recording water drawdown (Figures 2 and 3).

Table 1: Pumping wells data in the study area

Well no.	Longitude	Latitude	Depth of well (m)	Elevation (m a.s.l.)	Depth of water (m)	S.W.L* (m a.s.l.)
W1	E 42˚20' 11"	N 34˚ 06' 33"	80	137	55	82
W3	E 42˚22' 32"	N 34˚ 04' 02"	100	125	79	46
W5	E 42˚24' 16"	N 34˚ 01' 42"	55	111	31	80
W9	E 42˚20' 02"	N 34˚ 03' 18"	95	154	65	89
W14	E 42˚22' 38"	N 34˚ 01' 52"	65	133	21	112
W16	E 42˚17' 40"	N 34˚ 06' 32"	100	162	56	106

* S.W.L = static water level

Date: October 2023

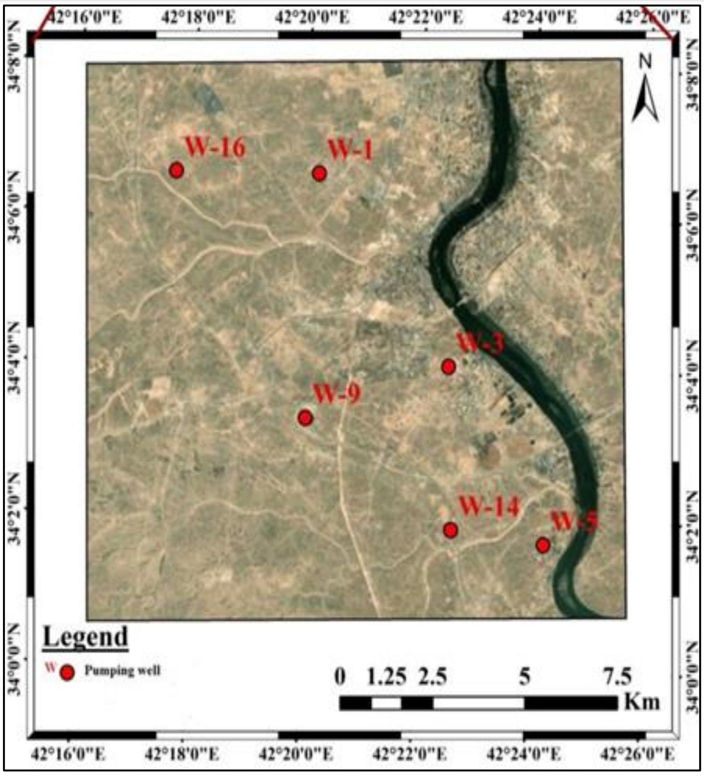

Figure. 2. Selected wells for pumping test

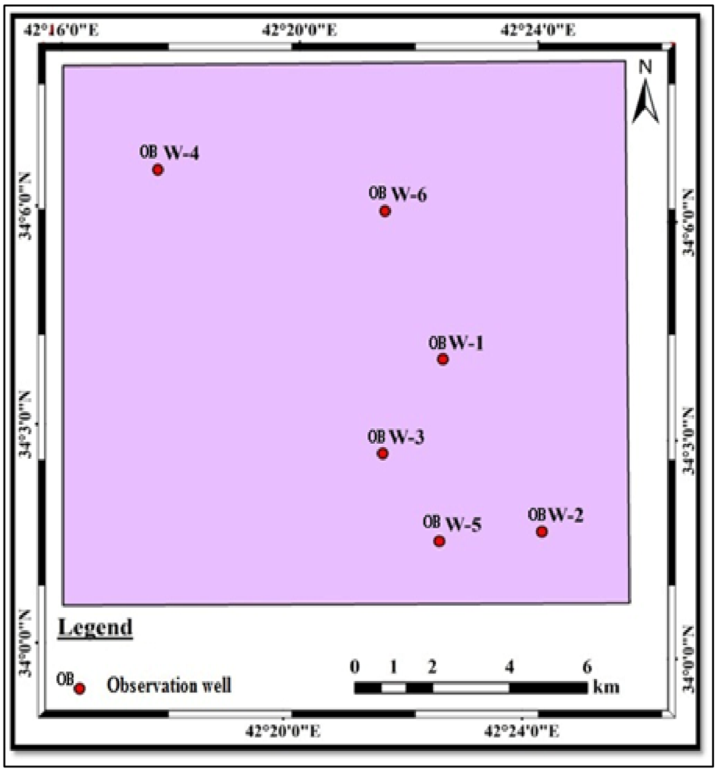

Figure. 3. Location of observation wells

The pumping test data analysis showed that the average of transmissivity value is (35.11 m^2 /day) and the average hydraulic gradient (I) is (0.0022) (Table 2).

Date: October 2023

Table 2 The results of pumping and recovery test analysis.

Well	Pumping Test T (m^2/day)	Pumping Test K (m/day)	Recovery Test T (m^2/day)	Recovery Test K (m/day)	T (m^2/day) Av.	K (m/day) Av.	Sy	Sc (m^2/day)
W1	43.65	1.68	43.65	1.68	43.65	1.68	2.06227	116.75
W3	16.48	0.50	11.30	0.34	13.89	0.42	0.07416	30.85
W5	30.14	1.12	26.37	0.98	28.25	1.05	0.47088	59.07
W9	79.11	3.16	73.83	2.95	76.47	3.05	0.26106	120.96
W14	31.64	1.09	21.57	0.74	26.60	0.91	0.69529	64.85
W16	27.19	0.91	16.42	0.55	21.80	0.73	0.09051	43.2

From the flow net map (figure 4), the width of the front inflow was determined by using geographic information system technique, and it was equal (25 km). Through the equation (4), the discharge quantity (Q_1) that flows during (365) days are:

$Q_1 = 35.11 \times 0.0022 \times 25000 \times 365$

$Q_1 = 704833.25\ m^3$ /year.

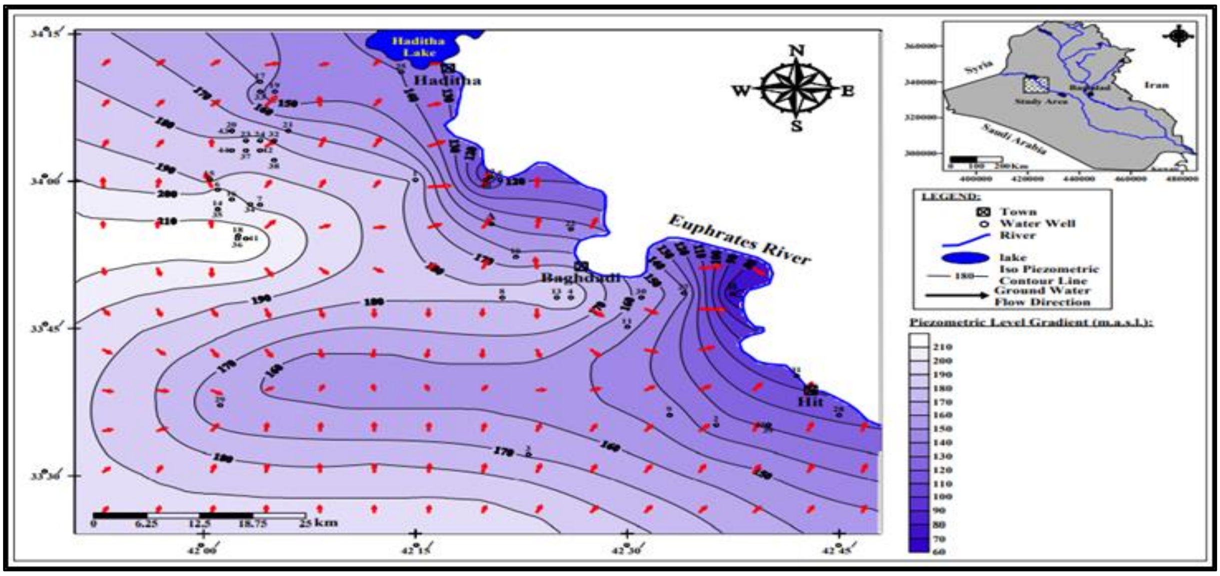

Figure. 4. Groundwater flow direction in the study Area [14].

Of the flow net map too (figure 4), the length of the inflow front for the studied area was determined by using (GIS) technique; it was equal (16 km). And according to the equation (4) the discharge quantity (Q_2) that flows along the study area through (365) days:

$Q_2 = 35.11 \times 0.0022 \times 16000 \times 365$

$Q_2 = 451093.28\ m^3$ /year.

So, the total inflow water (Q_{in}. Total) into the study area is equal to:

Q_{in}. Total = $Q_1 + Q_2$ ----------------------------- (5).

= 1155926.53 m^3 / year.

Output discharge (Q_{out})

The output discharge (Qout) indicates the total of groundwater consuming at the study area. The quantity of consumed groundwater to different purposes could be determined as follows:

3.2.1 A- Groundwater Consumption for Industrial Purposes

The study area is fundamentally distinguished by industrial activities due to the geological nature distinguished. Several quarries and mines of sand and gravels existed in the area. Through the field

Date: October 2023

survey, it was found approximately (5) extracting units and washing sand and fractionalizing gravels, all of these depend on groundwater in their work. After an inquiry from the proprietors of these extracting unit, this was evident that the wells work with an average of (3) hours per day. This means that the average working days for each well is (45.6) days a year with an average ground_water discharge of (518.4 m^3 / day) i.e. (6 L/ S.). There are too (4) manufactories for producing building blocks which are using ground_water at a rate of (3) hours per day with average working days for each well is (45.6) days a year and average yields (6 L/ S.) nearly about (518.4 m^3 / day).

Through the above information and data, the mean of ground_water consumed to industrial purposes can be calculated as follows:

1. Ground_water consumption via (5) extracting units of washing sand and fractionalizing gravels.

$G.W.C.I_1 = E_{.no1} \times Q \times T$ ------------------------ (6). [12]

Where:

$G.W.C.I_1$: Groundwater Consumption for Industries (m^3 / year).

$E._{no1}$: Number of quarries of gravel and sand "dimensionless".

Q: Discharge of wells (m^3 /day).

T: Time (in, day).

$G.W.C.I_1 = 5 \times 518.4 \times 45.6 = 118195.2$ m^3 /year.

2- Ground water consumption through (4) manufactories for production of building blocks.

$G.W.C.I_2 = F_{.no2} \times Q \times T$

$G.W.C.I_2 = 4 \times 518.4 \times 45.6 = 94556.16$ m^3 /year.

The total consumed of ground-water by industrial manufactories is:

$G.W..CI_{Total} = G.W.C.I_1 + G.W.C.I_2$ [12]

$G.W.C.I_{Total} = 212751.36$ m^3 /year.

3.2.2 B- Groundwater Consumption for domestic uses

There are two famous villages located in the study area (AL-Al-khafajia village, and Alus village), and there are a few scattered nomadism homes, however they do not have wells, where get water by their tankers of the Owners of farms and factories. Therefore, these are not used in calculating the consumption of groundwater. The two villages have a population of about (4000) persons. The people of these villages used groundwater for their everyday activities except for drinking. Based on field observations, where are (11) wells at these villages divided as follows:

1. Al-khafajia village has seven wells, however they count on tap water fundamentally, (but this tap water is not available at all time), this village has about (2500) persons, they use groundwater for their life activities (cleaning and washing in addendum to their animals) especially while a deficiency in tap water occurs. Moreover, there is a school which uses ground water to washing purposes. These wells work with an average of (20) days per month with about (4) hours/day. And this means that the average working days for the well is (40) days a year with an average discharge of (7 L/sec) i.e. (604.8 m^3 /day). So, the mean consumption of ground water to this village can be determined as follows:

$G.W.C._{v.1} = W_{.no} \times Q \times T$ [12]

Where:

$G.W.C._{v.1}$: Ground water Consumption to village no.1 (m^3 /year).

$G.W.C._{v.1} = 7 \times 604.8 \times 40 = 169344$ m^3 /year.

Date: October 2023

2. Alus village has four wells, but they rely on tap water essentially, that village has about (1500) persons, where use ground water for their life activities (cleaning, washing and their animals) especially when a shortage in tap water occurs. In addition, there is the school which utilizes ground-water to cleaning purposes. The wells work with a mean of (10) days per month with about (4) hours/day. And it means that the average working days for the well is (20) days a year with an average discharge of (6 L/sec) i.e. (518.4 m^3 /day). For that, average consumption of ground-water for this village can be calculated as follows:

$G.W.C._{v.2} = W_{.no} \times Q \times T$

Where:

$G.W.C._{v.2}$: Ground water Consumption for village no.2 (m^3 /year).

$GWC_{v.2} = 4 \times 518.4 \times 20 = 41472$ m^3 /year

The total consumed of ground water by domestic uses in the study area can be determined as follows:

$G.W.C._{v.\ Total} = G.W.C._{v.1} + G.W.C._{v.2} = 210816$ m^3 /year.

So, the nearly of whole the consumed ground water during the present study is:

$T.G.W.C = G.W.C.I_{Total} + G.W.C._{v.\ Total}$ [12]

Where:

T.G.W.C: Total ground water consumption (m^3 /year).

T.G.W.C = 423567.36 m^3 /year.

The variation between the quantity of "input discharge" ($Q_{in.\ Total}$) at the study area and the quantity of consumed ground-water of it (Q_{out}) could be determined according to equations (1) as follows:

$\pm\Delta S = Q_{in.\ Total} - Q_{out.\ Total}$

$\pm\Delta S = (1155926.53 - 423567.36)$

$\pm\Delta S = 732359.17$ m^3 /year.

These values represent the value of changing in storability only in the study area. Here the positive sign refers to the state of surplus in the renewable storability for the consumption in the study area. When dividing this value over the study area to the area of 150 km^2, the average annual drawdown in the underground level will be 0.048 m.

From the equation below, the volume of water drained from an aquifer (i.e. perennial yield) for the study area was calculated, in which could help to know the extent of the changing in constant storability as a result of water consumption for different purposes. The volume of water drained from an aquifer (V_W) may be expressed as:

$V_w = S_y \times A \times \Delta h$ -------------------------------- (7) [11] [13].

Where

A: the horizontal area for an aquifer in (m^2), and

Δh: is an average to the decline in head in (m) (i.e. Average increase or decrease in water table).

$V_w = 0.025 \times 150 \times 10^6 \times 0.42$

$= 1575000$ m^3

The annual drawdown values for this area are within the suggested limits. This shows that the drawdown amount in the Euphrates aquifer is little and had no effect on the general and constant storability for this aquifer. Through pumping test that were carried out on some selected wells in the study area, the recovery showed a fast recurrence of water level that a steady state was reached in short time after pump shut down. This gives evidence that the unconfined layer in the Euphrates aquifer is still good.

4. Conclusion

Through the water balance, ground water that entering the study region is (1155926.53 m^3 / year), as regenerated storage. The quantity of consumed groundwater at the region through the study is (423567.36m^3/year). So, the quantity of change in the water storage (±ΔS) you will be (732359.17 m^3/year). It is apparent that there is an increase in the continual storativity and the regenerated storage is enough to cover the water need. So, the existing water balance showed a good mark on ground_water consumption in the study area which considered as the major source of water for different uses.

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Water management of agricultural lands in Diyala Governorate

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Abstract: The existence of a large water deficit in Diyala Governorate, especially in July and August of the year 2020-2021 AD, and the reasons are due to the natural factors to which Iraq in general and the study area in particular were exposed, such as thermal inclusion and lack of precipitation, and human factors that are specific to the water policies of neighboring countries and events After 2003, a number of factors and field manifestations also combined to complicate the picture of the water deficit in the study area, represented in the pollution and lack of purification of waterways and the disruption of many water barriers and lifting stations. It was found from the results of analyzes of river water samples The drains have a quality within the second category (C 2). As for the drainage water, it was shown that it has a salinity of (2215-2230) micromoz / cm, and it falls within the third category (C3) and it is of high salinity. This water is used only in the presence of an effective drainage network and for crops High tolerance to salinity.

1. Introduction

Water resources are very important natural resources in sustaining human life as the natural environment on which agriculture is based, which contains nutrients necessary for the growth of plants whose quantity and quality are affected by the physical and chemical properties of water resources. The natural and human factors have an impact on the diversity of the physical and chemical characteristics of the water resources in the study area, and the importance of these factors in changing the surrounding environmental conditions. The hypothesis of current study are Natural factors have an impact on determining or diversifying the physical and chemical properties of water resources and Temporal and spatial variability of the physical properties impact of the distribution of water resources. Water resources are considered a major source of natural wealth, and there is no substitute for producing what man needs of food and many other necessary materials. It is not surprising that countries are striving to reclaim and preserve their water resources in order to meet their needs and support the foundations of their security. the aims of current study is The study aims to reach several objectives, the most important of which are Knowing the impact of natural and human geographical factors on the formation of water resources in the study area and analyzing the variation in their physical characteristics and their reflection on agricultural lands on the one hand and agricultural production on the other hand.

2. Materials and methods

2.1.Location of the study area

Diyala governorate is located in the center of Iraq, which is 60 km from the capital, Baghdad, from its northeastern side. The governorate borders Kirkuk governorate on the north, Wasit governorate on the south, Baghdad on the southwest, Salah al-Din on the west, and the international border with Iran to the east. It has two latitudes (33.50)5 and (33.40) 5 North and between longitudes (44.40) 5 and (44.30) 5 East, Figure (1). The area of Iraq, given that the area of Iraq the total area is (434920) km2.

Date: October 2023

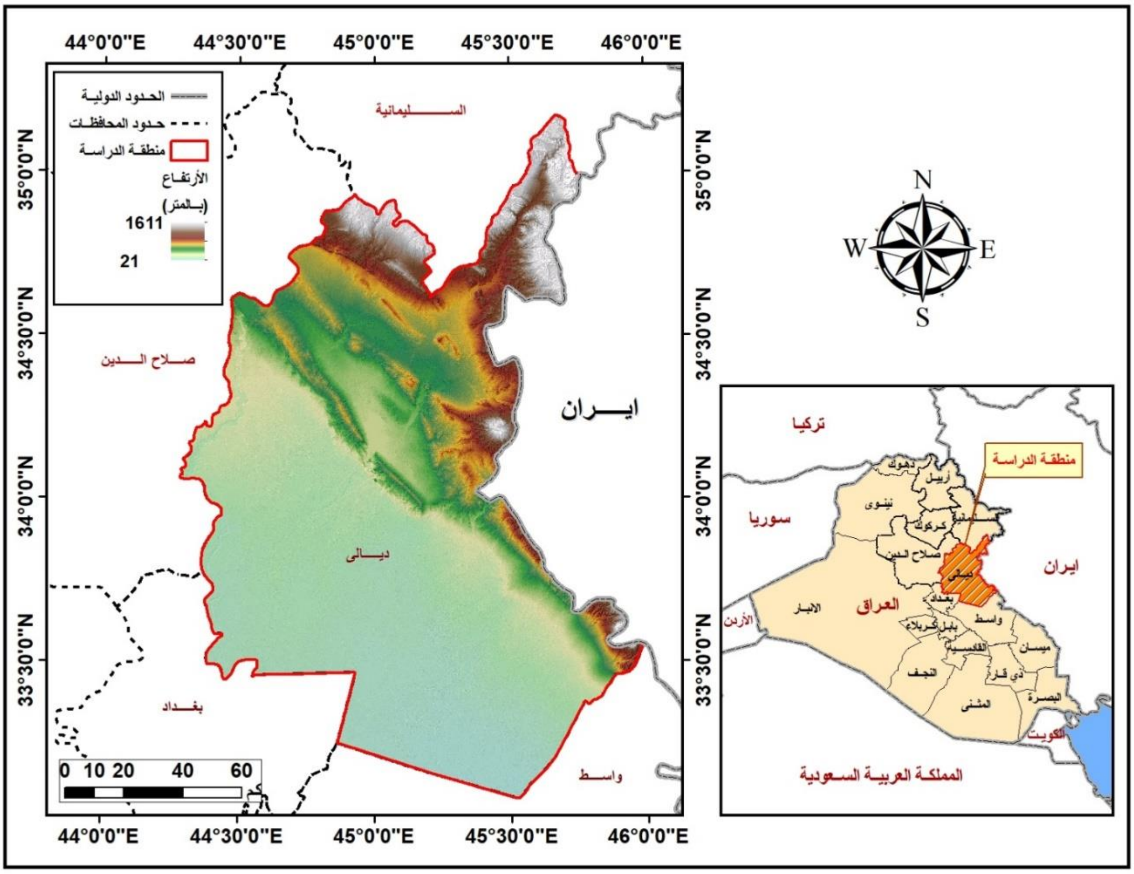

Figure 1. Map of Diyala Governorate for Iraq [1]

2.2.Study methodology

The study followed the analytical and descriptive research approach, by strengthening it with the results of laboratory analysis, geographic information systems, and the use of office and field work in extracting facts to reveal the relationship between geographical phenomena.

2.2.1. Irrigation:

It is the science that is concerned with supplying agricultural areas with water needed for agricultural uses in a carefully calculated manner based on climate, topography, and soil nature. And supplying the soil with water maintains the moisture content necessary for plant growth. Water shortage has a direct impact on the quantity and quality of agricultural production as a result of its impact on the productive capacity of the soil.

2.2.2. Irrigation network:

The study area depends mainly on supplying its various crops with their irrigation needs, on a network of rivers of varying degrees, including major and secondary rivers, the amount of water of which varies according to their sources, Table (1). They are as follows:

Table 1. The most important sources of surface water in the study area [2]

the name of the river	Length within the governorate / km	The highest discharge m3/sec	Lowest discharge m3/sec	The discharge rate is m3/sec
Diyala	290	3600	25	45
The left of the Tigris River	88	7120	163	500
Alound	48	500	5	10
Al-Azim river	230	285	2	25

Date: October 2023

2.2.3. Diyala River:

The Diyala River originates from the mountains located near the village of Asadabad to the west of Al-Wand Mountain, heading towards Iraq. It is called the Karoda River, meaning the cow river. Most of the tributaries of the Diyala River are fed by rain and snow. The Diyala River consists of two tributaries, the first of which is the tributary (Sirwan), which represents the real sources of the Diyala River. This tributary originates from the Lorestan region in western Iran. As for the second tributary, it is the (Tangro) river that passes near the city of Sulaymaniyah, and the first tributary meets the second tributary at the front of the Darbandikhan Strait, and at that confluence the Diyala River is formed. [17] Photo (1), and its length from its source to its mouth in the Tigris River is 386 km. As for the area of its basin, it is (72,000 km2), of which (47,928 km) is inside Iranian territory and (24,072 km) is inside Iraqi territory . It has been described as the angry or mad river due to the rapid variation in the rise and fall of its levels and discharges, which is due to natural causes represented by the nature of the topography of the river basin, the prevailing climatic characteristics, the geological composition of the rocks, the type of soil, the density of vegetation, as well as the shortness of the area between the feeding and estuary areas. The Diyala River is bounded from the east by the Karun River basin, from the north and northwest by the Little Zab River basin, while from the west it is bounded by the Azim River basin, and from the south and southwest by the Tigris River.

Figure 2. Diyala River in Baquba District, the center of the study area Field study in 20 -9- 2021

Table (2) The annual revenue of the Diyala River from Lake Hamrin from (2001-2020) million/m^3 . [3]

water year	The annual revenue rate of the Diyala River is million / m3	water year	The annual revenue rate of the Diyala River is million / m3
2001	3891667	2013	8216667
2002	7891667	2014	5866667
2003	1425	2015	3791667
2004	1275	2016	14875
2005	1306667	2017	5491667
2006	107	2018	9708333
2007	775	2019	4000
3008	3338554	2020	3891667
2009	3341667	the total	45638011.00
2010	8183333		
2011	3591667		
2012	5725		
2001	3891667		

Where spread on both sides of the Diyala River, especially the left side of the river, orchards were forests of palm trees, citrus and fruits, and the river continues to flow within the district with a distance of (48 km) and a discharge capacity of 10 m / s, and its maximum discharge is (500 m3 / s). Discharge before the year (2003) may exceed 350 m3/sec during the flood season, and it began to decrease until it reached less than 10 m/sec at the end of 2020, and the discharge ceased during the months (July, August, September).

3. Results and Discussion

3.1. Left Tigris River:

The river marks the natural border of Diyala Governorate, with both Baghdad and Salah al-Din Governorates. The Tigris River irrigates the agricultural lands located on the left side of it, through major pumps on the river designed for this purpose, such as the pumping station (Al-Nay project - Al-Jizani - north of the majority - south of Al-Rashidiya), in addition to the pumping stations of the private sector. The length of the Tigris River in Diyala Governorate is 142 km. Its discharge rate is (500 m3/sec) [17].The water scarcity of the Tigris River has been observed in recent years and the low level of the river, especially in the parts that pass through the Diyala governorate, and this has affected the productive capacity of the soil and the production of agricultural crops in the western parts of the study area, especially in the west of the Khalis district in the villages of (Sindiya, Al-Saadiya, Al-Jizani, and Al-Dougma).).

3.2. Alwand River.

It is a river with a length of 150 km, and it originates from the Iranian highlands adjacent to Iraq at an altitude of (2000 meters). A dam called (Al-Wand Dam) was built on the Al-Wand River, southeast of the city of Khanaqin, 3 km away. Then it flows westward into the province of Kermanshah, where it passes through the cities (Qasr Shirin and the city of Helwan), then it enters Iraq at the city of Khanaqin to flow into the Diyala River, which in turn flows into the Tigris River, and it was called the Alvand River after the commander Alvand Mirza Oglu, who is one of the descendants of Sultan Hasan Qusun the Sultan (Hassan Tawil). And because of the ill-considered government policies of the eastern neighbor Iran, where a number of dams were built on the Alwand River, Tire (2), which causes water scarcity even for drinking water for humans and animals in the border district of Khanaqin from Iran, and in some season the water flow in the Alwand River is interrupted in the lands Iraq permanently, and this affects the annual production rate of agricultural crops in the study area because of the poor productive capacity of the soil, which it is exposed to from deterioration and salinization, and the farmer’s reluctance to farm. Rather, the situation has reached in many villages of the district (Khanaqin and Kafri) a clear population migration from the countryside to the city in particular After the events (2003).

Figure 3. Al-Wand Dam, which was built on the Al-Wand River Field study in 5 -2- 2021

3.3. Al-Azim river.

The Al-Azim River is one of the most important tributaries of the Tigris River, and it is the only river that flows inside Iraqi territory. The Al-Azim River basin is located between the lower Zab feeding basin and the Hamrin mountain range. The Great River is one of the seasonal rivers, as large amounts of rain water descend to it in the winter, laden with sediment, but its course becomes almost a ditch in the summer. The length of this tributary is (230 km), while the area of its basin reaches (11217 km2), its discharge rate is (22.83) cubic meters per second, and its annual water revenue rate is (0.71) billion cubic meters, and it contributes about (1.64%) of the total water of the Tigris River (Sarah, 2020 , p. 59). The Azim River is one of the rainy rivers because it depends mainly on rain for its feeding.

Date: October 2023

Therefore, this river may be seasonal in which water flows during the winter season only.) Map (2) Water resources in Diyala Governorate.

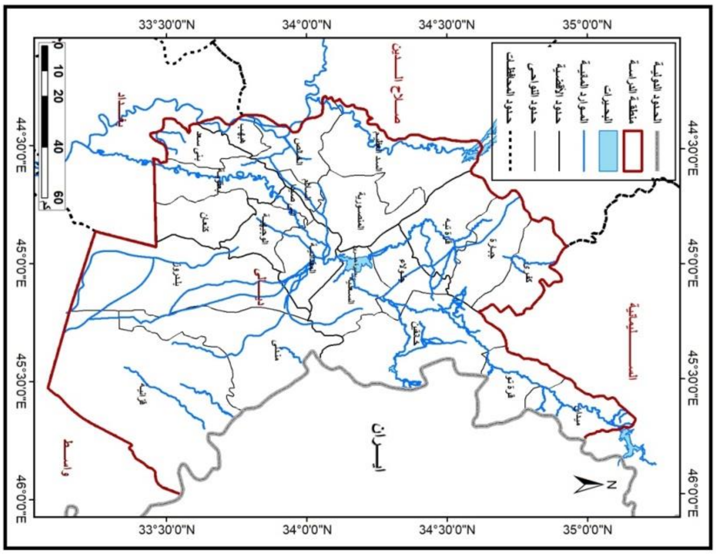

Figure 4. Map (2) Water resources in the study area [4]

3.4.The most important projects for controlling and storing water resources in the study area:

Hamrin Dam:

It is located on the Diyala River at the Hamrin Mountain Strait, 120 km northeast of Baghdad. It was established to secure the water needs of the lower Diyala projects, to generate electric power, and to prevent floods. Its height is (32 m) and the maximum storage level is (107.5) m. The design area is 104 m, the storage capacity is (3) billion cubic meters, and the lake area is 440 km2. Through the field study of Lake Hamrin, it was found that the lake has now become, on 3/5/2022, just a corridor, to cross the waters of the Diyala River coming from Darbandikhan, towards a regulator that divides the irrigation chests, north of Muqdadiya district, northeast of Baquba, the center of the study area. Photo (3) The lake constitutes the strategic storage of water in Diyala and feeds into 5 main rivers that secure the operation of liquefaction stations for more than a million people, especially with the severe drought that has been besieging it for many months, which led to an accelerated depletion movement. Its water, due to the lack of rain and torrential rains and the decline of the water flow of the Diyala River at unprecedented rates, and it is known that the scarcity of water at this large percentage in the study area will lead to a decrease in agricultural activities, a lack of production, and a lack of productive capacity, which may develop into an economic crisis, as The matter was not remedied by the central and local governments with political relations with the eastern neighbor, Iran, and northern Turkey. Where the Directorate of Water Resources confirmed (that there is no winter agricultural plan for the current season due to the lack of storage in Lake Hamrin, on which the Diyala Governorate depends for irrigation and drinking water).

Figure 5. Lake Hamrin, Al-Saadia district Field study in 3 -5- *2022*

Date: October 2023

3.5. Darbandikhan Dam:

It is located on the Diyala River within Sulaymaniyah Governorate, about 285 km north-east of Baghdad. The height of the dam is 128 m. The level of the top of the dam is 493.5 m. The normal storage rate is 3 billion cubic meters at a level of 485 m.), and the area of the lake (121 km2). The study area claimed river neighborhoods

3.6.Al-Azim

and the release of water in it to save Al-Azim district from the disasters of drought and the loss of life, because it is the only lake in which water reserves increased as a result of the rains that fell during the winter season of 2022.

The falling rains increased the waters of Lake Darbandikhan from (26 meters to 78 meters), picture (4) after great scarcity and drought (Directorate of Water Resources, Garmian, 2022). In Al-Azim sub-district within the study area, there are demands from the government and the people of the sub-district to re-launch the Al-Azim Dam towards Al-Azim River, the main artery of the district, after heavy amounts of rain fell and waves of torrential rain came towards the dam from the northern regions.

Figure 6. Darbandikhan Lake before the dam for the year 2022 Field study in *16 -5-* 202

Al-Azim Dam: An earthen dam built on the Al-Azim River, height (45.5m) and length (3800m). The amount of storage is (1.5) billion cubic meters. The total storage level is 131.5m and the highest level is 136.5m. The dam also suffers from a decrease in the water storage of the dam to about 20%. From its absorptive capacity, it was also found through the field study and personal interviews with the staff of the Al-Azim Dam, that the Directorate of Agriculture in Al-Azim district did not develop an agricultural plan for this year due to the lack of water storage, according to the directives of the Iraqi Ministry of Agriculture

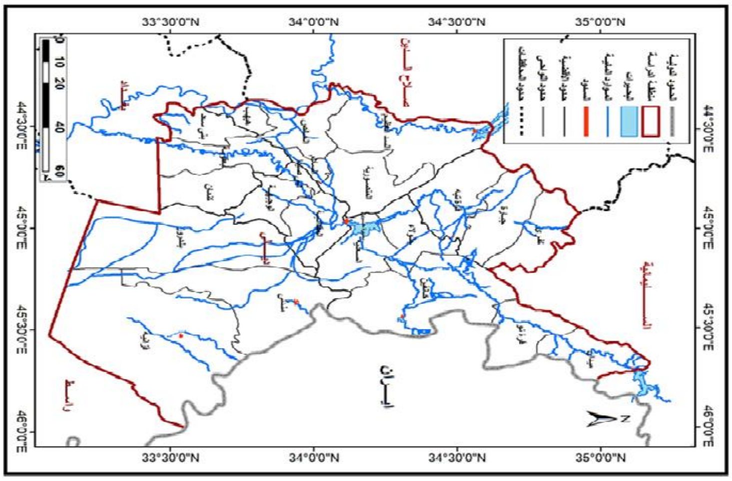

Figure 7 Map of control and storage projects in the study area [4]

Date: October 2023

3.7.The total water budget:

Irrigation, in general, aims to provide water to agricultural lands on a regular basis, and to deliver water to the root group and the soil that surrounds it, so that plant nutrients can be dissolved in soil water (irrigation water), to facilitate its transfer by the force of osmotic pressure to the group of the plant trophic system, where No movement of substances takes place within the plant, including growth processes, without the presence of water and there are several concepts that should be noted and the difference between them: Water consumption Transpiration ratio is the amount of water lost from the surfaces of plants and the land growing on them in addition to The amount of water withheld by the plant, usually expressed as the height of the water in inches or millimeters, and expressed in cubic meters per dunum. Water consumption differs from evaporation in that the latter does not include the amount of water retained by plant tissues, which does not exceed 1:2%. Of the water lost during the growing season, and the water consumption is useful in calculating the "rationed" water requirement, which is equal to the total water consumption plus losses of transportation, connection, use, and water leaking into the ground as well as The water used for any other operations related to the production of crops on the ground after studying the water needs of the study area and for the various agricultural, animal, domestic and industrial uses. The annual revenue of the river, noting that it is one of the important and vital issues to which economic and agricultural activity is linked, in both parts (plant and animal), rural settlement plans, and the needs of industrial factories.

The total water requirement for the study area is (5.108) billion m3 / year, when compared to the average annual revenue of the Hamrin Dam for the year (2018-2019), which amounts to (4) billion m3.

We conclude from the foregoing that there is a water deficit of about (1,108) million cubic meters, table (3) [17] noting that this was a rainy year. It rained heavily in the Diyala Basin inside and outside Iraq, which led to floods and torrential rains that caused great damage to agriculture. And the infrastructure of agricultural areas, and this means that there is mismanagement of water resources that requires finding modern and appropriate strategies to control water resources and prevent waste in them, such as building dams or reservoirs to preserve surplus water and benefit from it during the hunting seasons.

Table (3) Water Demand for Diyala province

kind of needs	The amount of needs billion / m3
agricultural	*2,929*
Livestock	*1,41*
household consumptions	*0,495*
industrial consumption	*0,074*
the total	*4,908*
waste by evaporation	*0,200*
total summation	*5,108*

Rescore: [5]

It is clear from the above table that the highest percentage of water need in the study area is the need for agriculture, which constitutes (929.2) billion cubic meters of the total water in the study area. Lack of agricultural production of all kinds of crops, fruit trees, or palm trees. It was also noted from the field study that pollution of river water with household waste and sewage, and the spread of aquatic plants and failure to control them are among the most common elements of water deficit problems in the study area. From the irrigation network in the study area, rivers of different degrees and locations were seen in the field, including rivers branching from the main Diyala River, which irrigate thousands of dunums of agricultural land, such as the Khalis River, the Khuraisan River and the Great River. Baquba is the center of the study area, and the water appears to be completely turbid

Date: October 2023

Figure 8 . Picture: (5) Pollutants on the Khuraisan River Field study in *6* -*6*- 202*1*

Figure 9. Natural vegetation pollutants on the Khalis River Field study in *6* -*6*- 202*1*

3.8. The water policies of the neighboring countries and their relationship to the productive capacity of the soil in the study area for the year 2021 AD

The study showed the impact of the people of Diyala Governorate on the governmental water policies of neighboring countries (Iran and Turkey), where Tehran changed the paths of a number of rivers to not deliver water to the border areas with Iraq, according to the (sky press) agency on November 28 of 2021 AD. The water coming from the rivers of Diyala and Alwand, which originates from Iran, provides 80% of the water needs of the people of the province. However, these water sources have now dried up or their water volume has shrunk by up to 70%. Photo (7) Diyala River in the summer of 2021. The water shortage crisis in Diyala prompted the Iraqi Ministry of Agriculture to stop its agricultural projects last summer, and it also decided to stop winter projects. The cessation of summer and winter agricultural projects will cause severe damage to about 20,000 farmers, while The water crisis and drought have already affected (32,784 dunums) in the province. The continuation of the drought problem that strikes Diyala province until next summer will face the threat of destruction to about 70% of the province's gardens and orchards, and a real disaster will occur. The repercussions of this crisis led to the emigration of more than (10,000) families from the villages of the province, where their lives depended mainly on agriculture, but they went to the cities in search of another profession to earn their livelihood. The amount of water coming from Iran to the Darbandikhan and Dukan dams was up to 45 cubic meters per second. While the quantity has decreased to 7 cubic meters since 2003, which witnessed Iran changing the course of the Karun River in favor of areas in Bahn Shahr, Iran. (Awn Dhiab, Advisor to the Iraqi Minister of Water Resources, 2021). The scarcity of water in the study area led to a significant and clear decrease in the quantity and quality of agricultural production, whether it was from grain and urban crops or fruit trees, due to the weakness of the productive capacity of the soil as a result of salinization and deterioration of agricultural lands. Before the events of 2003 and after the events to know the difference between the number of trees and productivity in tons and the extent of the impact of the events on that.

Date: October 2023

Figure 10. Diyala River in July 2021 AD Field study in *6* - *8*- 202*1*

Table 4. Number of trees and average production and productivity for the year 2002 by type in the study area [5]

Tree type	Number of fruit trees / 2002	Average yield kg/tree	production / ton
orange	*2008100*	*25.0*	*50203*
sour lemon	*123100*	*22.3*	*2745*
Sweet lemon	*71300*	*13.2*	*941*
pomegranate	*2685400*	*20.0*	*53708*
apple	*488100*	*18.7*	*9127*
the total	*5376000.000*	*99.20*	*117724.000*

Table 5. Number of trees and total production / ton and productivity / kg / tree for the year 2009 by type in the study area [6]

Tree type	Number of fruit trees / 2009	Average yield kg/tree	production / ton
orange	*1410161*	*8.8*	*12409*
sour lemon	*53409*	*3.6*	*192*
Sweet lemon	*14493*	*7.2*	*104*
pomegranate	*3461237*	*25.0*	*86531*
apple	*85341*	*19.9*	*1698*
the total	*5024641.000*	*64.500*	*100934.000*

Table 6. Total production / ton of agricultural crops for the years 2002 and 2009 in the study area [6]

agricultural crop	Production / tons in 2002	Production / tons in 2009	The difference between the two years
wheat	*135418*	*85582*	*49836.0000*
barley	*20648*	*9752*	*10896.0000*
yellow corn	*69055*	*4952*	*64103.0000*
cotton	*4004*	*46*	*3958.0000*
sophistication	*64320*	*31041*	*33279.0000*
the total	*293445.0000*	*131373.0000*	*162072.0000*

Date: October 2023

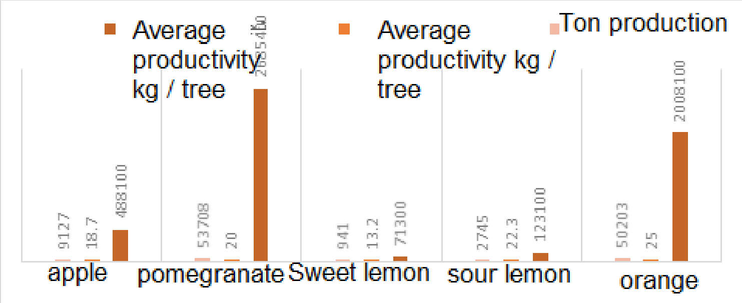

Figure 11. The number of trees and the average production and productivity for the year 2002 by type in the study area

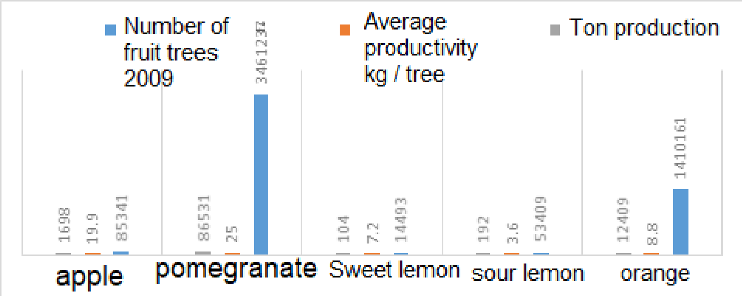

Figure 12. The number of trees and the average production and productivity for the year 2009 by type in the study area

3.9. Evaluation of the water quality of rivers and drains

The quality of irrigation water is one of the most important elements of the picture of the water situation in any agricultural environment, as the physical, chemical and biological characteristics of the water used in irrigation affect agricultural production in quantity and quality, and therefore it has an impact on the economic returns from the practice of agricultural activity, and it also has an impact on human health [7]. And the sustainability of the soil environment, and the concentration of salts in irrigation water is one of the most important determinants of its quality and suitability for use, as the high concentration of salts leads to their accumulation in the roots, which causes a loss in yield, which comes as a result of slow growth and manifestations of water stress, and plants often show symptoms similar to those of Dryness from wilting or dark bluish color of the leaves, and these symptoms vary according to the stages of growth, but they are more evident in the early stages of growth, and washing is the key to controlling the problem of salinity and its effects related to quality[8and presents the table (7) Some chemical properties of water samples from some rivers and drains in the study area, picture (8), there is a global classification according to the salinity laboratory, table (8).

Table 7. Classification of irrigation water in relation to salinity hazards, according to the salinity laboratory in the United States of America [9].

Irrigation water class	code	Total dissolved salts mg/L TDS		The validity of the water
1- Low salinity water	C1	less than 200	less than 250	Suitable water for irrigating all crops and most soils
2- Water of medium salinity	C2	500 -200	250 - 750	Suitable water for irrigating most salt-tolerant crops
3- Water with high salinity	C3	1500 – 500	750 – 2250	This water is only used in the presence of an effective drainage network and for highly salt tolerant crops
Irrigation water class				The validity of the water

Date: October 2023

The problem of soil salinization occurs because of the quality of irrigation water. When the amount of dissolved salts in the irrigation water is large, it accumulates in the soil sector, affecting soil properties and agricultural production.

Table (8) Results of laboratory analyzes of surface water in the study area for the year 2021

sample location	Ph	Calcium Ca	Magnesium	Sodium Na	bicarbonate HCO3	sulfate SO4	carbonate CO3	EC
Diyala river water	*7.79*	*4.8*	*5.8*	*3.9*	*3.8*	*5.6*	*0.3*	*340*
Great River waters	*7.80*	*4.10*	*5.11*	*5*	*4*	*5.8*	*0.4*	*330*
Alund River water	*7.76*	*4.7*	*5.6*	*4.6*	*3.7*	*5.4*	*0.3*	*355*
Trocar (1)	*8.25*	*9.6*	*11.10*	*5.12*	*4.10*	*12.6*	*0.5*	*2215*
trocar (2)	*8.15*	*8.9*	*13.9*	*6.6*	*6.8*	*11.5*	*0.5*	*2230*
trocar(3)	*8.10*	*8.6*	*13.7*	*5.3*	*6.5*	*12.5*	*0.6*	*2240*
Diyala river water	*7.79*	*4.8*	*5.8*	*3.9*	*3.8*	*5.6*	*0.3*	*340*

The water of the Diyala River and the Al-Azim River have a salinity of (330-340) micromoses / cm. According to laboratory analyzes of surface water in an area irrigating all crops and in most soils, according to the classification of the American Salinity Laboratory, it turned out that it falls within the second category (C 2), while the drainage water has It showed that it has a salinity of (2215-2230) µm/cm, and it falls within the third category (C3) and is highly saline. This water is not used unless there is an effective drainage network and for crops that are highly salt-tolerant. The drains were studied here as a source for filling the water deficit. [10]. Among the samples, there are some whose salinity is within the safe range for use, and it has been shown that their salinity takes the same focus as river water, and the least saline drains in the study area are the northeastern drains, and most of them fall within the weak to medium use restrictions[11]. A number of factors, some of them related to the nature and chemistry of the irrigated soil, and some of them to the degree of sensitivity of the crops, as many crops are very sensitive to salinity during seed germination, [12-14]. and that sensitivity decreases significantly during the growth stage at a later time. Including wheat and barley, it is known that maize is more sensitive to salinity in its early stages of growth compared to its germination and late growth stages, while the germination stage of sugar beet represents the most sensitive stage to salinity. [15-18].

Figure 13. sampling from the Diyala River in the center of the study area Field study in *7- 12-* 202*1*

Date: October 2023

Figure 14. Soil salinization due to salty water Field study in *7*- *12*- 202*1*

From the study of this chapter, it was found that there is a large water deficit in the study area, especially in July and August of the year 2020-2021 AD. The reasons are due to the natural factors that Iraq in general and the study area were exposed to, particularly from global warming and lack of precipitation, and human factors that represent a special The water policies of the neighboring countries and the events after 2003, as well as a group of factors and field manifestations combine to complicate the picture of the water deficit in the study area, represented in the pollution and lack of purification of waterways and the disruption of many water barriers and lifting stations.

• It was found from the results of the analyzes of rivers and drains water samples that its quality is within the second category (C 2), while the tap water showed that it has a salinity of (2215-2230) micromouse / cm, and it falls within the third category (C3) and is highly salinity, it is not used This water is only available with an effective drainage network and for crops that are highly tolerant to salinity.

• The results of the field study showed that the cleaning of banks twice a year was a general condition in the region until 2003, as 85% of those in the sample taken in the study area indicated that. one.

• The contamination of agricultural drains with any kind of pollutants that change the chemical properties of water and lead to a decrease in its quality is of course a matter with bad environmental returns, as the drains water represents a stockpile to fill the water deficit.

4. Conclusion

The sections close to the rivers are characterized by having good natural drainage, while the drainage was poor in the sections far from the rivers. The water of the rivers in the study area was characterized as water with medium validity for irrigation in case the permeability of the soil is high or medium, and with poor validity for irrigation in case the permeability of the soil is low. It became clear through the field study that there are large areas of land that are not cultivated due to the lack of access to water, especially the lands far from rivers. Such as the lands of Safra in Mansouriya and the lands of Saif Saad in Hibhab. It appeared from the study that irrigation by means is prevalent in the study area due to the low water levels in the Tigris and Diyala rivers and the streams branching from it, where the percentage of lands irrigated by means reached 91.7% of the total area of agricultural lands in the district. Negative effects on the properties of the soil due to its contribution to the high percentage of salts due to the activity of the capillary property that accompanies the high values of evaporation. It became clear from the field study represented by interviews with farmers that there is a decline in the productivity of a dunum of crops planted in recent years, and this is a result of the scarcity of water and the continuous without following modern irrigation systems.The current study Recommending the following . The use of modern technologies, geographic information systems, gas and remote sensing in determining and mapping soil. Introducing modern irrigation techniques such as sprinkler and drip irrigation to avoid wasting irrigation water and expanding agricultural lands. . Sustaining irrigation and drainage projects that exist on an ongoing basis, especially from jungles, reeds and sedge, and preventing encroachment on irrigation projects. The study area is characterized by high temperatures in summer. It is preferable to water during the night to reduce water losses and thus reduce the amount of salts that accumulate on the surface of the soil after the evaporation of water. The need to work on

Date: October 2023

afforestation of desertified lands and improvement of pastures to prevent soil erosion and erosion, which leads to soil preservation and cohesion, especially at the times of grazing release in proportion to the pasture load.

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Date: October 2023

The Effect of Treated Sulfur Water on the Microbial Content of The Soil and The Extent of Resistance of These Bacteria to Antibiotics

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Abstract. The research began on March 7, 2021, as the regions of Ain Al-Wusta and Ain Jarura were chosen to take soil samples. The sulfuric water was treated using laboratory batch reactors. Locally manufactured glass tubes were used, with dimensions 17 * 17 * 55 in length, width and height, respectively, Subsequently, microbiological and chemical analyzes of the soil were performed. The results of the study showed success of the physical treatment process that was used to reduce the levels of sulfur in the water Depending on the source of water and the type of material used, the triple-magnetic treatment achieved the highest removal rate of 73% in Ain Al-Wusta soil, 40% in soil sample B1, and 27% in soil sample B2 of Ain Jarura. The results of bacterial culture showed that Gram-negative bacteria were dominant by 100% in soil samples from Ain Jarura region treated with untreated sulfuric water (WA1, WA2, WA3) (Table- 4), as well as for the same soil samples treated with sulfuric water treated with sand filter (GB1), charcoal filter (GB2) and magnetic field filter. (GB3) Soil samples treated with untreated sulfur water were dominated by *Pseudomonas aeruginosa* with a percentage of 66.7% and *Acinetobacter lwoffii* with a percentage of 33.3%.The results of the bacterial count of soil samples from the Ain Jarura region showed that there were significant differences between the bacterial number with sulfuric water treated with the three filters, As for soil samples from Ain Al-Wusta region, only soil samples added to sulfuric water treated with charcoal filter (WB2) gave significant differences with a significant decrease of number (84×10^2 CFU) for the species *Aerococcus viridans*. The results of the antibiotic sensitivity test showed that *Elizabethkingia meningoseptica* gave the highest rate of resistance to antibiotics about 66%. The results of the study showed that the resistance of bacterial isolates to antibiotics did not show significant differences between soil samples treated with treated and untreated sulfur water, except for the GB2 isolate.

1. Introduction

The impact of the rapid technological development in the twentieth century, as it led to an increase in water consumption, including groundwater, which constitutes approximately 30% of the proportion of fresh water available on earth. High levels of hydrogen sulfide gas (H_2S) resulting from some chemical weathering and oxidation of minerals containing sulfur, in addition to chemical fertilizers [1,2].

The sulfur compounds in water are either in the form of sulfate So4 in aerobic conditions or in the form of H2S in anaerobic conditions [3]، Sulfur reducing bacteria (SRB) play an important role in geochemical processes such as the production of sulfide ores, especially in the sulfur cycle, as sulfates are reduced in the environment, which are harmful in their activities as they lead to corrosion of metal pipes due to the formation of iron sulfide [4]. The passage of groundwater over rocks rich in sulfur compounds and the high ability of sulfur to dissolve, and thus the water will contain a high concentration of sulfur compounds that may merge with cations such as sodium, calcium and magnesium [5]. The percentage of hydrogen sulfide increases in sandy soils compared to its percentage in other kind of soils, and the reason for this is attributed to the high percentage of organic matter and the dissolved sulfate ion [6]. Since the sulfur water in Heet is used for agricultural production and despite its non-toxicity, its impact on microorganisms and the environment cannot be neglected. The need has emerged to exploit sulfur water in establishing green belts and reducing dust storms, especially in the desert areas of Anbar Governorate [7, 8]. There are many ways to remove

Date: October 2023

sulfur from water through the establishment of biological or physical treatment systems, whether by sedimentation, adsorption or ion exchange. Here in our study, a system was created to treat sulfuric water before using it to irrigate crops in order to identify the extent of the effect of this treatment on the microbial content of the soil after using that sulfuric water treated with three different types of filters compared to the microbial content of the soil using untreated sulfuric water. At the same time, the extent of resistance to Isolated bacteria against antibiotics due to the effect of treated and untreated sulfuric water on them, as irrigating crops with sulfuric water may cause a change in the dominance of a bacterial species at the expense of another species that may have dangerous virulence factors such as antibiotic resistance.

2. Material and Methods

2.1. Study Region

Ain Al-Wusta was chosen, and it is called Ain Al-Sayala (Figure -1), in relation to the asphalt al-Sayal, which is an artesian sulfur spring. Al Ain location coordinates (Eº 53.5 48 042) (Nº) (21.6 38 33), Where sulfur and tar water flow from it continuously to pour its water into the Euphrates River through Wadi Basair (Basayrah). Al-Ain is about 1.5 km away from the side of the Euphrates River, Second region was Ain Jarura (Al-Mamoura) is located at a distance of 6.2 km west of the city of Heet towards the city of Kubaisa, at a distance of 4.2 km and has a diameter of approximately 10 m. (17L) by (3 containers) for each eye and when modeling, the container was washed with sample water twice before filling it with sample water, after which the container was filled, then closed directly, and the station number and the date of sampling were noted. The process of collecting and transporting samples to the laboratory took 3 hours.

Figure 1. Study Region

2.2. Treated and untreated sulfuric water

Tests were conducted for water samples before and after treatment, represented by electrical conductivity and suspended and dissolved solids [9, 10]. As for the chemical tests, they included the acidity (pH) and sulfate (SO_4), which was measured using a spectrophotometer at a wavelength of 420 nm, then the concentration of sulfate was calculated in mg/L [9], As for phosphate (PO_4), the absorbance was read at a wavelength of 885 nm and concentration calculated in mg/L [11], Nitrates (NO_3) were measured using absorbance at a wavelength of (430) nanometers, and the results were expressed in units of µg/liter [12, 13], Nitrite (NO_2) using a absorbance at a wavelength of 543 (nm) and the results were recorded in units of micrograms / liter [10]. Carbonates and bicarbonates according to Lind researcher [14], and the results were estimated in units of mg/liter.

2.3. Sulfur water treatment system

The sulfuric water was treated using laboratory batch reactors. Locally manufactured glass tubes were used, with dimensions 17 * 17 * 55 in length, width and height, respectively. The first filter (B1) consists of sand and gravel, and the thickness of the layer is (25 cm). The second filter (B2) consists of activated charcoal and large and small polyethylene granules with a thickness of (25 cm). The third filter (B3) magnetic. It is manufactured locally and consists of a carbon steel tube surrounded by magnetic poles with a strength of (205) gauss. Oxygen is pumped into the water for a period of 20 minutes, then it is passed to the (first) filter and is impounded for a period of (15 min.), then the water

Date: October 2023

is passed to the second filter and impounded for a period of (15 min.), and then it is passed to the magnetic filter (the third) is reserved for a period of (15 min), and tests are conducted for it, and the filters are washed after each stage (Figure -2).

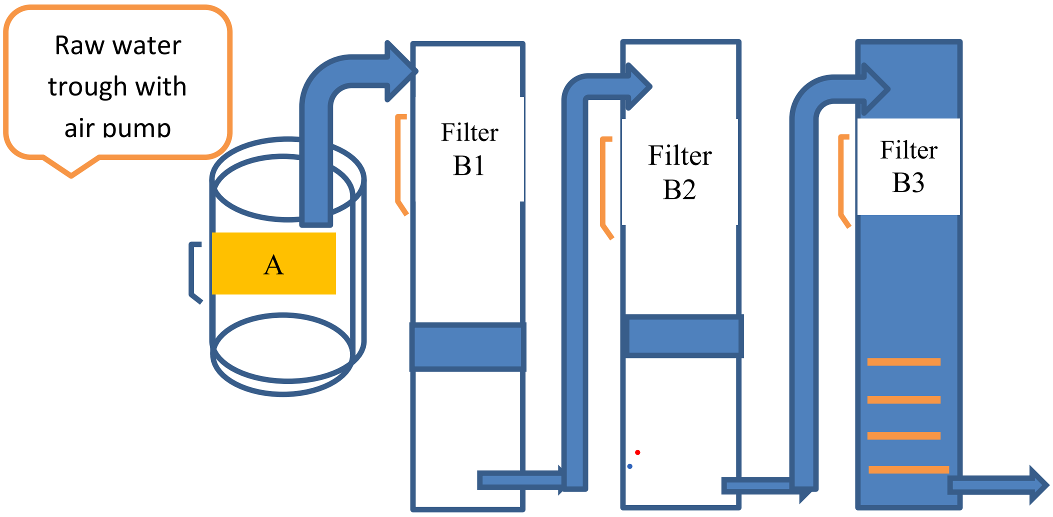

Figure 2. Scheme showing the sulfur water treatment system

2.4. Experiment design

For the purpose of conducting the experiment, (27 pots) of 2 replicates were prepared with a pot for the purpose of using it as a control group. One pot contains (15 kg) of soil. Cultivation took place on 3/7/2021. The pot was irrigated with treated and untreated sulfur water. The comparison pots were watered with ordinary liquid water and used Wheat plant as a botanical guide, then microbiological analyzes of the soil were carried out (Table-1).

Table 1. The physical and chemical properties of the study soil

No.	analysis type	estimate
1	(%) Sand	%50.80
2	(%) Silt	%44.00
3	(%) Mud	%5.20
4	Soil texture	Sandy mix
5	(pH)	7.8
6	(dS.m^{-1}) (EC)	1.3 0.85
7	(mg/L)TDS	2.5
	Dissolved Ions (mg/L	
8	N	407
9	K	200
10	P	0.033
11	SO_4^{-2}	256

EC/ degree of electrical conductivity; TDS/ Total Dissolved Salts; N/ Nitrogen; K/ Potassium; so_4^{-2}/ Sulfate

2.5. Preparation of culture media

The culture media was prepared according to the instructions of the supplied company, and its pH was adjusted to the number (7), Then the culture media was sterilized by autoclave and incubated at a temperature of (37)ºC for a period of (24) hours before use, in order to ensure its sterilization [15].

Date: October 2023

2.6. Soil sample collection

Using sterile containers, soil samples were collected in appropriate quantities from two region (Ain Al-Wusta and Ain Jarura), these samples were previously treated and untreated sulfuric water was added, and a control sample was taken that was not treated with sulfuric water.

2.7. Culture of bacteria

Soil samples were first cultivated on blood agar media for the purpose of growth all types of bacteria likely to be found in soil samples, then the culture were incubated for 24 hours at a temperature of 37 C°, after which the characteristics of the bacteria growth on the culture medium were determined, and then a sub culture was performed to obtain pure colonies, and then for the purpose of diagnosing bacteria a Gram stain test was carried out, and also growing them on differential culture media and conducting biochemical tests, The diagnosis included observing the growth shape of the bacterial culture and its characteristics on the plate after transferring it to the optional culture media, which included the shape of the colony, convexity, color, luster, diameter, edge, mucous and odor[16, 17, 18]. For the purpose of confirming the bacterial diagnosis, the Vitek 2 System was used.

2.8. Bacterial Count

The decimal series of dilutions method was used to calculate the bacterial number of different soil samples as follows:

First, 9 ml of sterile physiological solution was added to four sterile test tubes, and then 1 g of soil was added to the first tube to obtain the first dilution 10^{-1}. After shaking the tube, 1 ml was taken from the first dilution tube and added to the second test tube to obtain the second dilution 10^{-2}, and so on. In the same way for the other test tubes until obtaining the fourth dilution 10^{-4}, Draw 1 ml of the fourth dilution from a soil sample and add it to a sterilized Petri dish, then pour the nutrient agar medium, after cooling it to a temperature of 45 °C, and then pour the nutrient medium into the dishes at a rate of not less than (10-15) cm3 for each dish, and stir the dishes quietly three times clockwise and three times counter clockwise to ensure that the sample is mixed in the culture medium, After that, the dishes are left for a period of time to cool and the nutrient medium hardens inside them, Culture were incubated in the incubator at a temperature of 37 °C for 24-48 hours, The growing colonies were counted in the medium for each dilution, and the numbers were multiplied by the reciprocal of the dilution x 10, then the total rate of bacteria preparation per (1) ml of the soil sample was found [9, 19].

2.9. Bacterial susceptibility to antibiotic

A sensitivity test was conducted for all bacterial isolates using the Kirby Bauer method mentioned by [20] to identify the sensitivity of bacterial isolates obtained from soil samples. Twelve antibiotics were used for both Gram-positive and Gram-negative bacteria.

2.10. Statistical analysis

The data results of the experiment were analyzed statistically using a completely random design, and the statistical program SAS (2001) was used, and to determine the significant differences between the studied factors, the Duncun test was performed at a significant level (0.05) [21].

3. Results and discussion

3.1. The effect of treatment on the sulfuric water of Ain Jarura and Ain Al Wusta

Table (2) indicates some of the physical and chemical specifications of the sulfur water in Ain Jarura and Ain Al-Wusta during the study period, as the value of electrical conductivity for both was (3750.9 and 360.2) micro siemens/cm. The concentration of dissolved salts is another indicator of the amount of water salinity, and its ratios are used to identify the extent of crop tolerance to salts. The average total dissolved solids in Ain Jarura was (18316.0) mg / liter, which is higher than the middle spring, while the value of sulfate was (211.35) mg / liter for the middle spring, higher than the value of sulfate in Ain Jarura, and the concentration of dissolved phosphorus in the sulfuric water ranged from (27.67) to (14.83) mg/L for each of Ain Jarura and Ain Al-Wusta. The value of nitrates and nitrites were similar. (Table-3) shows the corresponding characteristics after the treatment process.

Date: October 2023

Table 2. Results of chemical and physical analyzes of soil samples for two regions of Ain- Jarura and Ain Al-Wusta

Region	CHO_3	NO3	NO_2	TPO_4	PO_4	SO_4	T.S.S	T.D.S	PH	EC
Ain Al Wusta	7.251	5.49	4.56	54. 34	14.83	211.35	497.,5	1172.,32	7.11	360.2
Ain Jarura	6.158	5.28	4.453	60.00	27.67	60.35	210.9	18316.0	6.61	3750.9

The use of several methods or techniques to treat sulfuric water, whether these treatments are physical, chemical or biological, has achieved good reduction rates and improved water quality to be used for irrigation purposes, as it is noted in (Table-3) the success of the physical treatment process that was used to reduce the levels of sulfur in the water Depending on the source of water and the type of material used, the triple-magnetic treatment achieved the highest removal rate of 73% in Ain Al-Wusta soil, 40% in soil sample B1, and 27% in soil sample B2 of Ain Jarura. The researcher [22] indicated that the efficiency of removing sulphate from the sulfuric water on the banana peel was 70% compared to 94% activated carbon. While [23] indicated a decrease in sulphate values by 90% when using a magnetic field with a strength of 1000 gauss for sulfur water treatment.

The results showed that the values of the acidity function of the treated water had a significant increase when using the treatments(B1,B2,B3).

A decrease in T.D.S occurred as a result of the use of treatments, as it decreased to 3313.2 mg/L in B3 treatment for Ain Al-Wusta water, and achieved a reduction rate of 80% in Ain Jarura water, and a reduction rate of T.S.S by 93%. And there was a decrease in the dissolved phosphorus values, as it reached 1.92 to 4.00 mg/L in Ain Jarura for both treatments (B1, B3). As it achieved removal rates of 93% and 86% in the middle eye, the treatments (b2, b3) they achieved 52% removal rates in the phosphorus value of the Ain Al-Wusta soil sample.

The values of total phosphorous (TPO4) were close to 25 mg/L in the third treatment and 28.84 mg/L for both Ain Al-Wusta and Ain Jarura sequentially, and achieving removal rates of 54% and 52%, respectively. The treatment achieved significant reduction of nitrites, nitrates and bicarbonates which affected plant growth and achieved high rates of productivity, in addition to its impact on the number of microorganisms present in the soil, as the treatment contributed to changing the number of bacteria in the soil.

Table 3. Effect of treatments on the physical and chemical properties of sulfuric water

TREATMENT	HCO3	NO3	NO2	TPO4	PO4	SO4	T.S.S	T.D.S	EC	PH
Analytics / Ain Jarura	6.158 a	5.28 a	4.453 a	60.00 a	27.67 a	60.35 a	210.9 a	18316.0 a	375.9 a	6.61 c
B1	5.997 a	2.50 b	1,666 b	35.84 c	4,00 b	44.35 b	96.2 c	3889.7 c	1289.2 a	7.16 a
B2	4,709 a	3,00 b	2.067 b	42,34 b	5.00 b	5.00 b	136,9 b	11219.7 b	2754.0 b	6,94 b
B3	2,397 b	3,28 b	1.245 b	28,84 d	1.92 c	145.5 b	91.0 c	3597.7 d	1539.7 c	7.22 a
Treatment	**HCO_3**	**NO_3**	**NO_2**	**TPO_4**	**PO_4**	**SO_4**	**T.S.S**	**T.D.S**	**EC**	**PH**
Analytics / Ain Al-Wusta	7.251 a	5.49 a	4.56 a	54. 34 a	14.83 a	211.35 a	497.5 a	1172.32 a	360.2 a	7.11 b
B1	4,375 b	2.00 b	1,520 a	39.34 b	8.84 b	61.16 b	110.2 c	3505.7 c	119.8 c	8.44 a
B2	4,75 b	2.00 b	3.945 b	34,17 b	7,17b	61.85	133,7 b	5278.2 b	160.4 b	8.12 a
B3	5,243 b	1.96 b	1.840 b	25.00 c	7.17 b	56.5 b	83.2 d	3313.2 c	95.2 c	8.39 a

Date: October 2023

a, b, c, d : Similar lower case letters mean that there are no significant differences between them

3.2. Isolation of bacteria

The results showed that Gram-negative bacteria were dominant by 100% in soil samples from Ain Jarura region treated with untreated sulfuric water (WA1, WA2, WA3) (Table- 4), as well as for the same soil samples treated with sulfuric water treated with sand filter (GB1), charcoal filter (GB2) and magnetic field filter. (GB3) Soil samples treated with untreated sulfur water were dominated by *Pseudomonas aeruginosa* with a percentage of 66.7% and *Acinetobacter lwoffii* with a percentage of 33.3%, The results are in agreement with the findings of a group of researchers in their study, as they found that *Pseudomonas aeruginosa* was more resistant in the presence of 1890 mg $SO4^{2-}$/L [24]. The results showed a change in the bacterial species *p. aeruginosa* after treating the same soil sample with sulfuric water treated with a charcoal filter, which led to the isolation of the bacterial type *Elizabethkingia meningoseptica*, and this result indicates the role of the charcoal filter in changing the environment suitable for the growth and dominance of type *P. aeruginosa*, While the bacterial type *P. aeruginosa* after treating the same soil sample (from Ain Jarura) with sulfuric water treated with a magnetic field filter.

Table 4. Diagnostic results of isolates

No.	Sample	Identification	Gram stain
1	*WA1*	*Pseudomonas aeruginosa*	-
2	*WA2*	*Pseudomonas aeruginosa*	-
3	*WA3*	***Bacillus cereus***	**+**
4	*GA1*	*Acinetobacter lwoffii*	-
5	*GA2*	*Pseudomonas aeruginosa*	-
6	*GA3*	*Pseudomonas aeruginosa*	-
7	*WB1*	***Bacillus thuringiensis***	**+**
8	*WB2*	*Aerococcus viridans*	+
9	*WB3*	***Bacillus thuringiensis***	**+**
10	*GB1*	*Burkholderia cepacia*	-
11	*GB2*	*Elizabethkingia meningoseptica*	-
12	*GB3*	*Pseudomonas aeruginosa*	-
13	*C*	*Kocuria kristinae*	+

W/ Ain Al-Wusta ; G/ Ain Jarura ; A/ Soil sample to which untreated sulfuric water was added. ; B1/ Soil sample to which sulfuric water was added after treatment with sand filter. B2/ Soil sample to which sulfuric water was added after treatment with charcoal filter. B3/ Soil sample to which sulfuric water was added after treatment with magnetic field filter. C/ Control.

In the soil samples of the Ain Al-Wusta region, (Table-4) showed a change in the totals of bacteria isolated from the soil treated with untreated sulfuric water, as at the beginning of the isolation there were Gram-negative and Gram-positive bacteria represented by *P. aeruginosa* (66.7%) and *Bacillus cereus* (33.3%) As for after treating the sulfuric water with the three filters and then adding it to the soil, the results showed that all the bacteria isolated from that soil were Gram-positive, represented by *Bacillus thuringiensis* at a percentage of (66.7%), which was isolated from the soil treated with the sulfuric water treated for each of the (B1, B3) filters. (B2) *Aerococcus viridans* was isolated from the soil by (33.3%) percentage, Therefore, there was a change in the dominance of the

Date: October 2023

bacterial type after treating the sulfuric water with the three filters of soil samples from region of Ain Al-Wusta.

From the aforementioned, the results show that there is a difference in the microbial diversity in the same region in each of the two study areas from which the three samples were taken, as well as between the two regions (Ain Al-Wusta and Ain Jarura) in terms of soil type and nutrients that bacteria need for growth in addition to the different environmental conditions. This has affected the quality of bacterial dominance in most of the microbial content. For the soil to which sulfur water was added after treatment with the three filters (B1,B2,B3), Only sample A3 from Ain Jarura region was able to maintain bacterial dominance after soil treatment with filter B3, which is the bacteria *p. aeruginosa.*

3.3. Count of bacteria

The results of the bacterial count (Table-5) of soil samples from the Ain Jarura region showed that there were significant differences between the bacterial number added to it with sulfuric water treated with the three filters and the untreated, as there was an increase in the number of bacteria for the soil to which untreated sulfuric water was added, and the soil to which water was added was Sulfur treated with sand filter (GB1) is the least decrease in the number of bacteria, as the soil samples GA1 gave a number of bacteria (252×10^2 cell forming unit) for species *Acinetobacter lwoffii*, while soil samples GB1 gave a number of bacteria (62×10^2 CFU) for species *Burkholderia cepacia*, and this indicates a significant decrease in the number of bacteria For these samples, at the same time, the bacterial diversity of them changed. As for soil samples from Ain Al-Wusta region, only soil samples added to sulfuric water treated with charcoal filter (WB2) gave significant differences with a significant decrease of nomber (84×10^2 CFU) for the species *Aerococcus viridans* for a soil sample to which untreated sulfur water (WA2) was added, with a nomber of (228×10^2 CFU) for *Pseudomonas aeruginosa*, As for the samples (WB1, WB3) compared with the numbers of bacteria for soil samples (WA1, WA2), there were no statistically significant differences.

Table 5. Count of bacterial cell for soil samples with treated and untreated sulfuric water.

N0.	Region	processing type	No. of bacteria (CFU/g Soil)
1	Ain Jarura	Untreated (GA1)	252×10^2
2	Ain Jarura	Untreated (GA2)	196×10^2
3	Ain Jarura	Untreated (GA3)	280×10^2
4	Ain Jarura	Sand filter treated (GB1)	62×10^2
5	Ain Jarura	Charcoal filter treated (GB2)	160×10^2
6	Ain Jarura	Magnetic Field Filter Processor (GB3)	86×10^2
7	Ain Al-Wusta	Untreated (WA1)	168×10^2
8	Ain Al-Wusta	Untreated (WA2)	228×10^2
9	Ain Al-Wusta	Untreated (WA3)	248×10^2
10	Ain Al-Wusta	Sand filter treated (WB1)	156×10^2
11	Ain Al-Wusta	Charcoal filter treated (WB2)	84×10^2
12	Ain Al-Wusta	Magnetic Field Filter Processor (WB3)	156×10^2
13	Control		296×10^2

3.4. Bacterial susceptibility to antibiotic

Use 12 antibiotics for Gram-positive bacterial isolates and 12 antibiotics for Gram-negative bacterial isolates (Table-6).The results of the antibiotic sensitivity test showed that *Elizabethkingia meningoseptica* gave the highest rate of resistance to antibiotics about 66%. This bacteria was isolated from the soil of Ain Jarura treated with sulfuric water treated with a charcoal filter (GB2), *Elizabethkingia meningoseptica* (previously called *Chryseobacterium meningosepticum*), is gram-negative bacillus first defined by King in 1959. isolated in epidemiological studies, it was responsible for the majority of cases of meningitis, this bacteria is most frequently isolated from soil, saltwater and freshwater and from dry and moist clinical environmental and equipment surfaces, intravenous lipid solutions, and municipal water supplies including those which have been adequately chlorinated [25].The results of the study showed that the resistance of bacterial isolates to antibiotics did not show significant differences between soil samples treated with treated and untreated sulfur water, except for

Date: October 2023

the GB2 isolate. The percentage of resistance in all Gram-positive bacteria against antibiotics was 41.7% for isolates of samples WA3, WB1, WB2, WB3, despite the difference in species in most of them, and the same percentage of resistance to isolate bacteria from the control region, While the rates of resistance were not similar in kind of antibiotic for isolates of Gram-negative bacteria of soil samples WA1, WA2, GA1, GA2, GA3, GB1and differed from it by the resistance of more isolated soil sample GB2 (Table-6).

Table 6. Results of antibiotic susceptibility testing of bacterial isolates from soil samples to which treated and untreated sulfuric water was added.

Bacteria	**Isolation Region**	**Piperacillin/ Tazobactam**	**Cefazolin**	**Ceftazidime**	**Cefepime**	**Imipenem**	**Amikacin**	**Gentamicin**	**Ciprofloxacin**	**Levofloxacin**	**Tigecycline**	**Ceftriaxone**	**Trimethoprim/ Sulfamethoxazole**	**Benzylpenicillin**	**Ampicillin**	**Cefotaxime**	**Moxifloxacin**	**Erythromycin**	**Clindamycin**	**Tetracyclin**	**Chloramphenicol**	**Linezolid**
Pseudomonas aeruginosa	WA1	S	R	S	S	S	S	S	S	S	R	S	S									
Pseudomonas aeruginosa	WA2	S	R	S	S	S	S	S	S	S	R	S	S									
Bacillus cereus	WA3									S		S	S	R	R	S	S	R	R	R	I	S
Acinetobacter lwoffii	GA1	S	R	S	S	S	S	S	S	S	S	S	S									
Pseudomonas aeruginosa	GA2	S	R	S	S	S	S	S	S	S	R	S	S									
Pseudomonas aeruginosa	GA3	S	R	S	S	S	S	S	S	S	R	S	S									
Bacillus thuringiensis	WB1									S		S	S	R	R	I	S	R	R	R	S	S
Aerococcus viridans	WB2									S		S	S	R	R	S	S	R	R	R	S	S
Bacillus thuringiensis	WB3									S		S	S	R	R	S	S	R	R	R	I	I
Burkholderia cepacia	GB1	S	R	S	S	S	S	S	S	S	S	S	S									
Elizabethkingia meningoseptica	GB2	R	R	S	R	R	R	R	S	S	S	R	R									
Pseudomonas aeruginosa	GB3	S	R	S	S	S	S	S	S	S	R	S	S									
Kocuria kristinae	C									S		S	S	R	R	S	S	R	R	R	S	S

C: control, R: Resistance, S: Sensitivity, I: Intermediated

4. Conclusions

The system used in this study to treat sulfuric water was designed locally. The sulfuric water can cause damage unless it is treated or its concentration is reduced before it is used to irrigate the soil. The magnetic field filter gave the highest removal of sulphate from the sulfuric water by 73%. The results of the soil samples of Ain Jarura region showed that using untreated sulfuric water with this soil, *P. aeruginosa* bacteria were dominant in the microbial content of the soil, while the soil of Ain Al-Wusta region when treated with untreated sulfuric water showed the presence of Gram-negative bacteria, which is the species *p. aeruginosa* with a rate of 66.7%, and Gram-positive bacteria, which are *Bacillus cereus*, with a rate of 33.3%. Soil sample of Ain- Jarura region the results showed a change in the bacterial species *p. aeruginosa* after treating the same soil sample with sulfuric water treated with a charcoal filter, which led to the isolation of the bacterial type *Elizabethkingia meningoseptica*, and this result indicates the role of the charcoal filter in changing the environment suitable for the growth and dominance of type *P. aeruginosa*, while the soil sample of Ain-Al-Wusta region which added treated sulfuric water the results showed that all the bacteria isolated from that soil were Gram-positive.

The results of the bacterial count of soil samples from the Ain Jarura region showed that there were significant differences between the bacterial number added to it with sulfuric water treated with the three filters and the untreated, as there was an increase in the number of bacteria for the soil to which untreated sulfuric water was added. The results of the antibiotic sensitivity test showed that *Elizabethkingia meningoseptica* gave the highest rate of resistance to antibiotics about 66%. This bacteria was isolated from the soil of Ain Jarura treated with sulfuric water treated with a charcoal filter (GB2).

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Assessment of Water Quality of Al-Habbaniya Lake by Using Statistical Techniques (Cluster and Factor Analysis)

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Abstract. Habbanyia lake is one of the most crucial resources of water, water lake is used mainly for agriculture, animal activities, and drinking water purposes. In addition, it represents a tourist city. Multivariable statistical approach was used to assess the quality of the water of Habbanyia lake in west Baghdad, to determine how the physical and chemical qualities relate of lake water and the local trend of water type. R-mode and Q-mode cluster and factor analyses were used to categorize chemical characteristics and determine the variables influencing changes in quality. The results show, the water samples are considered to be Fresh water and all the lake water samples were within the WHO standard. In general, Ca-SO_4 and Na-SO_4 facies were the most prevalent in the Habbanyia Lake water. The results show, there are two factors controlling the water quality of Habbanyia lake, the first is geological sitting and the second is human activities.

1. Introduction

Lake water is a necessary, a sustainable resource (renewable resource) for agriculture, the environment, human life, and industrial processes. For sustainable water use, ongoing observation is necessary [1]. Numerous research studies have been undertaken recently and will continue to be. For the purpose of identifying changes in properties. thus it is required to identify the many factors affecting the pollution level, as well as to categorize and model the water quality [2]. Multivariate data analysis methods such as PCA "principal component analysis", FA "factor analysis", and CA "cluster analysis" will aid in understanding complex data more quickly and it has been revealed to reduce data without losing the original information [3-5]. Many researchers used these methods to evaluation water resources [6-9]. These researchers claim that the principle component analysis of multivariate test may be successfully used to assess water quality. Clearer determination of the data, attributes, and effective interpretations is made possible by cluster analysis [3]. Dendrograms, the findings of cluster analysis, show the linkages clearly. While using factor analysis, the number of variables with many internal relationships was reduced. The best technique to get the fewest variables is explained by conducting a factor analysis. Numerous scholars have examined biological and environmental studies to evaluate the properties of Habbaniya lake. [10-18]. The present study aimed to evaluate using multivariate data analysis techniques on Habbaniyia lake water quality and its fluctuation in Chemical parameters.

2. Materials and Methods

2.1. Study Area

Habbaniya Lake is located in Anbar Governorate, 60km west of Baghdad (Fig. 1), the elevation ranges from 35 to 90 meters. between 39°18´03 N and 34°23´12 E. Habbaniya Lake has a 9-13 m depth, 35km length, 25km maximum width, 3. 26 x 10^9 m^3 storage capacity of [11]. The lake is principally fed by the Euphrates river. Al-Habbaniya depression joined the Euphrates River by an inlet channel

Date: October 2023

and it has two outlet channels one returns back to the Euphrates and the other goes to the Al-Razzazh depression. Geologically, the oldest rocks appear in the west of the lake where the Euphrates Formation(Early Miocene) is located on the west bank of Al Habbaniya. Injana Formation (Late Miocene) is located in the north, south, and east of the lake. Quaternary sediment in the Alluvial Fan area (Early-Middle Pleistocene). However, the gypcrete layer (Holocene) spreads to the east of Al-Habbaniya Lakes [19-21]. Semi-arid climate it has two major seasons, hot and dry summer and cold with rare rainfall in winter. The average temperature ranges from 13.9 °C to 39.4 °C. The average annual precipitation ranges from 7.12 mm to 22.26 mm, whereas the average evaporation ranges from 5.83 mm to 275.7 mm. Water from the lake is used mainly for multi –purposes (agriculture Irrigation, drinking water. and animal activities).

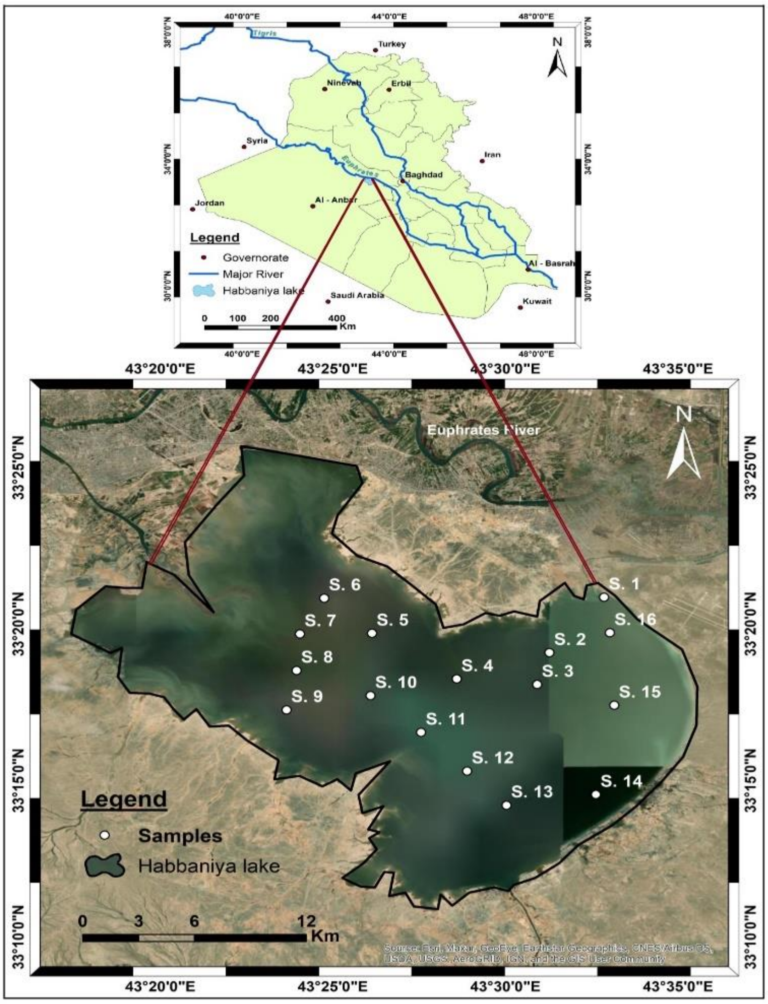

Figure 1. Location of water samples in the study area.

2.2. Water Sampling and Analysis

In the field, network monitoring sites were collected to determine the quality of Habbanyia water in March 2021. These sixteen water quality sample stations' data are made up of a variety of water quality characteristics. The selected criteria are listed below.: electrical conductivity(EC), total dissolved solids(TDS), sulfate(SO_4), total hardness(T.H), sodium(Na^+), potassium(K^+), calcium(Ca^{2+}), magnesium(Mg^{2+}), chloride(Cl^-), Bicarbonate(HCO_3) nitrate(NO_3) and Turbidity(Tur). 1.5 L polyethylene sampling bottles were used with high density. Then kept and transported to the chemical Laboratory, water research center/ Ministry of Science and Technology, for analysis.

2.3. Analytical Methods

The water samples were subjected to a variety of analytical techniques, depending on the characteristics of interest. All field and laboratory analyses have been performed in according of standards methods [22].

Date: October 2023

Statistical Analysis

On all data sets, descriptive statistics have been determined as range, mean, and standard deviations to assess water quality, cluster analysis(CA) and factor analysis(FA) was applied. For descriptive statistics and multivariate data processing, the SPSS. 16.00 version of the statistical software was used. Cluster analysis was applied to classify groups of samples with similar cations and Anions contents [23]. The Ward-algorithmic formula for TCA was used, and the linkage distance was used to calculate the separation between clusters metals concentrations. The relationship between several water quality metrics and polluting sources was discovered using R-mode CA. The link between the components was also determined using Pearson's correlation matrix.

3. Results and Discussion

Following a statistical analysis of the physicochemical properties of Habbanyia lake samples, results such as the maximum (Max), minimum (Min), mean, and standard deviation are given in Table 1.

Table 1. Chemical parameter of Habbanyia samples – March 2021

Sample No.	EC (µS./cm)	TDS (mg./l)	T.H (mg./l)	Turb. (N.T.U)	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	SO_4^{2-}	HCO_3^{-}	NO_3^{-}
L1	1037.72	726.40	403.31	4.14	85.50	46.25	93.00	7.10	185.00	248.13	48.70	3.00
L2	850.06	630.66	342.52	2.50	70.50	40.57	71.00	6.30	142.59	235.79	53.57	3.10
L3	956.89	725.54	364.00	1.50	72.00	44.90	91.00	7.00	172.66	271.00	43.83	4.00
L4	934.60	740.33	280.08	1.30	72.45	46.66	88.00	6.90	162.96	278.17	48.70	3.50
L5	678.19	532.24	320.68	2.10	60.45	31.51	52.00	6.00	112.00	179.00	66.00	5.00
L6	615.94	455.22	276.64	1.90	55.00	30.17	47.00	3.80	97.00	158.00	46.00	4.20
L7	603.86	489.67	287.56	1.30	59.25	34.02	48.00	8.60	102.00	162.95	71.00	3.40
L8	640.10	502.88	289.02	1.60	62.25	32.55	52.00	4.80	103.00	178.18	66.00	6.00
L9	642.88	499.12	291.20	1.80	61.50	33.54	52.00	4.50	105.00	173.24	56.00	6.20
L10	785.02	612.35	331.24	1.30	73.50	35.99	72.00	6.90	139.00	209.87	62.00	5.60
L11	923.45	675.18	358.54	1.30	71.40	43.93	87.00	7.00	155.20	250.19	48.70	4.50
L12	991.27	745.78	374.92	1.40	73.50	46.65	100.00	7.30	160.44	280.64	53.57	3.20
L13	1012.63	811.73	395.30	1.80	74.10	51.25	107.00	7.50	176.54	297.10	77.92	3.30
L14	967.11	780.55	400.40	2.60	75.00	51.95	112.00	7.70	178.48	304.92	34.09	4.90
L15	1009.85	746.62	378.56	1.35	72.90	47.90	103.00	7.10	172.66	291.34	38.96	5.00
L16	1001.49	733.65	371.28	1.70	74.25	45.30	102.00	7.10	166.84	289.28	43.83	2.30
Min	**603.86**	**455.22**	**276.64**	**1.30**	**55.00**	**30.17**	**47.00**	**3.80**	**97.00**	**158.00**	**34.09**	**2.30**
Max	**1037.72**	**811.73**	**403.31**	**4.14**	**85.50**	**51.95**	**112.00**	**8.60**	**185.00**	**304.92**	**77.92**	**6.20**
Average	**853.19**	**650.50**	**341.58**	**1.85**	**69.60**	**41.45**	**79.81**	**6.60**	**145.71**	**237.99**	**53.68**	**4.20**

The EC ranged between 603.86 and 1037.72 µs/cm with a mean value of 853.19 µs/cm. The maximum allowed value for each sample was 500 µs/cm [24]. The TDS values ranged between 455.2 and 811.7 mg/L with a mean value of 650.50 mg/L. The TDS levels were up to the WHO-permitted range of 500 mg/L for drinking water [24] except for stations, L6, L7, and L9. According to Todd (1980) classification Table (2).

Table 2. Classification of water salinity according to TDS

Class	Todd, 1980
Fresh water	0-1000
Slightly water	-
Slightly-Brackish water	1000.0-10000.0
Brackish water	10.0-100000.0
Saline water	-
Brine water	>100000

Date: October 2023

According to (Todd, 1980), the water samples are considered to be Fresh water. Figure 2 shows the relationship between EC and TDS with R^2=0.945.

The total hardness values ranged between 276.6 and 403.3 mg/ L with a mean value of 341.58 mg/L. These numbers fell under the 300 mg/L limit for total hardness in drinking water set by the WHO in 2011. The concentration of calcium and magnesium ions ranged from 55 to 85.5 mg/L and 30.17 to 51.95 mg/L, with a mean value of 69.60 and 41.45 mg/L respectively, the concentration of chloride in the water ranged from 97 to 185 mg/L with a mean value of 145.71mg/L. The sulfate concentration ranged from 158 to 304 mg/L, with a mean value of 237.99 mg/L. The concentration of bicarbonate ranged between 34 and 72 mg/L with a mean value of 237.99 mg/L. The nitrate concentration ranged from 2.3 to 6.2 mg/L with a mean value of 4.20 mg/L. finally, The Turbidity concentration ranged from 1.3 to 4.14 mg/L with a mean value of 1.85 mg/L. For the Ca, Mg, Cl SO_4, HCO_3,NO_3 and Turbidity values, all the lake water samples were within the WHO (2011) [24],

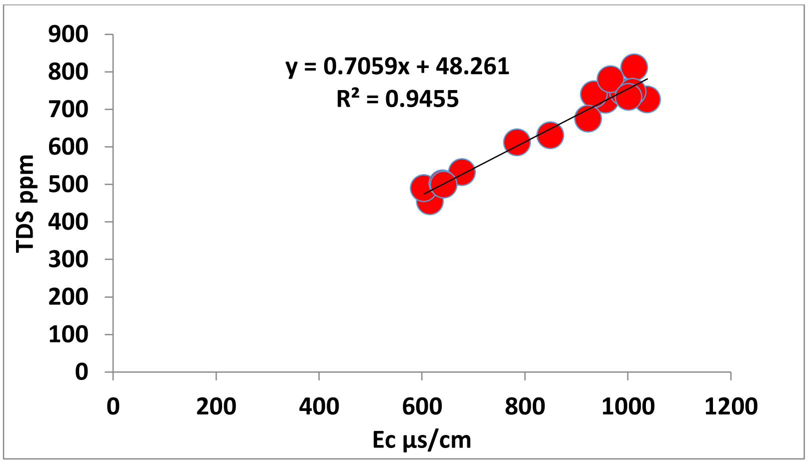

Figure 2. Relationship between EC and TDS in the study area

Sulfate was the predominant anion and calcium and sodium the predominant cations in the Habbanyia lake during the studied period. the 50% from water samples is Ca-SO_4, and 50% on other side is Na-SO_4. Because Ca^{2+} and SO_4 predominated, the pattern was indicative of a freshwater system. The interaction of the rocks and water is connected to the ion dispersion in the water samples. and the effect of a geological factor that occurs as the water recharge through the Euphrates river. The relationship between cations and anions and TDS is shown in Figures 3 and 4.

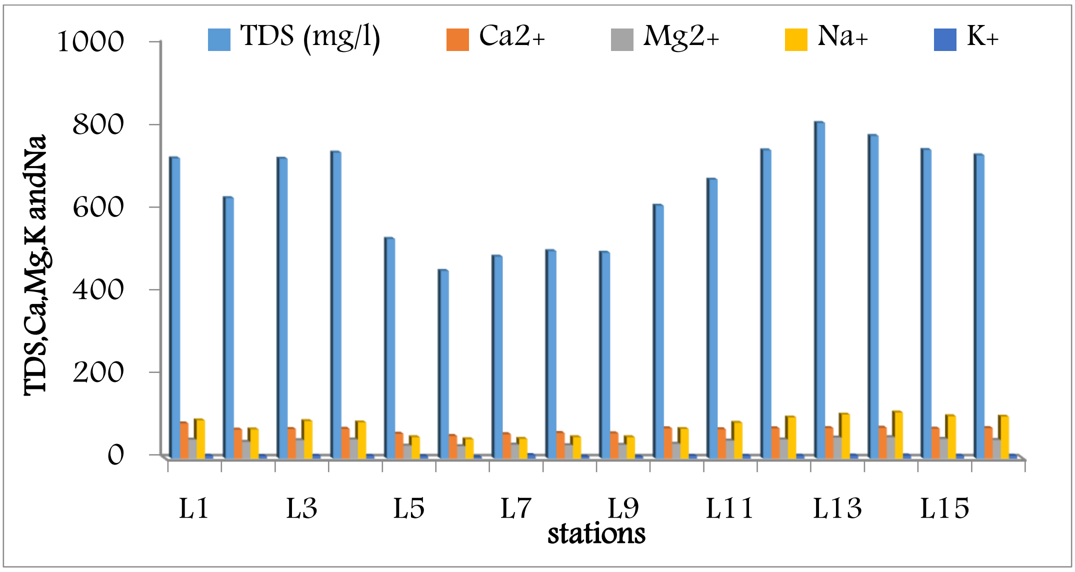

Figure 3. Relationship in the study area between TDS and Cations

Date: October 2023

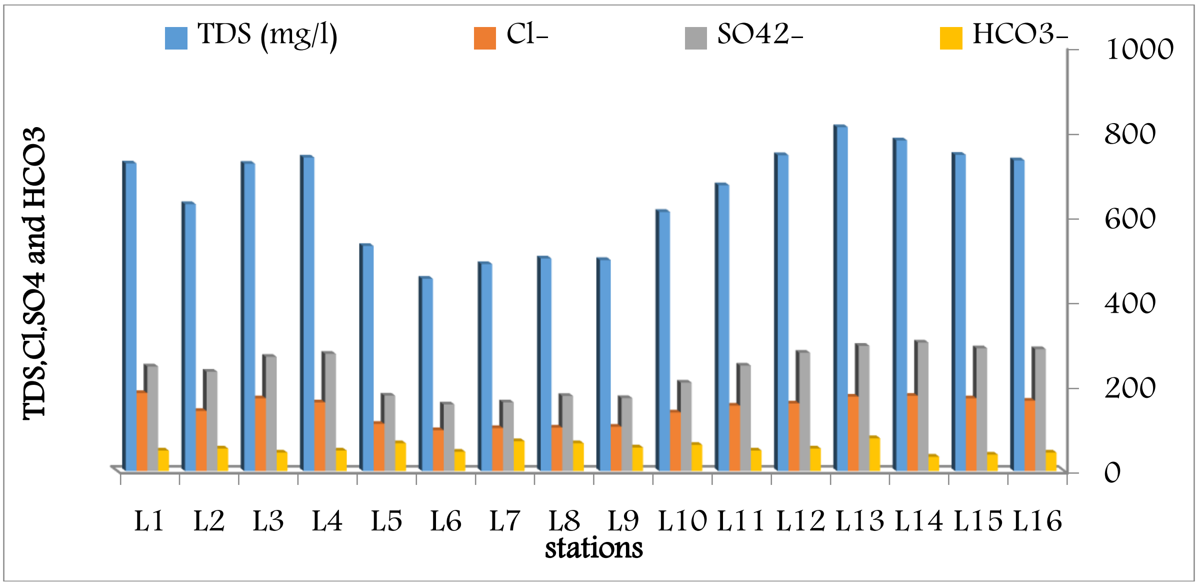

Figure 4. Relationship in the study area between TDS and Anions

On the basis of their interconnectedness, many water quality measures may be grouped [25]. Alternatively, sampling sites might be grouped based on chemically similar in the studied samples [8].

On the basis of the similarities among the chemical parameters involved in the water quality, the cluster analysis (Q-mode) divided the lake samples into three groups (Fig. 5). Group A represents L1, L3, L11, L12, L13, L14, L15, and L16. Group B 2 represents L4, L2, and L10. Group C represents l5, L6, L7, L8, and L9. On the other hand, the cluster analysis (R-mode) was applied. Depending on Figure 6, the similarity between the physio-chemical characteristics of the lake samples is demonstrated by this cluster. The results show same similarity between TDS and EC in all studied samples. and close linkage between Mg and HCO_3, on the other hand Ca, Na, Mg related with Cl and SO_4. This indicates that the chemical composition of lake has changed as a result by geological processes.

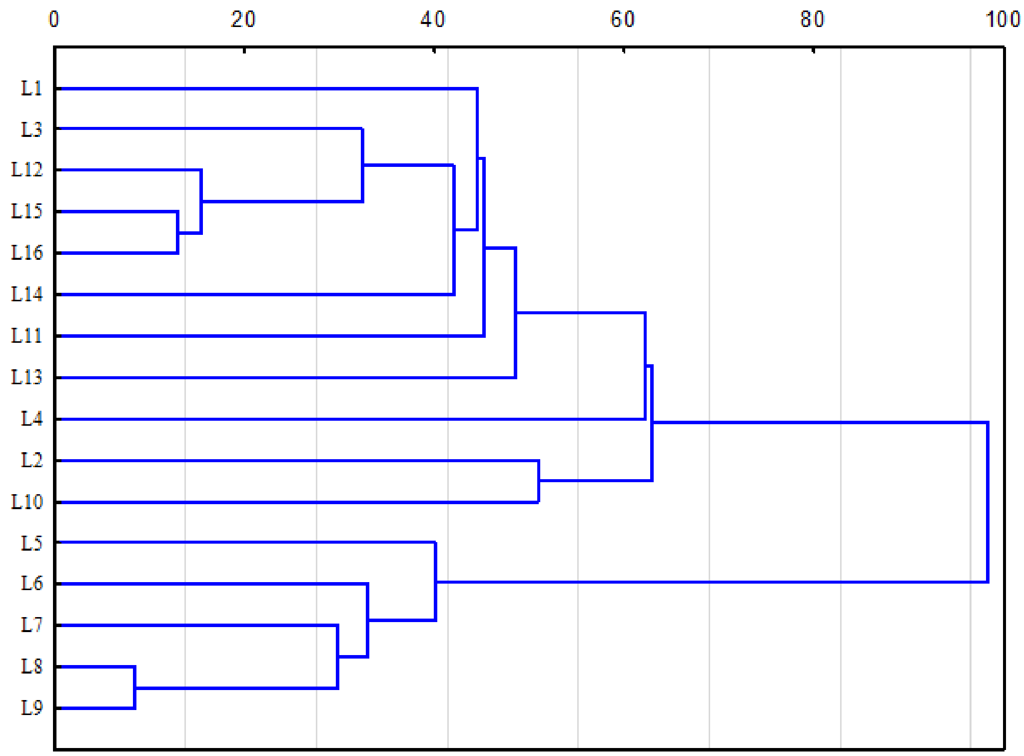

Figure 5. Cluster analysis of samples in the study area showing the linkage distance

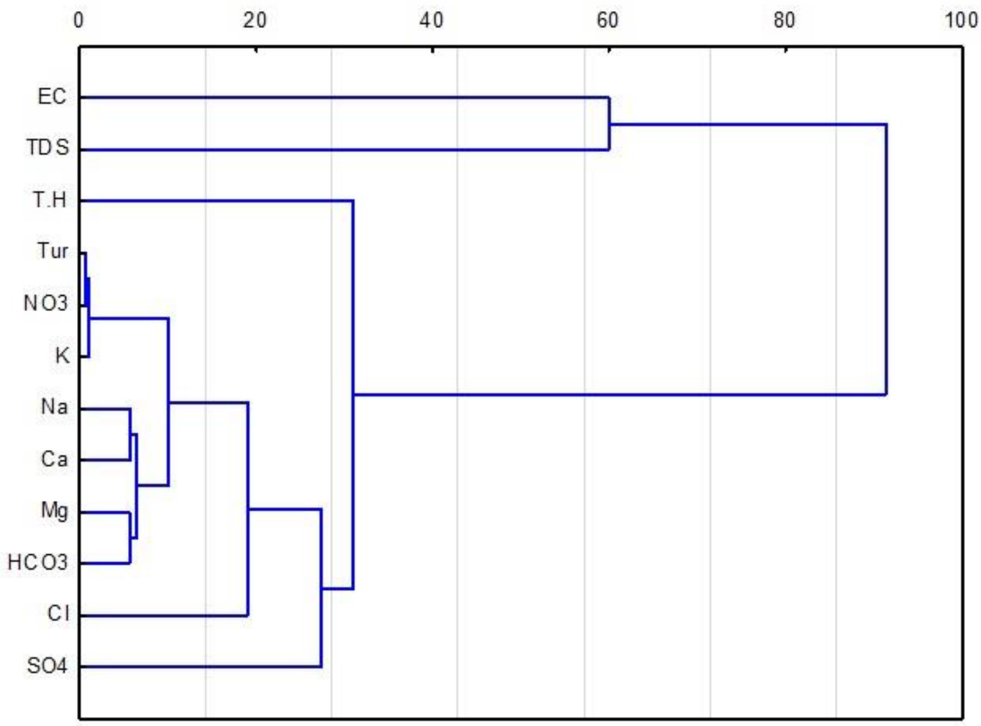

Figure 6. The cluster analysis of chemical components of water samples in the study area

Table 3 The matrix of correlation between the variables is displayed. Significant change is defined as (r>0.5) as the reference coefficient value, the EC inspection related to Na,Cl,SO4, TDS, T.H is positively related. Turbidity has a negative relation with EC. While T.H shows a positive correlation with Ca^{2+} and Mg^{2+}.

Table 3. The correlation matrix of chemical variables of water samples

	EC	TDS	Tur	K^+	Na^+	Ca^{2+}	Mg^{2+}	SO_4	Cl^-	HCO_3	T.H	NO_3
EC	1.00											
TDS	.95	1.00										
Tur	-.23	-.43	1.00									
K^+	.43	.54	-.23	1.00								
Na^+	0.76	.92	-.34	.41	1.00							
Ca^{2+}	.78	.76	-.22	.43	.54	1.00						
Mg^{2+}	.65	.63	-.21	.33	.34	-.24	1.00					
SO_4	.78	.79	-.52	.43	.77	0.07	.04	1.00				
Cl^-	.86	.89	-.43	.33	.94	0.01	.43	.84	1.00			
HCO_3	.75	.67	-.34	.23	.88	-.23	.34	.05	.43	1.00		
T.H	.77	.76	-.56	.45	.34	.76	.76	.76	.52	.23	1.00	
NO_3	.32	.32	-.23	.23	0.04	.34	.34	.03	.04	.06	.03	1.00

From the principal components analysis in Table 4., two factors were extracted that accounted for 85.23 % of the total variance. The extracted factor results suggest that EC, TH, TDS, Ca^{2+} and Mg^{2+}, Na, SO_4, and HCO_3 have high positive factor loadings in factor 1. Weathering may be responsible for Factor 1. and the effect of the geological setting on the water quality of Habbanyia lake. Factor 2 which describes 13.323 % of the total variance has low positive loading for Cl, EC, SO_4 .T.H this reflects the influence of anthropogenic activities from Warar channel and wastewater that was discharged from Habbanyia city. Chloride (Cl^-) is thought to be released from the leaching of upper soil layers, which receive from domestic activities through Warar channel. Agian from table 3. Ca^{2+} and Mg^{2+} concentration were significantly correlated with TH (r=.76), which indicates that hardness is an approximate measure of Ca^{2+} and Mg^{2+}. Total hardness was also significantly correlated with SO_4^{2-} (r = 0.52), implying that TH is essentially a permanent hardness.

Table 4. The factor analysis for water samples in the study area

Parameters	F. 1	F. 2
EC	.9843	.3241
TDS	.9675	.3211
Tur	-.1623	-.0322
K	.5423	.2341
Na^+	.9763	.4121
Ca^{2+}	.9912	.3211
Mg^{2+}	.9683	.3.218
SO_4	.9654	.4321
Cl^-	.9844	.5356
HCO_3	.9743	.2333
T.H	.8756	.4532
NO_3	-.3242	.3222
Expl.Var.	**8.7431**	**3.8567**
Prp.total	**85.232**	**13.323**

4. Conclusion

The quality and suitability of Habbanyia lake for multi-purposes have been assessed. The results of samples analysis show that Habbanyia lake water is freshwater. Except for EC and TDS, all physicochemical parameters were determined to be within the WHO's permissible drinking water guidelines. According to multivariate statistical analysis, the two Factors that were retrieved accounted for 85.23 and 13.32% of the total variance. The PCA results indicated that weathering, leaching, and human activity are the main factors affecting the lake's water quality. In general, Ca-SO_4 and Na-SO_4 facies were the most prevalent in the Habbanyia Lake water.

Date: October 2023

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Date: October 2023

One-Dimensional Model to Study the Sediment Transport of the Euphrates River Upstream of Ramadi Barrage

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Abstract. One of the main variables influencing the Euphrates River's river morphology is sediment. The design engineer's principal aim during the construction of hydraulic structures like a dam or irrigation channel would be sediment transport. The Euphrates River is the biggest in Iraq and has considerable interest because of strategic and environmental conditions regarding water resources project planning, agriculture, hydropower, and industrial scope. Therefore, to reduce the issues brought on by changes in river morphology, the study of sediment movement and the features of river beds is crucial. The river reach is selected upstream Ramadi barrage. In this study, a hydraulic analysis of the sediment transport model was created using the Hydrologic Engineering Center's River Analysis System (HEC-RAS). The HEC-RAS model was run for 70 days to calibrate the model results with field measurements. We found an excellent convergence between them, which allows the model application to predict the amount of sedimentation upstream of Ramadi Barrage. The model's output indicates that the amount of sediment retained by the upstream Ramadi Barrage is 2749 tons per day.

1. Introduction

Excessive deposition and bank erosion occur in rivers as a result of both natural and human processes. Depending on the location and hydrological regime, the long-term impacts of erosion and accumulation result in significant changes in river geomorphology. River sediment transport is influenced by several variables, including sediment type and particle size, drainage area size, land use and vegetation near the catchment areas, temperature and climate change patterns, flood occurrences, and basin slope [1–3].

The process of sediment transport and sedimentation upstream of the Ramadi Barrage caused a problem that resulted in a rise in the level of the river bed and negatively affected the functions of the source. This problem arose in the early years when the water was impounded in the river section at the front of the Ramadi Barrage, but having frequent high discharges at that time greatly reduced the problem [4]. In recent years, due to the increasing water scarcity and the significant decline in the discharges of the Euphrates River, the sediment problem in the river section before the dam has increased to a large extent, which affects the characteristics of the river section and the operational viability of the structure, as well as the continuous increase in the cost of sediment removal [5,6]. All this requires finding some practical solutions to this issue. The research simulates the sediment transport through the Euphrates River upstream of the Ramadi Barrage and the impact of this deposit on the operation of the project. This study will help to manage the Ramadi Barrage operation and estimate the annual quantity of sedimentation upstream of the Barrage.

The modelling of rivers needs more physical relationships for sediment transport processes. It is challenging to present the fluvial processes because they are complicated and controlled by continuity, flow resistance, sediment movements, river bank stability, and variations in channel width [7–9]. Typically, modifications in the river bed profile, slope, channel pattern, and river channel roughness occur concurrently with changes in the river's width. Any factor that is forced on the river will be

Date: October 2023

absorbed with a combination of the aforementioned reactions since all those changes are connected and maintain a dynamic state of balance [10–12].

The HEC-RAS 1D model is frequently used to simulate sediment transport. The geometry of river cross-sections is modified at each time step. This process is achieved by moving the entire cross-section. Also, it can be achieved by assuming an equal amount of deposition and erosion. The ability to simulate a large network of streams, channel dredging and encroachment options and the use of several sediment transport equations are all noteworthy features. The model HEC-RAS bases its computations in large part on the fundamental principles underlying fluvial hydraulics and river mechanics.

2. Materials and Methods

2.1 study area

The research is related to Ramadi Barrage, one of Iraq's most important water resources projects which was constructed in 1957 on the Euphrates River. The Euphrates River, which flows through Turkey, Syria, and Iraq, is regarded as one of the international rivers [13–15]. In Anbar, the Euphrates River stretches for about 450 km, accounting for 43% of the entire length in Iraq [16–19]. In this study, a part of the Euphrates River upstream of Ramadi Barrage was selected, as shown in Figure 1, with a length of 3000 meters, since the problem of sedimentation resulting in this part is affecting the operation of the Ramadi Barrage [20–22]. The Barrage is located in the city of Ramadi, which is the largest city in the Anbar Governorate in Iraq. Ramadi Barrage is 209 meters long and consists of a concrete building with 24 openings, each 6 meters wide and 8 meters high. The Barrage is designed to discharge 3600 m^3/s at the height of 51.50 meters above sea level.

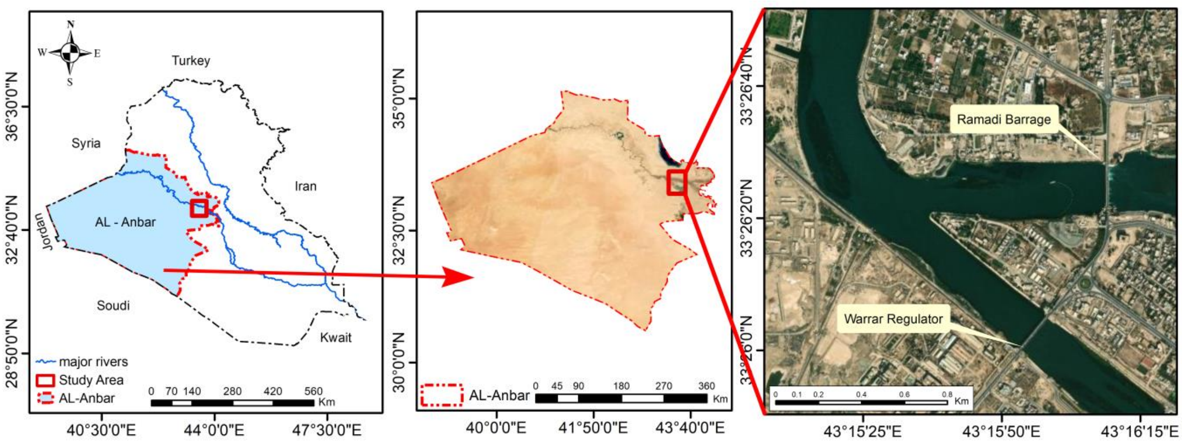

Figure 1.The location of the study reach

2.2 Field measurements

To accurately mimic the sediment data analysis of a specified river reach, the HEC-RAS 6.3.1 model needs precise input data. The input data for the simulation model can be divided into three categories: geometric data, quasi-unsteady data, and sediment data.

The river survey works included 24 selected cross-sections along the study area. The river's topographical characteristics and geometric changes determine the distance between the cross-sections. Using the Acoustic Doppler Current Profile (ADCP) technology, the following parameters were measured: bed elevation, top breadth, water level, area of cross sections, water velocity, and discharge. SonTek River Surveyor Live software version 4.2 were used for this purpose. All information about fieldwork which lies in computed discharge, cross-section area, and other hydraulic properties appears in the SonTek River Surveyor Live program starts recording all information after interconnecting with

Date: October 2023

the ADCP device. The total river width was divided into five vertical widths for sampling suspended load and bed load. The measurement point is situated in the middle of each of the five verticals.

A sampling of Suspended Load: There are 490 Suspended load samples taken. A depth-integrating suspended-sediment sampler was used to measure the transport of suspended loads of sediment, as shown in Figure 2.

A sampling of Bed Load: Bed Load is the amount of sediment that is always in constant touch with the river bed and carried forward by rolling, sliding, or hopping. For this test, there are (350) samples of the bed load sediment were taken by using the bed load sampler as shown in Figure 3. bed load movement measured for a period of (30 minutes) at each sample**.**

A sampling of bed material: Bed material samples were taken for each vertical width of the river cross-section by using Van Veen grab sampler as shown in figure 4. The grain size distribution considers one of the most important characteristics of sediment. The grain gradient of the soil was determined using the sieve analysis method. Figure 5 displays the grain size distribution curve.

Figure 2. depth-integrating suspended sediment sampler

Figure 3. Bed load sampler

Figure 4. Van Veen grab

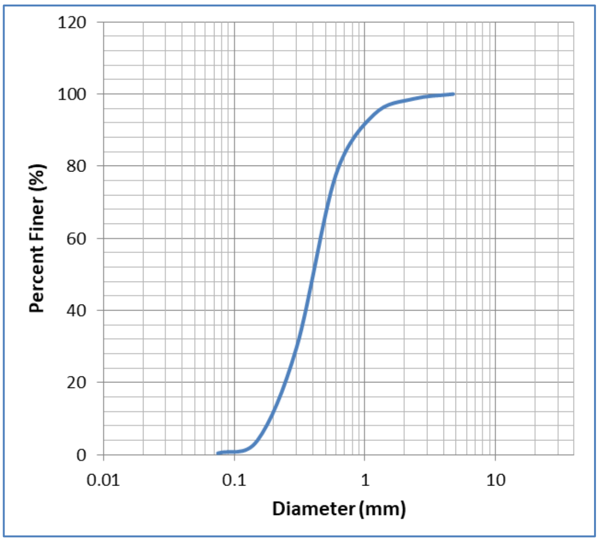

Figure 5. Grain size distribution curve

3. Results and Discussions

Calibration of the model and results verification are crucial procedures for applying the model, and these two processes are what determine model reliability. The calibration and verification processes

Date: October 2023

took place from July 26, 2022, to September 30, 2022, and from October 1, 2022, to December 31, 2022, respectively, show that the roughness coefficient for the study site equals (0.033), resulting in the lowest error ratio between the calculated and observed water surface elevations. Model calibration was followed by sediment investigation to determine the best sediment transport equation. The HEC-RAS system has seven transport equations, the Engelund-Hansen formula produced better-fit results with the field data. Thus, the Engelund-Hansen formula is chosen for further simulation.

Figure 6 shows cross-section No.24. Figure 7 shows the velocity of flow along the study area, and its lowest value is at the end of the reach due to the presence of the Ramadi Barrage. The concentration of sediment increased upstream of the study area due to the high velocity of flow, this concentration reached 204 mg/L see Figure 8. Figure 9 illustrated the stage and Flow Hydrograph for cross-section No.24 and Figure 10 represented the Sediment concentration for the first and last cross-sections of the study area. Figure 11 shows the simulated sediment discharge produced by the Engelund-Hansen formula and the measured sediment discharge. One of the leading causes of the sedimentation phenomenon can be the sudden reduction of flow velocity upstream of Ramadi Barrage. Because there are so large aggregated sediments in the river and because necessary precautions weren't taken early on, these sediments have solidified into bars and are now a part of the river section. Large sand bars that have formed as a result of sedimentation and a lack of routine river dredging have led to several issues, such as a reduction in the river's ability to pass flood discharge, high cost resulting from the removal of this sedimentation, severe deterioration in the water quality of the Euphrates, and a negative impact on the appearance of Ramadi city. High discharges resulting from rainy days could cause increasing in sediment load up to 400 mg/L and this could make the problem of sedimentation very huge and need a heavy cost for treatment and effect negatively on human life and activities.

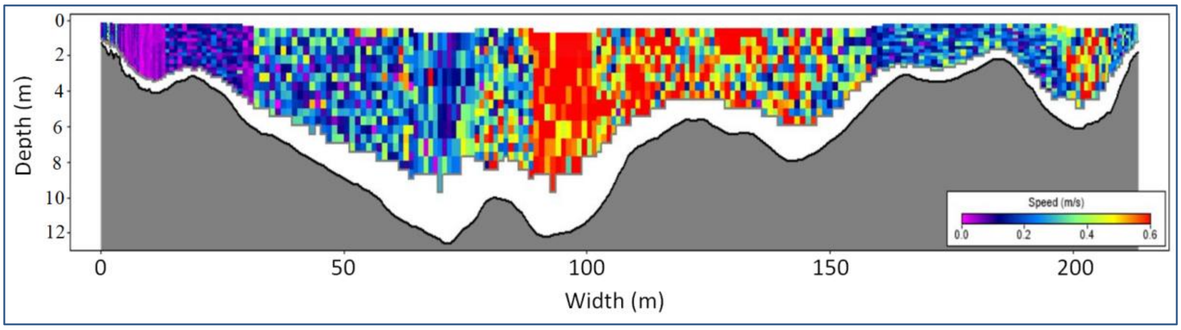

Figure 6. cross section No. 24

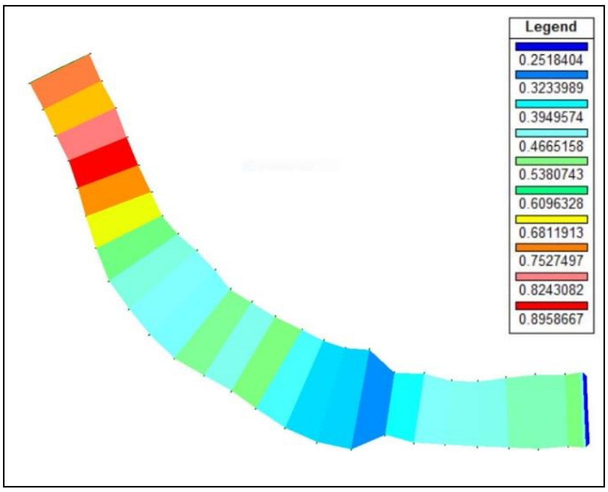

Figure 7. velocity along the study area

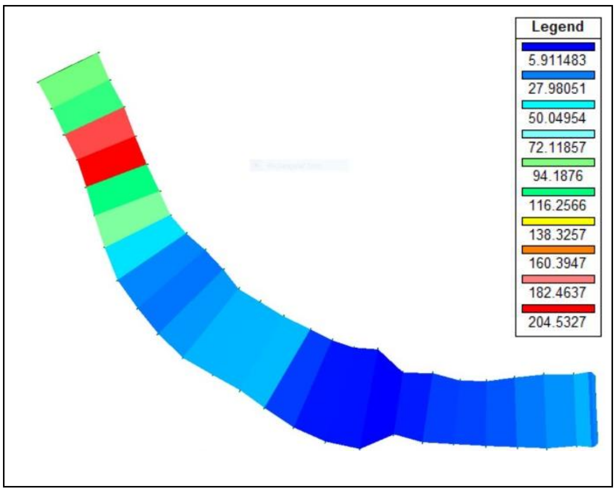

Figure 8. Sediment concentration along the study area

Date: October 2023

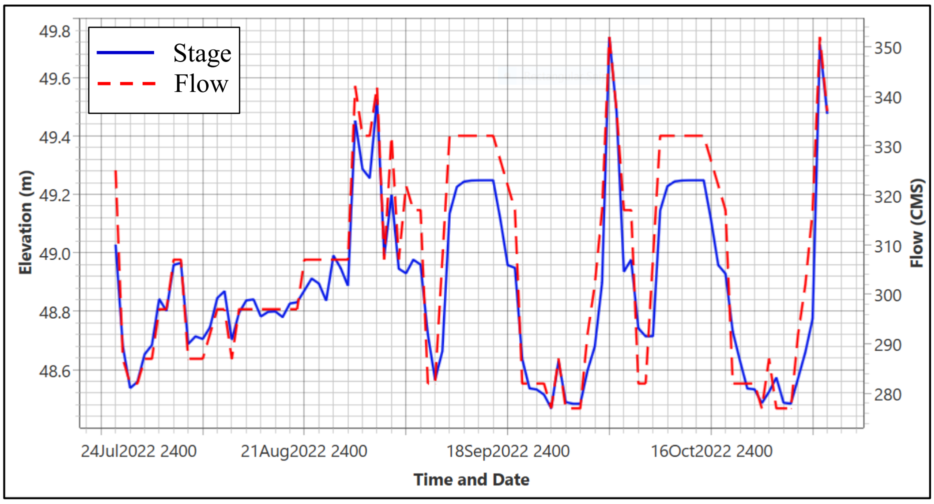

Figure 9. Stage and Flow Hydrograph for cross section No.24

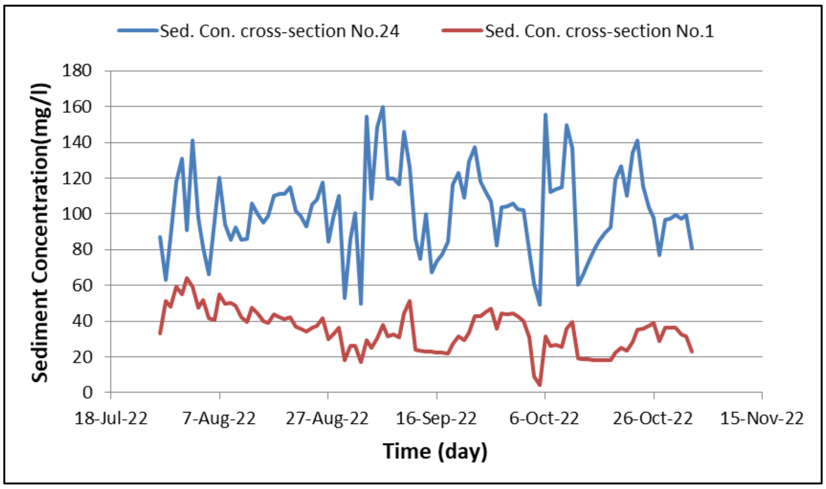

Figure 10. Sediment concentration for the first and last cross-section

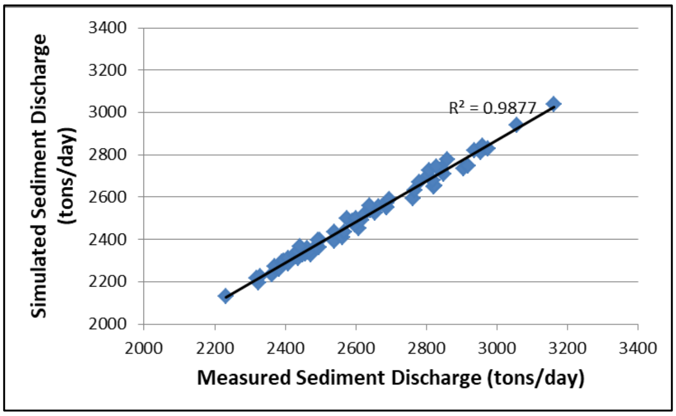

Figure 11. Measured and Simulated Sediment Discharge using the Engelund-Hansen formula.

Date: October 2023

4. Conclusion

The significant findings of this study are. The analysis of the resulting model indicated that significant sedimentation in the Euphrates River upstream of Ramadi Barrage agrees with the actual river situation. The sediment transport model indicated that the river bed level rises more near the Ramadi Barrage with A maximum deposition is about 3.17 m. The annual sediment yield calculated for the Euphrates River is 1002240 tone which is equal to 378203$\boldsymbol{m^3}$/year . It has been noted that sedimentation has been more prevalent in places with broad transverse sections, whereas erosion has been more prominent in areas with tight transverse sections. The Engelund-Hansen equation obtained accurate sediment discharge calculation. The Ramadi Barrage management may benefit from the projected sediment transport from this model in the long run. The capacity of the river reach, the nature of the river, and the physical characteristics are all examined as part of sedimentation research, which is crucial for making practical decisions about water management. The results of this study will also be helpful to water managers and decision-makers to prevent sediment erosion or deposition and so limit the consequences on the stability of the economy that may result from effects on bank infrastructure.

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Date: October 2023

Identification the Hydrogeochemical Facies of Groundwater in Rutba-Dhabaa, Western Iraq Using Multivariate Statistics Methods

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Abstract:The groundwater in the Rutba-Dhabaa region in Western Iraq has been studied using multiple statistical methods. These methods proved successful in giving a hydrochemical description of water as an alternative to the Piper scheme, and therefore they can be relied upon in future studies, whether for groundwater or surface water. The groundwater in the Rutba-Dhabaa region is hard and the percentage of calcium is high, due to the type of rocks incubating that groundwater, represented by the carbonate rocks that make up the Mulussa aquifer in the study area. According to the Piper diagram, correlation matrix analysis, cluster analysis, and principle component analysis, the hydrogeochemical facies are: Class 1 (Ca^{2+} - Mg^{2+} - Cl^- - SO_4^{2-}) where the wells (W1, W4, W13, W15, W16, W17, W20) fall within the category I (SO_4^{2-} - Cl^- and Ca^{2+} - Mg^{2+}) and rest of the samples falls within the category V (Mixing zone); Class 1 (Ca^{2+} - Mg^{2+} - Na^+ - SO_4^{2-}- Cl^- - HCO_3^-), Class 2 (Na^+ - Ca^{2+} - SO_4^{2-}), and Class 3 (Na^+ - HCO_3^-); Class 1 (Mg^{2+}, Na^+, and K^+), Class 2 ($HCO_3^-$and SO_4^{2-}), and Class 3 (Cl^- and Ca^{2+}); and Class 1 (Mg^{2+}, HCO_3^-, and Cl^-), and Class 2 (Na^+, K^+, and SO_4^{2-}) respectively.

1. Introduction

Groundwater is a significant natural water supply for residential, agricultural, and industrial uses. Groundwater is divided into different portions across the globe, with 65% being used for drinking water, 20% for animal feeding and farming, and 15% for industrial and mining uses [1]. Hydrogeochemical facies are defined as distinct zones that possess cation and anion concentration categories [2]. Facies are expressed as the measured concentration of major ions in decreasing order [3]. Hydrogeochemical facies interpretation is a useful tool for determining the chemical histories of groundwater bodies [4]. Hydrogeochemical facies are frequently compared by graphical methods, such as the Piper diagram [5]. The major cations and anions such as Ca^{2+}, Mg^{2+}, Na^+, K^+, HCO_3^-, SO_4^{2-}, and Cl^- in meq/l are plotted in Piper's trilinear diagram to evaluate the hydrochemistry of groundwater. Piper's classification [5] is used to express similarity and dissimilarity in the chemistry of different water samples based on the dominant cations and anions [6]. Although the Piper diagram is extensively used in the literature, it suffers from a serious drawback, namely that percentages of the various ions are considered and actual concentrations of the dissolved solids are therefore neglected [4].

Several authors employed multivariate statistics to interpret the hydrogeochemical facies of groundwater. The factor analysis can be used in much the same way as the graphical methods [7]. Using a multivariate statistical method, groundwater categorization and hydrogeochemical evaluation have recently been researched in various regions, Bangladesh [8], Latvia [9], India [10], Morocco

Date: October 2023

[11], Mexico [12], USA [13], South Africa [14], China [15], Egypt [16], India [17]. The researches in Iraq used multivariate statistical analysis to evaluate the quality of groundwater, such as in Makhmor plain [18], Baghdad City [19], Jisser Diyala [20], Erbil City [21], Al -Waffa and Kubayasa regions [22], in Zuber area [23], and in Rutba Area [24].

The study area is rich in previous studies related to water resources, for example, the studies presented by [25,29], all of these studies focused on water management and evaluating climatic factors in the region, but lacked statistical methods for interpreting hydrochemical facies and evaluating the water quality therein. Therefore, the aim of this study was an interpretation of the hydrogeochemical facies in groundwater using a multivariate statistics approach as an alternative to the Piper diagram.

2. Materials and Methods

2.1. Methodology

Multivariate statistics, such as correlation matrix analysis, cluster analysis (CA), and principal components analysis (PCA), were used in the current study as an alternative to the Piper diagram to evaluate the hydro-geochemical faces.

2.1.1. Correlation Matrix Analysis

A statistical technique for potential linear evaluation is matrix correlation analysis. The correlation can be used accurately based on the kind of parameter and the kinds of present variables being examined [30]. Effective factor analysis is another name for the process of displaying the relationships between multiple variables, including influencing factors, in addition to the sources of chemical elements [31].

2.1.2. Cluster Analysis (CA)

In order to overcome the difficulty of grouping, the CA process is performed prior to data analysis. This method aims to group or nodulate data. Each cluster has great internal homogeneity and high outer heterogeneity [32]. The most widely used cluster analysis method splits the data into distinct clusters before connecting each cluster one at a time until only one cluster is left [33].

2.1.3. Principle Component Analysis (PCA)

A process for assessing observations presented as data matrices and defined by a set of dependent variables that are frequently correlated with one another is called principle components analysis [34]. The factors, eigenvectors, and loadings are a collection of previously inferred variables used in the analysis of the basic components to gain significant information. According to the principal component estimate generated for each unit, a score is assigned to it.

2.2. Data Used

To identify the effectiveness of multivariate statistics in interpreting the hydrogeochemical facies of groundwater, the results of the chemical analysis of groundwater collected from 20 wells between Rutba and Dhabaa (Fig. 1) for the dry and wet seasons were chosen (Table 1).

Date: October 2023

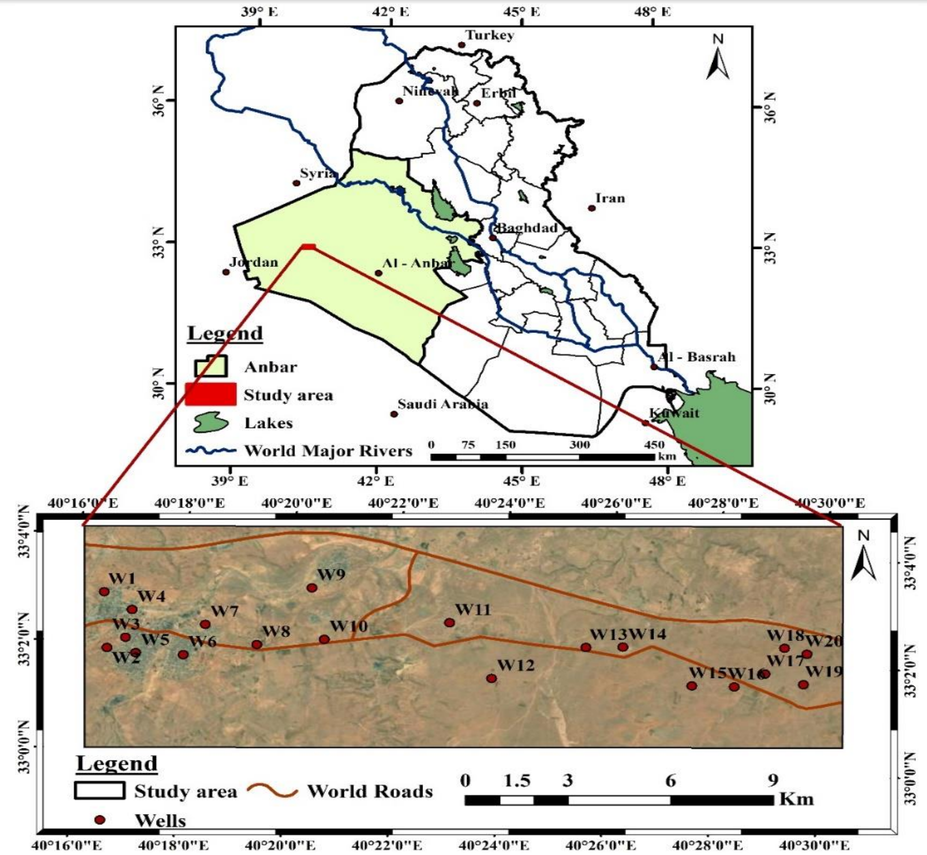

Figure 1. Location map of Rutba and Dhabaa, Western Iraq

Table 1. Concentrations of anions and cations of groundwater from Rutba and Dhabaa area

Well	Dry Period							Wet Period						
	Na^+	K^+	Ca^{2+}	Mg^{2+}	SO_4^{2-}	HCO_3^-	Cl^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	SO_4^{2-}	HCO_3^-	Cl^-
W1	36.7	3.4	177	85	290	225	270	33.4	2.8	171	77	271	211	251
W2	25	2.5	120	36	112	231	116	24	2	116	34	96	225	110
W3	28.7	1.8	110	42	125	256	111	25.4	1.6	104	35	106	248	98
W4	54	0.1	140	73	310	259	136	49	0	133	63	283	242	118
W5	39.3	2.9	110	42	188	250	88	35.6	2.8	102	36	168	236	75
W6	35.5	2.3	100	48	120	250	122	32	1.6	95	47	114	241	107
W7	28.6	0.9	80	39	101	237	80	25.2	0.5	76	32	85	221	69
W8	28.4	0	80	43	110	243	82	24.8	0	75	37	99	228	68
W9	15	3.5	90	33	136	189	60	12	3	87	29	130	185	48
W10	9.3	2.7	60	22	100	134	30	6.6	2.2	54	18	88	115	21
W11	20.6	2.1	60	34	120	156	40	12.2	1.2	55	29	109	144	33
W12	25	2.8	80	29	127	200	50	23	2.4	78	25	119	196	41
W13	24.7	1.2	90	37	169	178	67	23.4	0.9	86	30	159	168	55
W14	28	1.8	100	36	181	204	67	24	1.7	96	29	162	192	53
W15	45	0.8	300	24	402	225	222	42	0.7	268	21	378	210	182
W16	31	3.9	200	46	312	227	167	29	3.5	198	41	298	222	156
W17	60	10	149	55	366	200	120	53	8	143	51	356	190	106
W18	55	8	120	24.5	199	223	81.55	50	6	114	22	184	210	77
W19	23.5	0.9	110	30.5	160	204	71	21	0.4	103	24	144	193	58
W20	44	7	140	38.5	290	206	90	40	5.3	131	36	273	200	80

Date: October 2023

3. Results and Discussion

3.1. Piper's Diagram

To describe the hydrochemical facies of the groundwater samples in the area between Rutba and Dhabaa, the Piper diagram was used as a representative diagram showing the type of groundwater for the two periods (dry and wet) in the study area (Figures 2 and 3, Table 2). Where all groundwater samples were within the first class (class 1) represented by (Ca^{2+} - Mg^{2+} - Cl^{-} - SO_4^{2-}) but some of them (W1, W4, W13, W15, W16, W17, W20) fall within the category I (SO_4^{2-} - Cl^{-} and Ca^{2+} - Mg^{2+}) viz., permanent hardness (calcium chloride type) for the groundwater of Rutba and Dhabaa and the other part (rest of the samples) falls within the category V (Mixing zone (no one anion – cation exceed 50 %)). It is worth noting that the water is always hard and the percentage of calcium is high. It came from the type of rocks incubating that groundwater, represented by the carbonate rocks that make up the Mulussa aquifer in the study area.

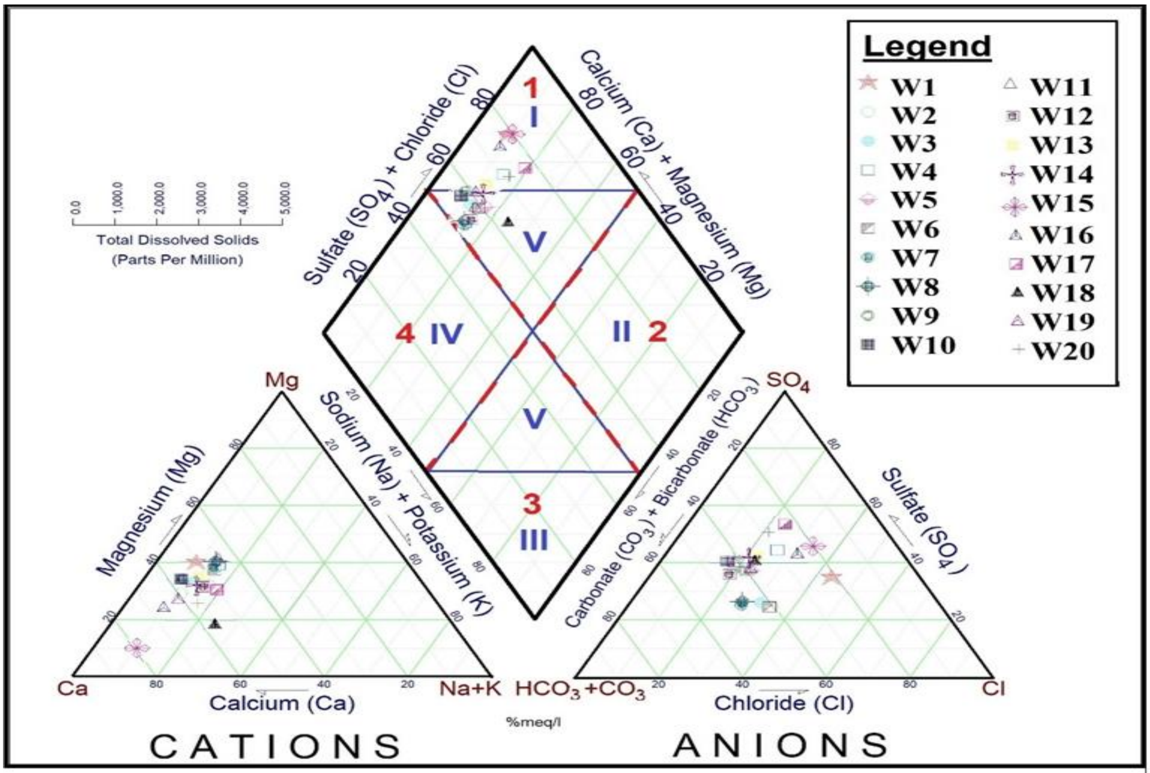

Figure 2. Piper’s diagram of the groundwater samples in the area between Rutba and Dhabaa (dry period)

Date: October 2023

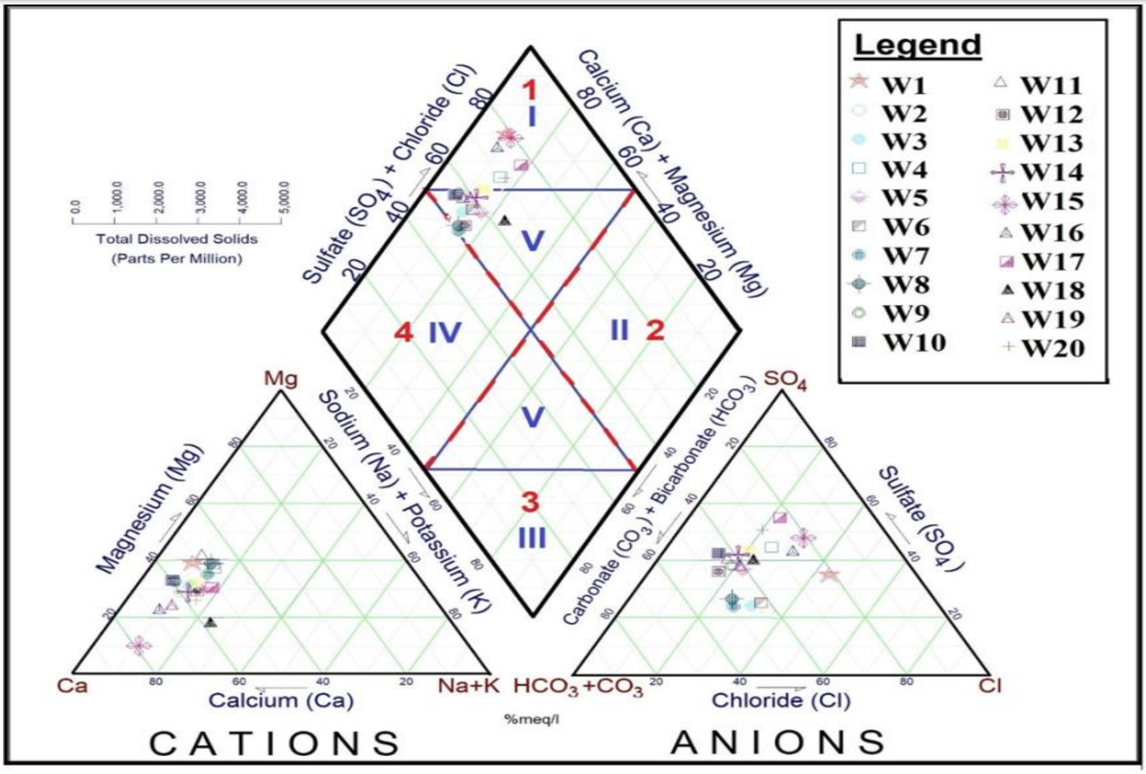

Figure 3. Piper's diagram of the groundwater samples in the area between Rutba and Dhabaa (wet period)

Table 2. Classification of the groundwater samples according to the Piper trilinear diagram

Hydrochemical Facies	Class	Water Type	Category
Ca^{2+} - Mg^{2+} - Cl^- - SO_4^{2-}	1	SO_4^{2-} - Cl^- and Ca^{2+} - Mg^{2+} (Permanent hardness); (non-carbonate hardness exceeds 50 %) calcium chloride type.	I
Na^+ - K^+ - Cl^- - SO_4^{2-}	2	SO_4^{2-} - Cl^- and Na^+ - K^+ (Saline); (non-carbonate alkali exceeds 50 %) sodium chloride type.	II
Na^+ - K^+ - HCO_3^-	3	HCO_3^- - CO_3^{2-} and Na^+ - K^+ (Alkali carbonate); (carbonate alkali exceeds 50 %) sodium bicarbonate type.	III
Ca^{2+} - Mg^{2+} - HCO_3^-	4	HCO_3^- - CO_3^{2-} and Ca^{2+} - Mg^{2+} (Temporary hardness); (carbonate hardness exceeds 50 %) magnesium bicarbonate type.	IV
		Mixing zone (no one anion–cation exceeds 50 %)	V

3.2. Correlation Matrix Analysis

Correlation is a measure of the relationship between two or more variables. The correlation coefficient (r) represents the linear relationship between two variables. In order to assess the association between variables, it is important to know the magnitude or strength of the relationship as well as the level of significance. The calculated significance level of the correlation is a primary source of information about the reliability of the correlation. The results of the correlation matrix analysis of the anions and cations of the groundwater in Rutba- Dabaa area for dry and wet periods are listed in Tables 3 and 4, respectively. From comparing the values of the correlation coefficients at the significance level $p \leq 0.05$ for the data of the two sampling periods, insignificant differences were recorded. For example, the values of the correlation coefficient (r) between the SO_4^{2-} and the Na^+ and Ca^{2+} were equal in the two sampling periods, while the differences between the values of the correlation coefficient (r) for the other ions ranged between 0.01 and 0.06, which are non-significant differences that do not greatly affect the strength of the correlation. This result indicates that the sampling season does not affect the correlation coefficient between anions and cations. A correlation coefficient (r) ≥ 0.7 often denotes a strong correlation between two variables, while a value of (r) from 0.50 to 0.70 denotes a moderate association [35]. The obtained results showed a significant strong positive correlation between the SO_4^{2-} - Ca^{2+} (r = 0.85) and SO_4^{2-} - Na^+ (r = 0.72). The results also showed that the Ca^{2+} - Cl^- ions were associated with a strong positive significant correlation (r = 0.82), and Cl^- was correlated with a medium positive significant correlation with the SO_4^{2-} (r =0.68) and Mg^{2+} (r = 0.61). The significant, strong, and medium positive correlations between the positive and negative ions of water of the study area indicate origin or common source of it, which in turn determines the hydrogeochemical facies and the types of groundwater. Depending on the significant positive correlations between the anions and cations of groundwater in the Rutba-Dahbaa region, three hydrogeochemical facies were classified: (1) Ca^{2+} - Mg^{2+} - Na^+ - SO_4^{2-}- Cl^- - HCO_3^-, (2) Na^+ - Ca^{2+} - SO_4^{2-}, and (3) Na^+ - HCO_3^-.

Table 3. Correlation matrix analysis of groundwater in Rutba-Dahbaa area (dry period)

Metals	**Na^+**	**K^+**	**Ca^{2+}**	**Mg^{2+}**	**SO_4^{2-}**	**HCO_3^-**	**Cl^-**
Na^+	1.00						
K^+	**0.50**	1.00					
Ca^{2+}	**0.52**	0.11	1.00				
Mg^{2+}	0.40	0.01	0.20	1.00			
SO_4^{2-}	**0.72**	0.37	**0.85**	0.38	1.00		
HCO_3^-	**0.50**	-0.17	0.32	0.44	0.17	1.00	
Cl^-	**0.46**	0.01	**0.82**	**0.61**	**0.68**	**0.48**	1.00

Marked correlations are significant at $p \leq 0.05$.

Table 4. Correlation matrix analysis of groundwater in Rutba-Dahbaa area (wet period)

Metals	**Na^+**	**K^+**	**Ca^{2+}**	**Mg^{2+}**	**SO_4^{2-}**	**HCO_3^-**	**Cl^-**
Na^+	1.00						
K^+	**0.47**	1.00					
Ca^{2+}	**0.57**	0.17	1.00				
Mg^{2+}	0.43	0.10	0.27	1.00			
SO_4^{2-}	**0.72**	0.42	**0.85**	0.40	1.00		
HCO_3^-	**0.52**	-0.10	0.34	0.43	0.15	1.00	
Cl^-	**0.49**	0.08	**0.81**	**0.67**	**0.65**	**0.47**	1.00

Marked correlations are significant at $p \leq 0.05$.

3.3. Cluster Analysis

Cluster analysis aims to classify the variables into homogeneous groups. The hierarchical cluster analysis (HCA) was carried out using Ward's method on the standardized data set. The dendrogram of the hierarchical cluster analysis for the anions and cations from the groundwater in the Rutba-Dahbaa region for dry and wet periods are shown in Figures 4 and 5, respectively.

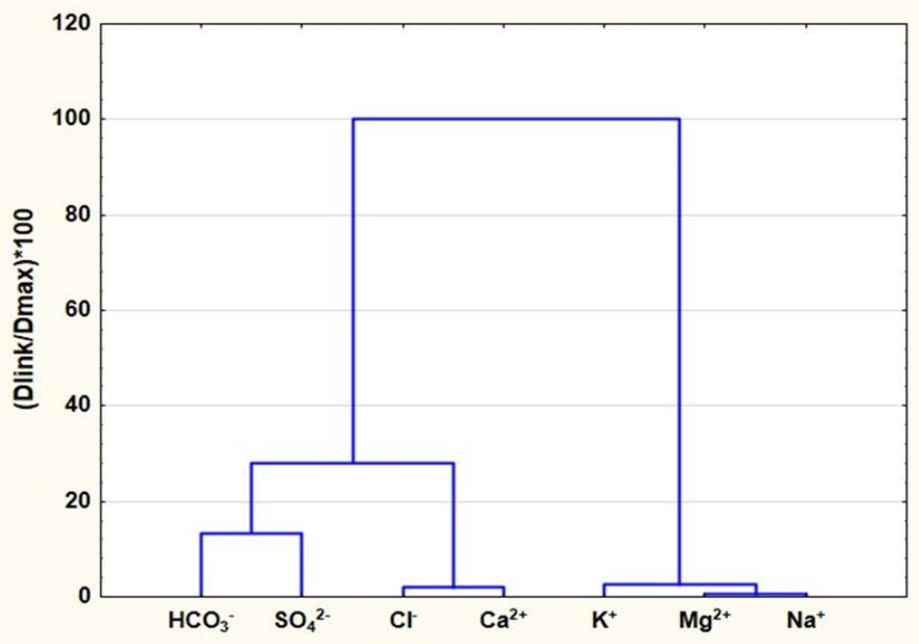

Figure 4. Dendrogram of the cluster analysis of the groundwater (dry period) in Rutaba–Dahbaa region

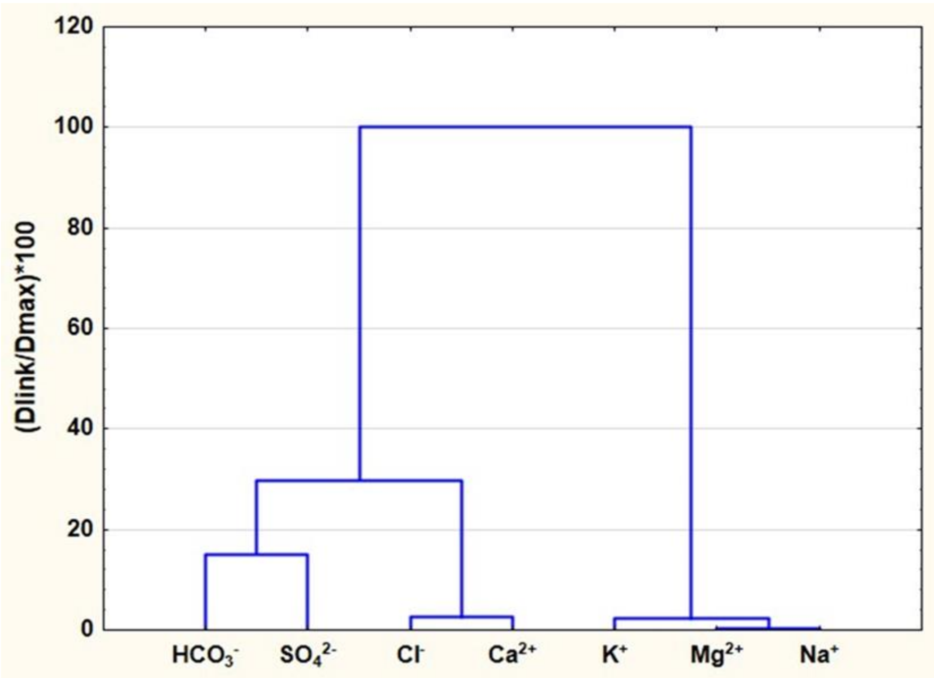

Figure 5. Dendrogram of the cluster analysis of the groundwater (wet period) in Rutaba – Dahbaa region

The results showed a complete agreement between the dendrogram of the positive and negative ions of the water collected in the dry period and that for the water collected in the wet period, and this suggests that the sampling period has not to effect on the results of the cluster analysis. Two clusters were identified: the first cluster includes Mg^{2+}, Na^{+}, and K^{+}, while the second cluster comprises two

Date: October 2023

subclusters, (1) HCO_3^-- SO_4^{2-}, and (2) Cl^- - Ca^{2+}. Grouping of cations (Mg^{2+}, Na^+, and K^+), anions ($HCO_3^-$and SO_4^{2-}), and anions and cations (Cl^- and Ca^{2+}) in same cluster shows that there are positive relationships between them, which in turn argues that they have a common source. According to the results of the cluster analysis, the groundwater in Rutba – Dahbaa region has the following hydrogeochemical facies: (1) Mg^{2+}, Na^+, and K^+, (2) $HCO_3^-$and SO_4^{2-}, and (3) Cl^- and Ca^{2+}.

3.4. Principle Component Analysis (PCA)

PCA was used to determine the hydrogeochemical facies of the groundwater collected from the Rutba-Dahbaa region by combining varimax rotation with Kaiser Normalization. Results of the PCA of the anions and cations in groundwater of the Rutba-Dahbaa region, for dry and wet periods, are listed in Table 5.

Table 5. Factor loadings (varimax rotation) of anions and cations in groundwater samples (dry and periods, left and right, respectively) from the Rutba - Dahbaa region

Ion	Factor 1	Factor 2	Ion	Factor 1	Factor 2
Na^+	0.38	**0.76**	**Na^+**	0.48	**0.71**
K^+	-0.38	**0.80**	**K^+**	-0.25	**0.81**
Ca^{2+}	0.56	0.62	**Ca^{2+}**	0.58	0.61
Mg^{2+}	**0.70**	0.15	**Mg^{2+}**	**0.72**	0.16
SO_4^{2-}	0.41	**0.83**	**SO_4^{2-}**	0.41	**0.83**
HCO_3^-	**0.78**	-0.01	**HCO_3^-**	**0.80**	-0.07
Cl^-	**0.80**	0.41	**Cl^-**	**0.82**	0.38
Eigenvalue	3.66	1.41	**Eigenvalue**	3.76	1.31
% Total variance	52.31	20.19	**% Total variance**	53.73	18.83
%Cumulative	52.31	72.50	**%Cumulative**	53.73	72.56

Marked loadings are >0.70

The result of the PCA for the ions of groundwater samples in Rutba- Dahbaa area that was collected in the dry period is in consistent agreement with those results for the samples collected in the wet period. This result shows that the groundwater sampling season does not affect the results of the PCA. The PCA findings reveal that there were two eigenvalues with values greater than one, accounting for a total of 72.50% and 72.56 % of the variance, for dry and wet periods, respectively. Factor (1) has significant positive loadings on Mg^{2+}, HCO_3^-, and Cl^- and accounts for 52.31% and 53.73 of the overall variation for dry and wet periods, respectively. Factor (2) exhibits 20.19 and 18.83% of the total variance for dry and wet periods, respectively, and has substantial positive loadings on Na^+, K^+ and SO_4^{2-}. [36] divided positive loading levels into three categories: strong positive loading (0.75–1.0), moderate positive loading (0.5-0.75), and weak positive loading (0.3–0.5). The strong positive loading suggests that factor (1) and Mg2+, HCO3-, and Cl-, as well as factor (2) and Na+, K+, and SO42-, have strong linear correlations. Based on strong loadings, the anions and cations of groundwater in Rutba-Dhabaa region may be coming from a common origin. According to the PCA results, two types of hydrogeochemical facies were identified: Mg^{2+}, HCO_3^- and Cl^- and Na^+, K^+, and SO_4^{2-}. According to the findings of correlation matrix analysis, cluster analysis, and basic compounds analysis of groundwater ions in the Rutba-Dhabaa area, the hydrogeochemical facies of that water is summarized in Table 6.

Table 6. Hydro-geochemical faces of the groundwater samples according to multivariate statistics methods and Piper's diagram

Class	**Hydro-geochemical Facies**			
	Correlation Analysis	**Cluster Analysis**	**Principle Component Analysis**	**Piper's Diagram**
1	Ca^{2+} - Mg^{2+} - Na^{+} - SO_4^{2-}- Cl^- - HCO_3^-	Mg^{2+} - Na^{+} - K^{+}	Mg^{2+}- HCO_3^- - Cl^-	Ca^{2+} - Mg^{2+} - Cl^- - SO_4^{2-}
2	Na^{+} - Ca^{2+} - SO_4^{2-}	HCO_3^- - SO_4^{2-}	Na^{+}- K^{+} - SO_4^{2}	Na^{+} - K^{+} - Cl^- - SO_4^{2-}
3	Na^{+} - HCO_3^-	Cl^- - Ca^{2+}.		Na^{+} - K^{+} - HCO_3^-
4				Ca^{2+} - Mg^{2+} - HCO_3^-

4. Conclusion

A statistical multivariate approach proved as a hydrochemical facies of water samples and gave water quality to several classes, and thus it can be used to describe the type of groundwater in the Rutba-Dhabaa area as an alternative to the Piper scheme. According to the Piper diagram, the groundwater is always hard and the percentage of calcium is high. It came from the type of rocks incubating that groundwater, represented by the carbonate rocks that make up the Mulussa aquifer in the study area. Three hydrogeochemical facies were classified according to correlation matrix analysis (1) Ca^{2+} - Mg^{2+} - Na^{+} - SO_4^{2-}- Cl^- - HCO_3^-, (2) Na^{+} - Ca^{2+} - SO_4^{2-}, and (3) Na^{+} - HCO_3^-. According to the findings of the CA, the groundwater in Rutba – Dahbaa region has three hydrogeochemical facies (1) Mg^{2+}, Na^{+} and K^{+}, (2) $HCO_3^-$and SO_4^{2-}, and (3) Cl^- and Ca^{2+}. Finally, according to the PCA results, two types of hydrogeochemical facies were identified: (Mg^{2+}, HCO_3^-, and Cl^-), and (Na^{+}, K^{+}, and SO_4^{2-}).

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Date: October 2023

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Date: October 2023

Effect of Nano phosphorous and Arginine on the Wheat *Triticum aestivum* L. Under water Deficit Condition

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Abstract: To investigate the effects of Nanophosphorous and Arginine on wheat, a field experiment was conducted in one of the farmers' fields in the east of Anbar, Iraq, in order to improve wheat drought tolerance. The plants were sprayed with Nano phosphorous, and Arginine was shown to have the highest rate of all the investigated features. The results demonstrated that the interaction between the study parameters was successful in increasing plant resistance to water deficiency.

1. Introduction

The wheat crop is one of the most widely grown cereal crops in Iraq, although there are many attempts to increase the yield. The wheat crop is considered the most important nutritional crop for humans in Iraq and the world, as it is provided to an adult 25 % of his need for protein and more than 50% of his need for energy [1].

Iraq is one of the origins of wheat, which has success factors for cultivation, but productivity remains below the required level. The cultivated area in Iraq for the year 2018 was estimated at 1.43 million hectares, and Iraq produced 1.25 million tons with a yield rate of 0.87 tons.[2, 3]. According to The (FAO) was increasing the The globe has paid close attention to Wheat's agronomic qualities, especially when it comes to making the best use of irrigation water [4] Thus, in order to maximize the use of water, effective water resource management must be developed. The lack of water alters the natural environment of plants in general, which ultimately affects physiologic function and decreases production [5]. Water sources must be considered since a long-term water shortage reduces plant development and production more than all other deficiencies combined. A lot of emphasis has also been paid in recent years to how crops might adapt to drought in order to identify efficient ways to deal with dehydration.

The sustainability of agricultural frameworks and environments is threatened by the constant rise in fertilizer applications on soil. In fact, fertilizers play a big part in ensuring the safety of the food in developing nations, especially when high yielding sets are used, which require a lot of fertilizer. Despite this, it was believed that excessive fertilization and the loss of soil organic matter were to blame for the yields of many crops starting to drop. In addition, intensive fertilizer applications of phosphorus (P) and nitrogen (N) contaminated groundwater and aided in the eutrophication of aquatic habitats. Given that fertilizer effectiveness varies between 20 and 50 percent for N and 10 to 25 percent for P fertilizers, food producers will need to be much more effective and well-organized than in the past. Nanofertilizer application is a recently developed technology. Because less fertilizer is wasted, there is less chance of environmental degradation, which contributes to the technique's superiority over conventional fertilizers [6]. One of the amino acids, arginine, has the ability to regulate osmotic pressure within the cell specifically [7], The relationship between the gap and the cytoplasm is affected by the presence of an imbalance in internal osmosis, which pushes arginine to

Date: October 2023

accumulate in the cytoplasm and create an equilibrium condition. It also has an impact on the maintenance of bulge cells and the preservation of enzymatic activity in the cytoplasm by maintaining the installation of cellular organelle membranes. Additionally, as an energy source for the aerobic respiration process, arginine helps plants overcome their water deficits and return to their natural states.

Wheat is one of the most crucial crops for human nutrition. Wheat's high protein content makes it an important source of plant protein in the human diet in addition to its basic caloric value. Due to its adaptability and flexibility in end products, wheat serves a crucial role as a food crop. According to calculations, the world will need to produce as much food in the next 50 years as it has since agriculture first emerged 10,000 years ago. [8].

2. Materials and Methods

2.1. Site of Study

The wheat has been cultivated in one of the farmers' fields in Juabh, east of Ramadi city in Anbar province, Iraq, in order to evaluate the effect of integrated treatment on wheat in order to increase the resistance of wheat to drought and the lack of irrigation water, Where the extraction of Nano phosphorous use it in two periods, First the seeds were soaked before planting and then sprayed on the leaves.

The study was divided into:

1.Experiment I: Soaking the wheat seeds in arginine increases the rate of germination.

2.Experiment II: Analyze the impact on the wheat of applying nanophosphorous and arginine when there is a water shortage.

Before planting, soil samples were taken from the field, crushed, and then passed through the sieve diameter of the openings to estimate some of the soil study's chemical and physical parameters.

The following techniques were employed:

1- The pipette method, as described in 1., was used to estimate soil texture. [9] explained in [10].

2- estimated Bulk density in core sampler method [9] explained in [11].

Three different sites on the experiment site were used to gather soil samples using a vicious cylinder (wet soil). The choice of soil was made at random. The cylinder's diameter and height were measured, and the samples were then weighed carefully in a balance, the weights were recorded, and the samples were then heated in an oven at 105 ° C for 8 hours.

Bulk Density = $[M \div D] \times L$ (1)

BD = soil bulk density (g / cm 3).

M = Dry sample weight (grams).

D = diameter of cylinder (cm).

L = cylinder Length (cm).

3- Electrical conductivity (EC): measured in a saturated dough extract using a conductivity bridge as detailed in (Page, 1982). (Peralta & Costa, 2013).

4- Soil moisture: The percentage of soil moisture was determined using a pressure membrane device pressure plate at tensile pressures of 33 kpa (field capacity) and 1500 kpa (wilting point).

Take samples of moist soil from three different, preferably random locations on the experiment field, weigh the samples using a sensitive balance, and record the weights of the samples to determine the percentage of soil moisture. After 8 hours in an oven set to 105°C, use the formula below to calculate the soil's moisture content.:

MC= $W1 - W2$ (2)

MC = content of soil depending on dry weight (%).

W_1 = moist sample weight (grams).

W_2 = dry sample weight (grams).

5- Determination of soil response (pH): using a pH-meter to measure in a leaking soaked soil dough.

Date: October 2023

6- Matter determination: One gram of air-dried soil sample was weighed in a 500 mL Erlenmeyer flask to determine the organic matter. A pipette was used to add 10 ml of 1N potassium dichromate solution at a rate of 10 ml each sample, as well as 20 ml of concentrated sulfuric acid. Shaking was used to mix the sample, which was then left for 30 minutes. 150 mL of distilled water, plus 0.5 N ferrous sulfate solution at the rate of 25 ml was added to the sample, and the excess was titrated to a pink end point with a 0.1 N potassium permanganate solution.
7-Available nitrogen in the soil: a micro-Kjeldahl device is used to assess available nitrogen in the soil using the approach of (Page, 1982).
8- Available phosphorus using the method (Olson) described before (Page, 1982).
9- Available Potassium: as mentioned, extraction using an ammonium acetate solution (1n) was estimated using an optical flame device flame photometer.[9]. The results recorded in Table 1.

Table 1. Before planting, the soil's chemical and physical attributes.

Measurement	Value
Available Phosphors (P) (mg.kg^{-1} soil)	**3.1**
The degree of soil interaction	**7.30**
Nutrients:	
Total nitrogen (N) %	**1.13**
Available Potassium (K) (mg.kg^{-1} soil)	**95.8**
Electrical conductivity ds.m^{-1}	**4.80**
Organic Metter (OM) %	**0.19**
Apparent density megagram/m^3	**1.75**
Volumetric distribution of separate soil gr kg soil)	
Clay	**10.72%**
Sand	**70.31%**
Silt	**17.93%**
Conception	**Sandy Loam**
Percentage soil moisture when pulling 33 KPa	**19.0**
Percentage soil moisture when you lift 1500 kPa	**6.7**

2.2. Experimental Design

This study used a split-plot design based on a randomized complete block design with three replications. Irrigation at three levels (25 percent, 50 percent, and 75 percent of field capacity) was used in the main plot, as well as optimum irrigation (no-deficit irrigation). The secondary plot will be sprayed with nanophosphorous, while the sub-secondary plot will be sprayed with the highest amounts of arginine.

2.3. Preparation of Nano phosphorous and Arginine:

It had been sprayed. phosphorous nanoparticles (0, 50,100,200 and300ppm) It was made in the following manner:

A solution concentration of 1000 mg per liter was achieved by dissolving one gram of nanophosphorous and arginine in a few drops of 95 percent ethanol (ethyl alcohol), which was then added to one liter of distilled water (1000 ml). The concentration of 50 mg per liter was attained by dilution of 50 ml of the original solution to a concentration of 50 mg per liter (concentration of 1000 mg. Liter) It was completed to a volume of 1000 ml of distilled water in order to prepare the concentration of 100 mg. After completing the first 100 ml of the original solution to a volume of 1000 ml, Liter repeated the process with the remaining 100 ml. [12]:

V_1 = Original size for solution (stockpiling).

C_1 =The concentration of stockpiling.

C_2 = Required concentration.

V2 =The required size.

(C1V1 = C2V2).

Date: October 2023

At the stage of (4-6) leaves, these concentrations were sprayed once on the leaves. As a surfactant agent, Tween (80) was added to the foliar solution at a concentration of (0.025) percent. Using a manual sprayer, spraying activities were carried out in the morning (6 a.m.) until the solutions were run off all plants. Nano phosphorous was sprayed one day, and arginine was sprayed the next.

3.4. Characteristics of study

3.4.1. Gibberellic Acid Concentration (GA_3) ($mg.kg^{-1}$).

The fermented broth was removed, centrifuged for 10 minutes at 13200 rpm, and the supernatant was then acidified with 1N HCl to a pH of 2-2.5. There, GA3 was extracted three times using an equal mixture of ethyl acetate and sodium hydroxide. [13]. To get rid of the ethyl acetate, the extract was held overnight in a hot air oven at 50°C. It was calculated using a spectrophotometric approach, and a UV-VIS spectrophotometer read the absorption at 254nm. [13]. The plant matter was air dried in the shade before being pulverized into small particles. The powdered leaves (1000 g) were macerated twice in each solvent: petroleum ether, ethyl acetate, chloroform, and ethanol. The extracts were filtered through muslin cloth on a glass wool plug in a glass column, and solvents were added. were evaporated invacuum using a rotary evaporator and stored in refrigerator at -20 °C.

3.4.2. Leaf relative water contents (RWC)

After harvesting, the leaf area and dry weight of the shoots were measured. To acquire their dry weights, 5 plants from each group were weighed fresh and then dried in an oven at 60oC for 1 night (DW). Nine leaves were weighed (fresh weight, FW) immediately after the plant was harvested to determine plant RWC. The same tissues were then placed in a distilled water vial for 2 hours at 25 degrees Celsius, and their turgid weights (TW) were calculated. To get their dry weights, the samples were dried in an oven at 110 C0 for 24 hours (DW).

Relative water contents calculated by following [14]:

$$RWC = \frac{(FW - DW)}{(TW - DW)} \times 100 \quad (3)$$

3.4.3. Estimate the Levels of Ribonuclease Enzyme.

The method of [15] was used with some modifications described by [16]. 2 gram of wet Wheat grains were ground in a casserole to extract the grain's enzyme. 0.05 moles of phosphate buffer were used. The volume of 5 ml was completed with a pH of (6.5). Transfer the mixture to the centrifuge tube R / min for ten minutes, and you must finish all of the earlier stages at a low temperature. You must also conduct absorption to the solution in order to get the activated charcoal to remove the pigments. It was finished to a known size using phosphate buffer, which served as an enzyme source. To calculate the enzyme's activity The acetate buffer solution with pH 5 was used to create the ribonuclease enzyme. 1% RNA was then added, and 0.5 ml of the enzymatic extraction was added. For one hour, the reaction mixture was heated to 30 m. Then, 1 ml of 10% trichloroethylene acetic acid (TCA) was added to cease the interaction, and the sediment was removed using a centrifuge tube at 10.000 R/min for ten minutes. The optical density/gram weight wet/h change was used to calculate the enzyme activity. After twenty minutes, samples were read using a UV/visible spectrophotometer at a wavelength of 710 nm. expressed appreciation for the activity of the enzymes by the following equation [17]:

Optically dense (O.D) Approximately 60 minutes total
weight × sample size× time

(4)

Date: October 2023

3.4.4. Estimate the levels of α-amylase enzyme:

The method followed [18] was used with some modifications described by[19]. A known weight was obtained from the wet samples and ground in a 5 mm potassium phosphate buffer solution with a pH of 7.6. Following filtration, the filtrate was centrifuged at 1500 rpm for 20 minutes at 4 C°, after which it was used immediately. Were followers using the [20] To estimate the amylase, 1% of starch was dissolved in 0.01 moles of pH 7.6 phosphate buffer on the same experimentation day. Putting 2.5 ml of the starch solution, 0.15 ml of distilled water, and 0.05 ml of the preceding grain extract in a test tube. After 5 minutes of incubation at 30 °C, the tube was subjected to the procedure. [21] The enzyme that has been isolated and put in the tube works on converting starch to glucose, and its activity can be determined by measuring sugars.

3. Results and Discussion

3.1. Gibberellic acid (GA_3) Concentration in the leaves (µm mg^{-1}tissue).

Table 2 and Figure 1 demonstrate how water shortage has a major impact on the Gibberellic acid (GA3) concentration in the leaves (µm mg^{-1} tissue). The findings revealed that the plants received the highest rate of Gibberellic acid (GA3) concentration in the leaves when they were irrigated at 25% of field capacity, which was 114m mg-1 tissue. This was noticeably higher than the other treatments of 50% and 75%, which produced 110 µm mg^{-1} tissue and 104 µm mg^{-1} tissue, respectively. Although 75 percent of the field's watering capacity resulted in the lowest rate of Gibberellic acid (GA3) concentration in plant leaves, this treatment stood out from the 50 and 25 percent field capacity alternatives in a significant way. These conclusions are supported by the study of these results. [22] Which emphasized that water deficit in Wheat markedly increased ABA accumulation, whereas drought substantially decreased Gibberellic acid (GA_3) contents in grains.

The findings of the triple interaction between amounts of irrigation, sprayed nanophosphorous, and arginine on the content of gibberellic acid (GA3) are shown in Table 1. In the greatest rate of Gibberellic acid (GA3) concentration was 136 m mg-1 tissue with a significant difference from the other, the results showed superiority of interaction 25% of field capacity and 300 ppm Nano phosphorous and 300 ppm Arginine. When plants that have not been treated with Nano phosphorous and Arginine 75% of field capacity, which has given an average Gibberellic acid (GA3) concentration 104m mg-1tissue with a significant decrease when compared to the other interactions, were used, the Gibberellic acid (GA3) concentration was recorded at the lowest rate. The interactions 75% of field capacity, 0 pm Nano phosphorous, and 100 ppm Arginine came next, and at a rate of Gibberellic acid (GA3) concentration of 105 µm mg^{-1} tissue, they were the only ones to differ significantly from the others interactions, 75% of field capacity, 0 pm Nano phosphorous, and 0 ppm Arginine, did not.

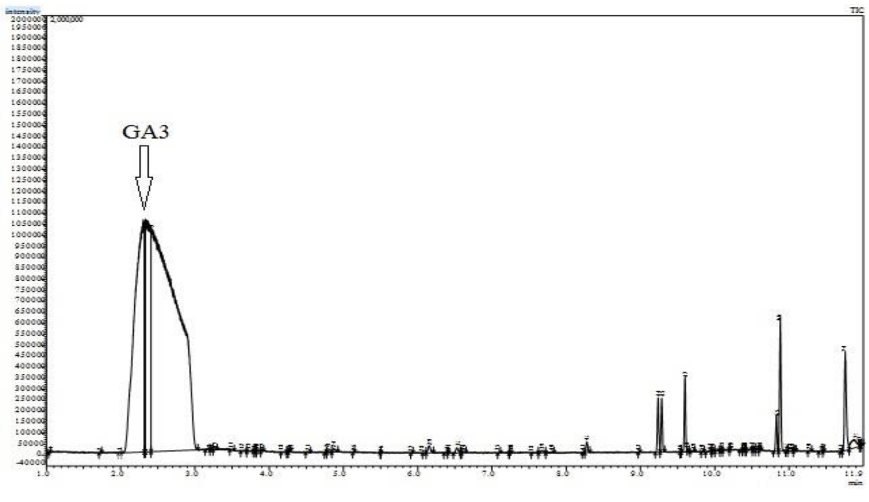


Figure1. GCMS analysis of the extract of the leaves showing the presence of Gibberellic acid (GA_3) concentration (µm mg^{-1}tissue) 25% of field capacity and 300ppm Nano phosphorous and 300ppm Arginine.

Date: October 2023

3.2. Leaf relative water contents (RWC)

Figure 3 shows how a lack of water has a substantial impact on the relative water content of leaves (RWC). The plants performed better when watered at 25% of the field capacity because they produced more leaf relative water contents at that rate, which was 67.44 percent, as opposed to 50% and 75 percent, which produced 61.13 percent and 54.12 percent, respectively. There was a significant difference between the treatments using 50% and 25% of the field capacity, even though the lowest rate of total Leaf relative water contents in plants was 54.33 percent when 75% of the field capacity was watered. These results are consistent with those of (1), who discovered a similar decline in total Leaf relative water content in alfalfa due to a water shortage.

Table 2 demonstrates that the tripartite interaction of arginine, nanophosphorous, and field capacity produces the strongest results. The greatest rate of leaf relative water contents was 96.33 percent with 25% of field capacity, 300 ppm Nano phosphorous, and 300 ppm Arginine, which is a significant difference from other interactions. The lowest rate of leaf relative water contents, which was much lower than other interactions, was 54.12% at the interaction between 75% of the field capacity, 0 ppm Nano phosphorous, and 0 ppm Arginine. The conversation With the exception of the treatment 75 percent of field capacity and 0ppm Nano phosphorous and 0ppm Arginine, the interaction of 75 percent of field capacity and 50ppm Nano phosphorous and 0ppm Arginine was followed by the treatment 75 percent of field capacity and 0ppm Arginine with the leaf relative water contents rate of 55.67%.

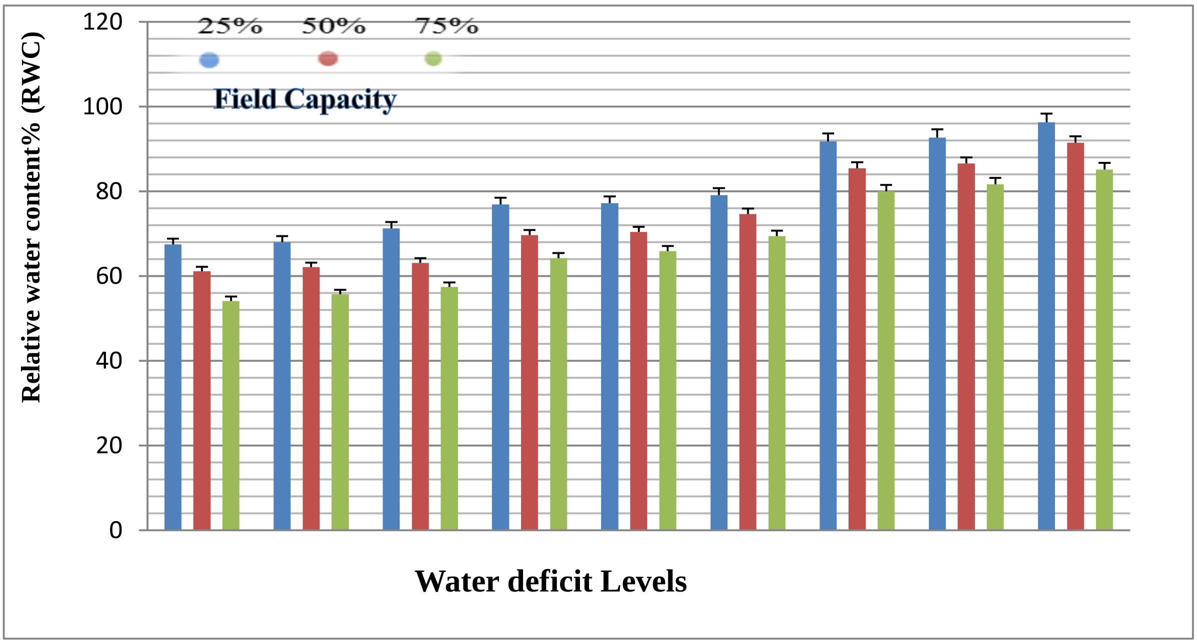


Figure 2. Effect of Field capacity, sprayed Nano phosphorous and Arginine on relative water content% (RWC).

Date: October 2023

3.3. Ribonuclease Enzyme Levels (µm mg^{-1} tissue).

The search results shown in Figure 4 reveal a significant impact of water deprivation on the levels of the enzyme ribonuclease. The best rate of Ribonuclease enzyme levels was 3.55 m mg-1 tissue, which was superior to the other treatments' 3.31 m mg-1 tissue and 2.80 m mg-1 tissue, respectively, when the plants were watered to 75% of the field capacity. Although plants irrigated at 25% of field capacity had the lowest rate of Ribonuclease enzyme levels (2.86m mg-1 tissue), this was significantly different from the two treatments at 50% and 75% of field capacity. The data shown in Table 3 show a threefold interaction between irrigation levels, nanophosphorous sprayed levels, and arginine levels on ribonuclease enzyme levels. The outcomes revealed that the 75 percent field capacity interaction with 300ppm Nano phosphorous and 300ppm Arginine had the highest rate of ribonuclease enzyme levels at 8.34 µ mg^{-1} tissue, which was significantly greater than the other interactions. When plants were not treated with Nano phosphorous and Arginine 25 percent of field capacity and 0 ppm Nano phosphorous and 0 ppm Arginine, the lowest rate of ribonuclease enzyme levels was seen. This led to an average ribonuclease enzyme 2.80 µ m mg^{-1} tissue with a significant decrease in comparison to the other interactions.

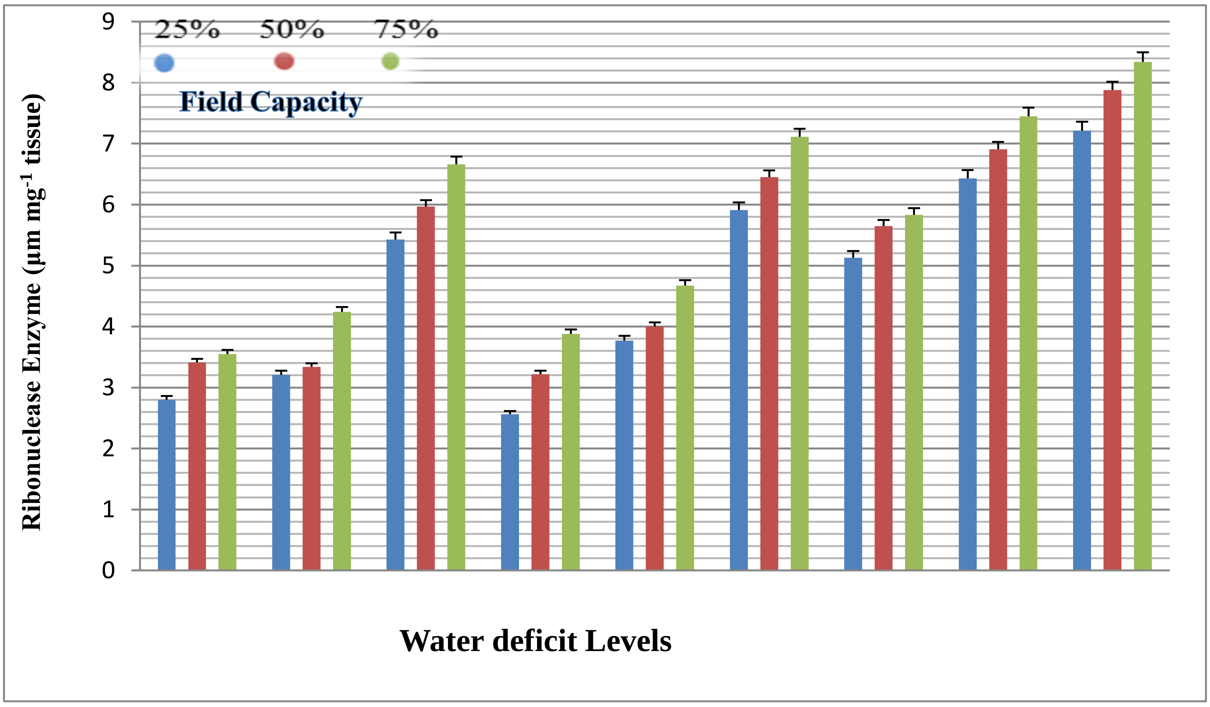


Figure 3. Effect of the Field capacity, Nano phosphorous and Arginine on Levels of Ribonuclease Enzyme (RNases) (µm mg^{-1} tissue).

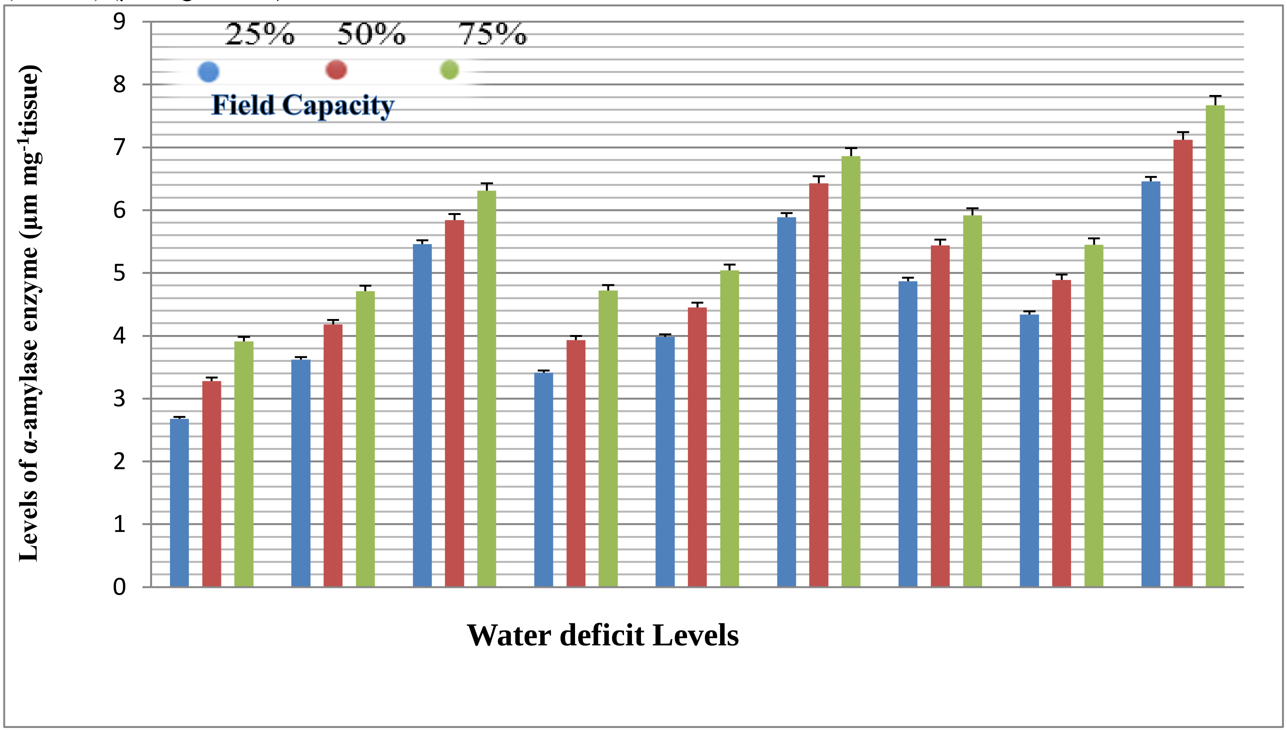
3.4. Levels of α-amylase enzyme (µm mg-1tissue)

Figure 4 demonstrates how low amylase enzyme levels are significantly impacted by dehydration. In comparison to the control treatments, amylase activity is higher in the experimental plants. According to the findings, plants that received watering at 75% of the field's capacity had the highest amylase enzyme levels, reaching 3.91 µ mg^{-1} tissue. This was significantly higher than the levels obtained with the other treatments of 50% and 25%, which were 3.28 µ mg^{-1} tissue and 2.68 µ mg^{-1} tissue, respectively. The treatments that resulted in the lowest amylase enzyme levels in the plants were those that irrigated at rates of 25%, 75%, and 50% of field capacity, respectively. Figure 4 shows how the three-way interaction of arginine, nanophosphorus, and field capacity enhanced certain research

Date: October 2023

results from a blogger of the wheat characteristics The results showed that the 75 percent field capacity interaction with 300ppm Nano phosphorous and 300ppm arginine was superior to the other interactions, with the greatest rate of -amylase enzyme levels of 7.67 μ mg^{-1} tissue. The lowest rate of -amylase enzyme levels was 2.68 μ mg^{-1} tissue at the contacts 25% of field capacity, 0 ppm Nano phosphorous, and 0 ppm Arginine, which was a significant decrease compared to other interactions.

Figure 4. Effect of the Field capacity, Nano phosphorous and Arginine on Levels of Ribonuclease Enzyme (RNases) (μm mg^{-1} tissue).



4. Conclusion

An enzyme can be used as an indication of exposure to plant stress, according to experiments and the results of the previous study, which found that water stress has a major impact on all essential plant functions. One of the primary elements that is highly vital to plants and plays a part in all of their activities is phosphorus. Arginine also clearly contributes to the efficiency of plants.

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Spatial and Temporal Analyses of Precipitation and Temperature in Iraq

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Abstract: Historical climate observations show that Iraq, and the rest of the world, is passing through a dramatic change in precipitation and temperature for the last twenty decades. Temperature trends are increasing with extreme precipitation events causing flooding, heatwaves, and drought affecting millions of people and costing billions. This study is focusing on the trends, seasonal variability, and the relationship between precipitation and temperature in Iraq. The study includes two analyses, spatial and temporal. The spatial analysis is investigating the relationships between precipitation and four other parameters: ground elevation, temperature, latitude, and longitude. The purpose of this analysis is to see how well precipitation is correlated spatially to these climatological and topographical variables. Results show that there is a good relationship between precipitation and latitude, which represents the distance from the equator, with coefficients of determination, R2, of 0.907. Temperature and elevation have a weak spatial relationship with precipitation, especially in the western part of the country. The second analysis includes the temporal trends of precipitation and temperature. Temporal analysis of precipitation shows the extreme climate events by calculating the error of observed precipitation from the best fit curve of historical data. Finally, both spatial and temporal analyses of precipitation were validated using different periods of observed data. The first 50% of the data was used for calibration and the second 50% of the data for validation and verse versa. Results show that calibrated equations have similar coefficients of determination compared with the validation results. In general, the relationships between monthly precipitation and both seasonality change and temperature are weak with coefficients of determination, R2, of 0.697 and 0.6858 respectively.

1.Introduction

Many previous studies and evidence have reported that there is a correlation between precipitation and temperature [5, 17, 14, 15]. It has been found that the northern part of Iraq, particularly over the mountains, has relatively higher average precipitation and lower temperature [16]. This reflects a negative correlation between temperature and precipitation and a positive correlation between ground surface elevation and precipitation. Precipitation and temperature can even affect snowpack trends [8]. These correlations are critical for expanding our knowledge of climate and water resources [6, 7].

Poage and Chamberlain [13] analyzed the empirical relationships between elevation, the isotopic composition of precipitation, and surface waters. They found that, in most regions of the world, the isotopic composition of precipitation decreases with increasing elevation. In addition, the trend analysis of temperature and precipitation over Iraq was previously investigated under the Special

Date: October 2023

Report on Emissions Scenarios (SRES) for the observed period 1971–2020 [9]. This leads to further analyses of the relationship between precipitation and temperature. The future prediction of precipitation and temperature has been analyzed in Ref. [3] using historical data to create future projection models. Prediction modeling results show an increasing trend of temperature and a decrease in precipitation for the next twenty years [2].

Salman et al. [16] studied the spatial and temporal spatiotemporal changes of precipitation and temperature in Iraq using different socioeconomic pathways and scenarios. Their study was focused on the changes in precipitation and temperature and the implications of these climate analyses in arid regions more specifically in Iraq. The authors used different methods to estimate the future annual and seasonal temperature and precipitation in Iraq and their results confirm the predicted increase in temperature and decrease in precipitation as predicted by previous studies [2, 3].

Other studies focused on the seasonal and annual variation of precipitation. Concerning the region of Iraq, Mail et al. [12], investigated the past variability of precipitation. Such studies provide information about the potential future climate risks in Iraq. These analyses are critical for water management authorities and agriculture development. In addition to large-scale analysis, many previous studies analyzed regional areas. Some studies focused on the changes in temperature and precipitation in Baghdad as a regional study using the recorded historical climatology data [1, 10]. These studies analyzed the trends of rainfall in Baghdad using recorded monthly data and different models and techniques [1, 10].

In this study, the relationships between precipitation with ground surface elevation, average temperature, latitude, and longitude were analyzed. The spatial and temporal distribution of precipitation against the other four parameters were analyzed to find the best-fit curve. The purpose of this study is to see how well precipitation is correlated to elevation, temperature, latitude, and longitude across Iraq using the historical monthly climate data.

2. Materials and Methods

Ground surface elevation (Figure 1a) was specified using the HydroSHEDS digital elevation map [11]. Monthly and annual precipitation and temperature data for the years 1991 to 2020 in Iraq were collected from (https://climateknowledgeportal.worldbank.org) the Climate Change Knowledge Portal (CCKP) database of the World Bank Group [4]. Precipitation, maximum, minimum, and average temperature data (Figures 1b, 1c, and 1d) are used in the spatial analysis of annual mean values for the data from 1991 to 2020. While monthly time series of precipitation and temperature for the period between 1960 and 2020 used for the temporal analyses.

First, precipitation and temperature were analyzed spatially over Iraq using average values with a resolution of 0.5 degrees (55.505 km) grid cell. Then, time series analyses were conducted for precipitation and temperature using monthly historical data. The temporal analyses include the annual trends as well as the seasonal variability of temperature and precipitation over Iraq and its major cities. Three major cities were selected in this study besides analyses of overall Iraq: Baghdad, Mosul, and Basrah. These cities were selected because they are distributed over the study area (north, middle, and south of the country) and have a higher population. Finally, best-fit equations resulting from the analysis were validated using different periods of observed climate data.

Precipitation was spatially analyzed with respect to four parameters: elevation, average temperature, latitude, and longitude. The spatial analysis was conducted with a resolution of 0.5 degrees (55.505 km) grid cell as provided by the data source. First, the study analyzed the relationship between precipitation and the four other parameters (Figures 2a, 2b, 2c, and 2d) using a nonlinear polynomial best-fit curve. In addition, the relationship between temperature and elevation and the relationship between temperature and latitude (Figures 2e and 2f) were also calculated using the same method to test the spatial distributions of both precipitation and temperature with respect to elevation

Date: October 2023

and the vertical distance from the equator. Since the western part of the country, which is mostly desert, has a relatively high ground surface elevation and low precipitation the relation analysis for this particular region was separately analyzed (Figure 3).

Second, the historical monthly time series data of precipitation and temperature are used to analyze the trend of these two parameters over time. Seasonal variation (Figure 4) and the relationship (Figure 5) between precipitation and temperature were analyzed for the average monthly data to find the regression constants and the residual errors. Then, the annual trends of precipitation and temperature are calculated using time series analysis (Figure 6) to describe the annual and seasonal change of both precipitation and temperature. Historical data show increasing in the average annual temperature and decreasing in precipitation trends for the period between 1960 and 2020. In addition, the relationship of monthly seasonality change between precipitation and temperature (Figures 7a and 7b), and the relationship between precipitation and temperature (Figure 7c) for each month from 1960 to 2020 were analyzed and the regression constants were calculated. These relationships and best-fit equations are used for different time frames to validate these methods. Finally, the best-fit equations were validated and error over time was calculated to study how well these analyses can fit the observed data and what years have the most extreme precipitation events that result in higher calibration errors. Regression constants are calculated for all best-fit curves.

3.Results and Discussion

3.1. Spatial analysis

Results show that precipitation has a poor relationship with temperature and ground surface elevation, especially in the western part of the country (Figure 2a and 2b) with a coefficient of determination, R^2, equal to 0.3 and 0.018 respectively. This happens because the western part of the country, which is mostly covered with desert, has a relatively higher elevation compared with the other parts with low precipitation. While the relationship between the central and eastern parts of the country, from north to south, results in higher precipitation with higher elevation. Figure 3 demonstrates how well precipitation is related to ground surface elevation and temperature when the western part of the country is analyzed separately. The western part is located to the west of 42° longitude with average annual precipitation of less than 225 mm. The highest relationship among all parameters tested in this study was precipitation versus latitude (Figure 2c), this is because precipitation increases farther away from the equator and closer to the mountains in the north.

3.2.Temporal analysis

Results show a high relationship between precipitation and temperature best-fit curves over the seasonal variability whether calculating the mean values of each month for each city (Figure 4) or using the monthly data (Figures 7a and 7b). For example, the monthly seasonality change of both precipitation and temperature over Iraq has a coefficient of determination values, R^2, of 0.93 and 0.99 respectively (Figure 4). Results show that there is a low relationship between precipitation and temperature in Iraq using monthly observations from 1960 to 2020 (Figure 7c) with a coefficient of determination values, R^2, of 0.685. The best-fit equations and regression constants for the precipitation versus temperature (Figure 7c) data are validated. The validation of best-fit equations is explained in detail in the next section.

Date: October 2023

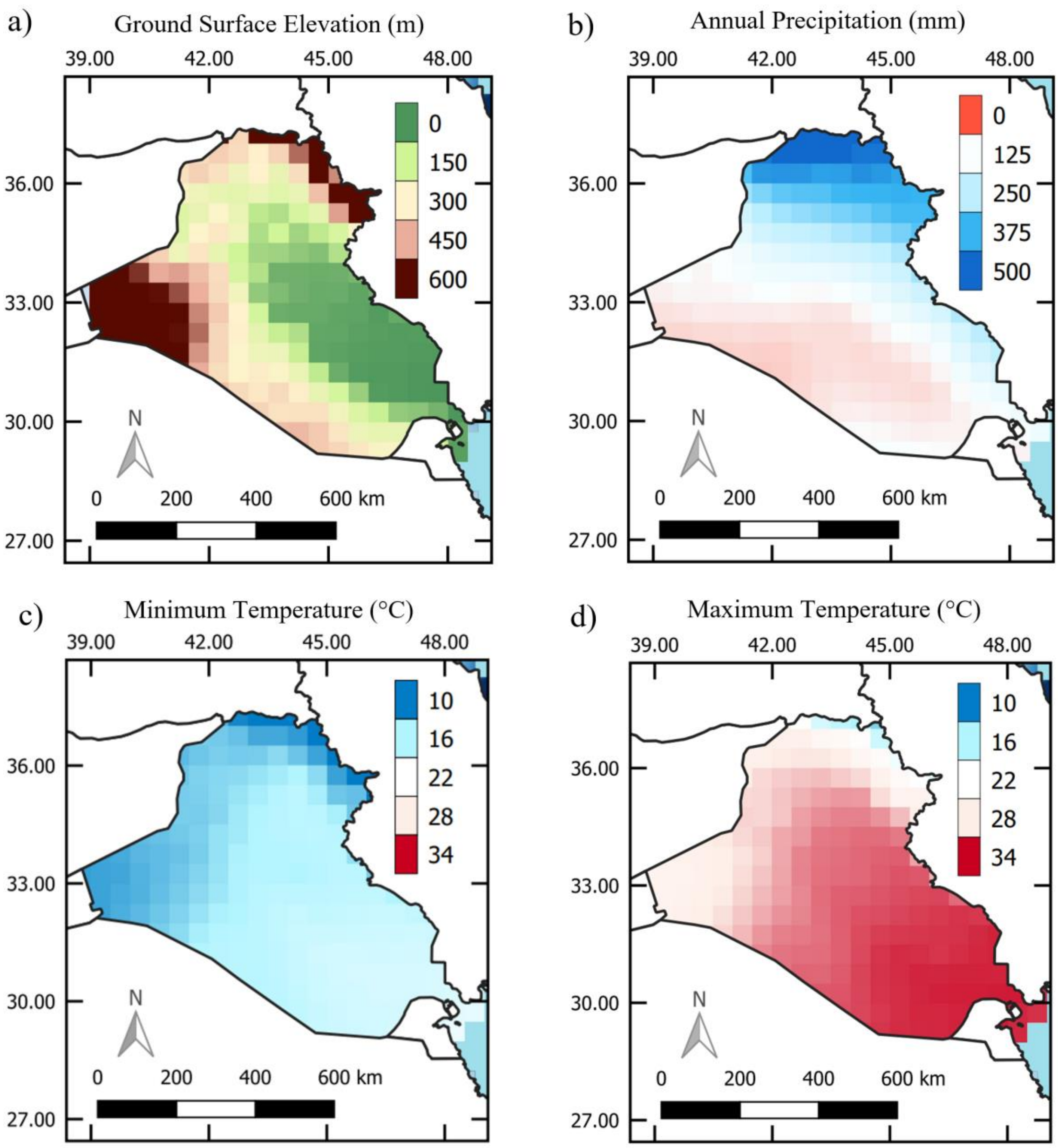

Figure 1. Meteorological and topography data in Iraq; (a) Ground surface elevation [m] above sea level. Data from Ref. [11]; (b) Average annual precipitation [mm], (c) minimum, and (d) maximum average annual temperature (°C) (resolution of 0.5 degrees (55.505 km) grid cell). Data from Ref. [4].

Date: October 2023

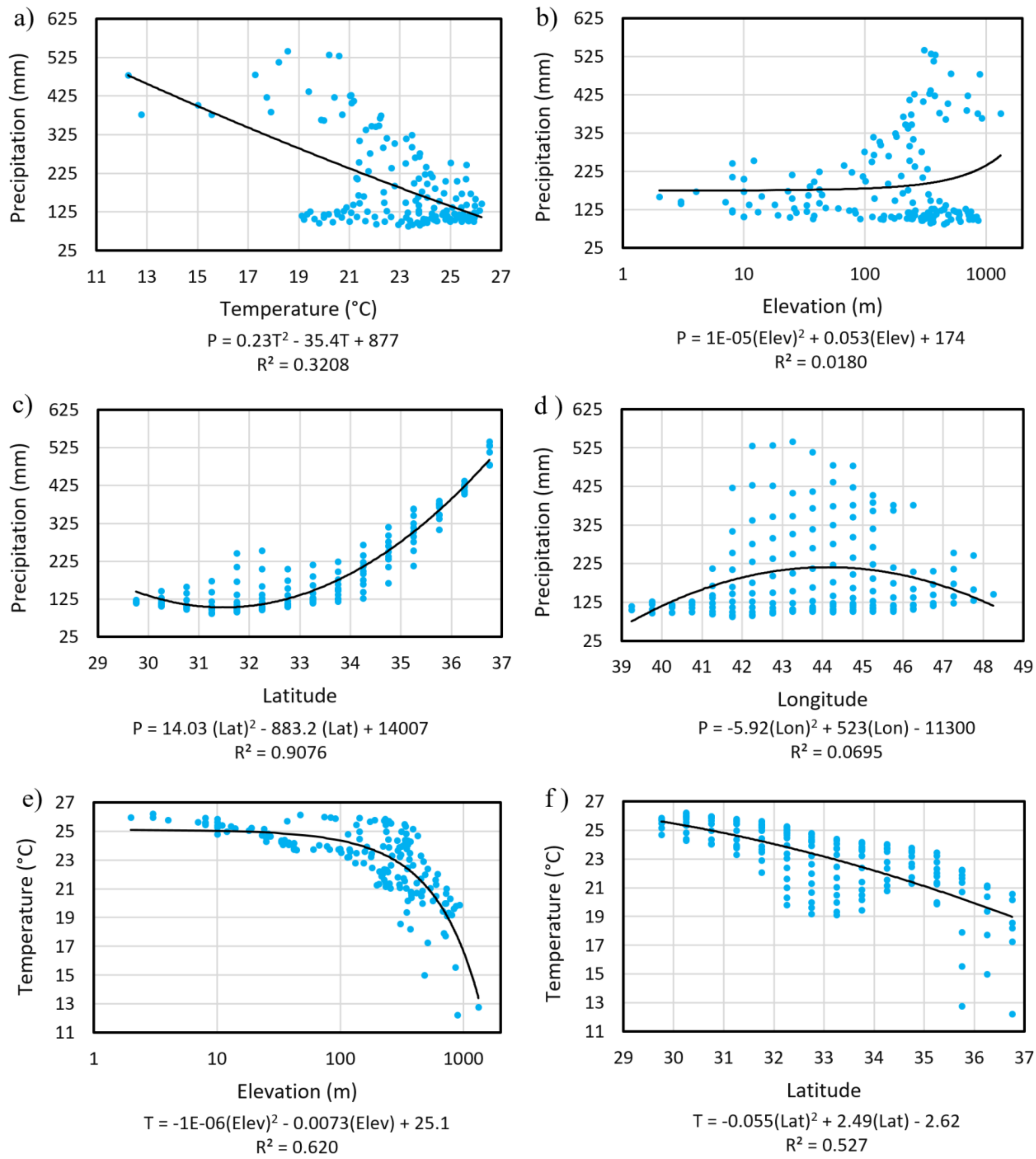

Figure 2. Relationships of (a) precipitation versus temperature, (b) precipitation versus ground surface elevation, (c) precipitation versus latitude, (d) precipitation versus longitude, (e) temperature versus ground surface elevation, and (f) temperature versus latitude. Spatial climate data of Iraq are collected from Ref. [4] from 1991 to 2020 with a resolution of 0.5 degrees (55.505 km) grid cell.

Date: October 2023

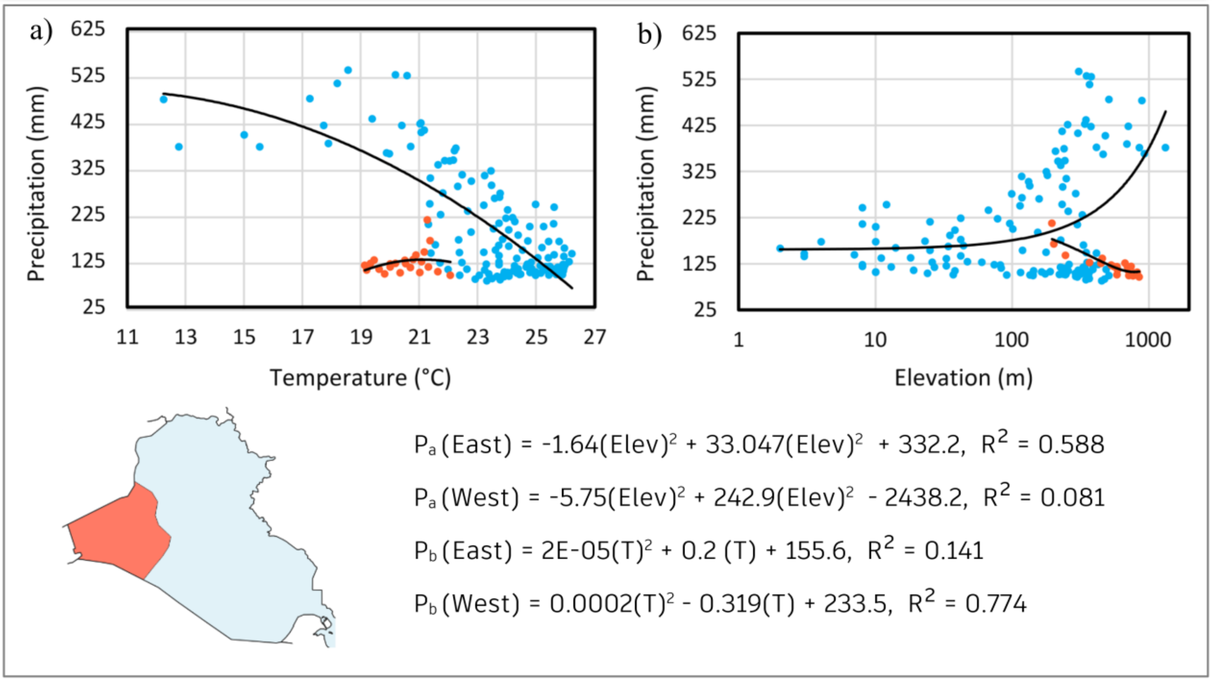

Figure 3. (a) precipitation versus temperature and (b) precipitation versus ground surface elevation separating the western part with a longitude value of less than 42° and average annual precipitation of less than 225 mm.

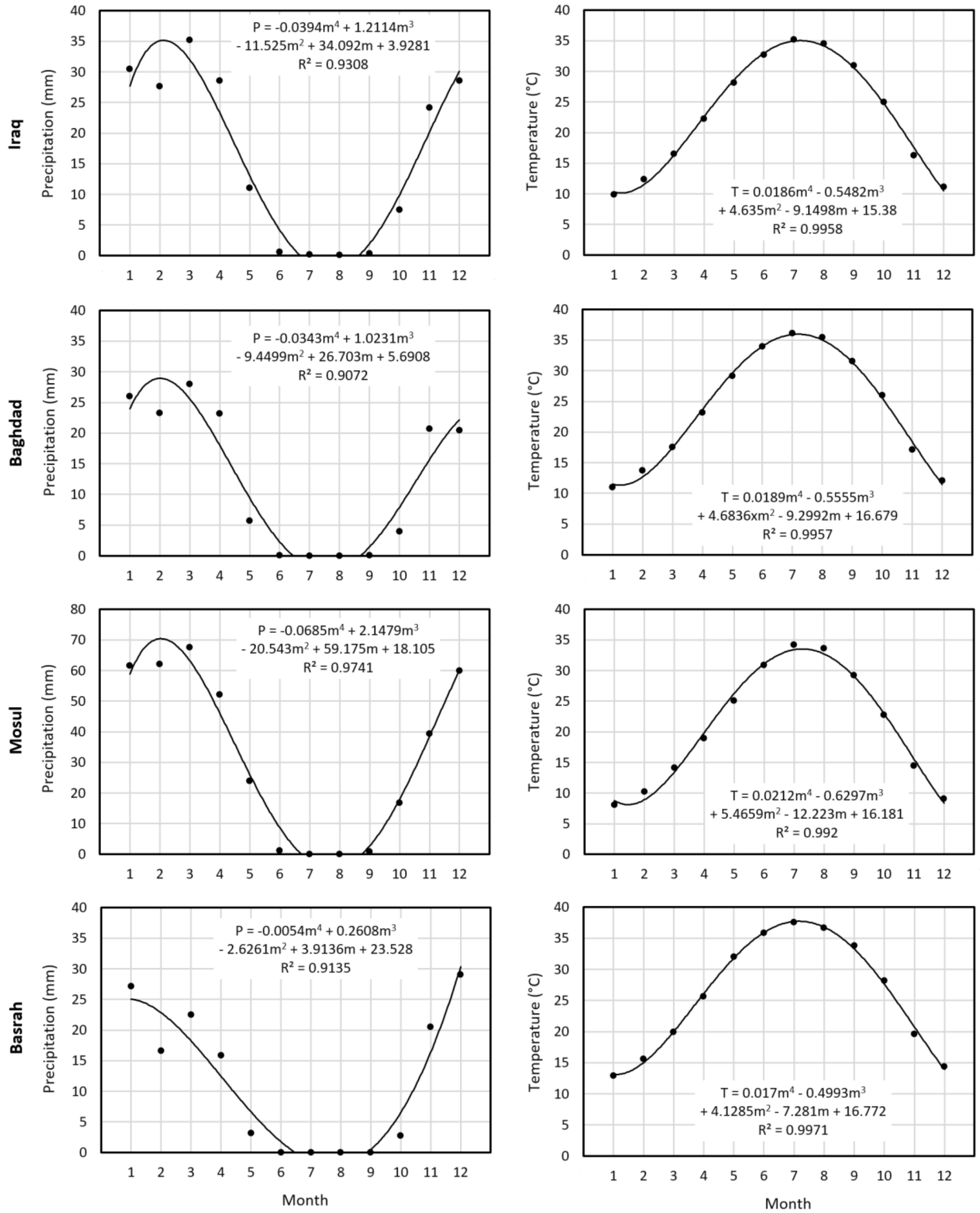

Figure 4. Seasonal variability of temperature and precipitation over Iraq and its major cities. Data were calculated as the mean values of precipitation and temperature for each month of 1991 - 2020. T is temperature, P is precipitation, and m is the month.

Date: October 2023

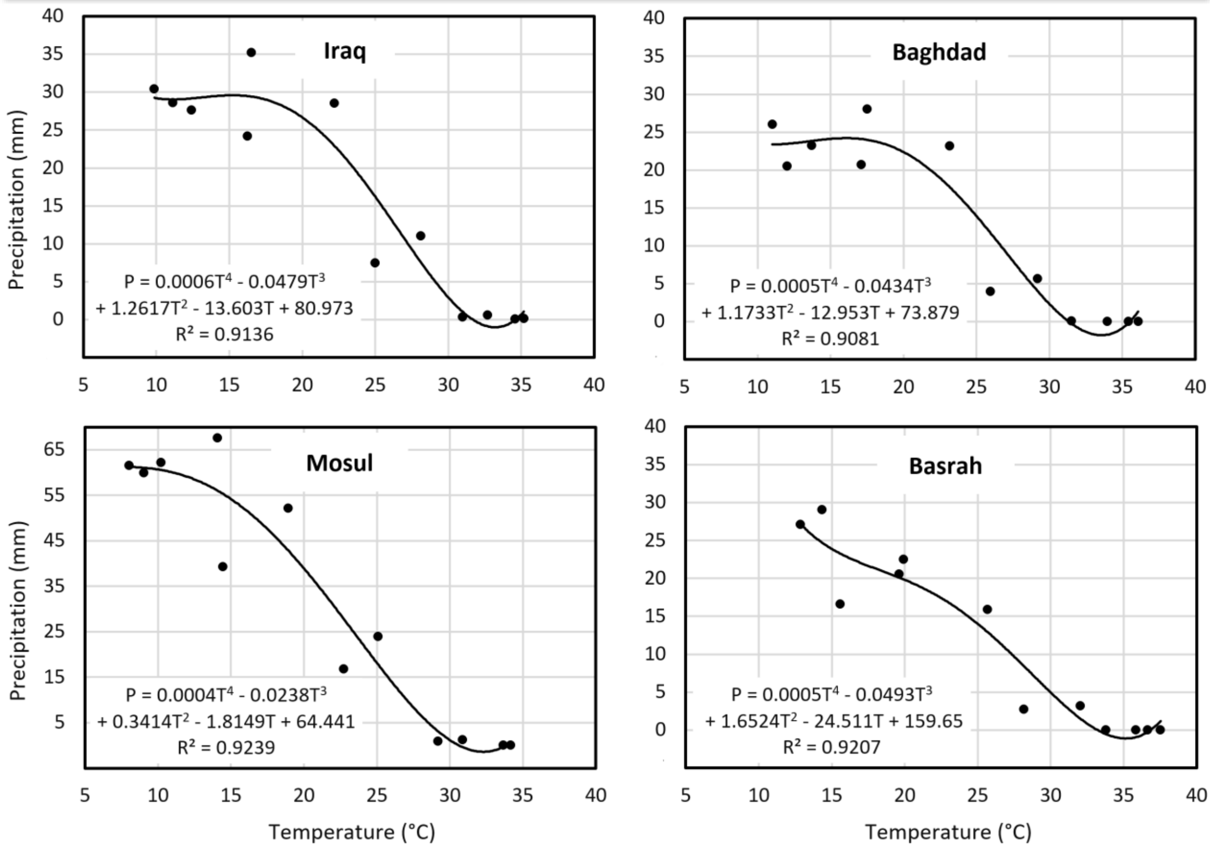

Figure 5. The relationship between average precipitation and temperature for each month of 1991 - 2020 in Iraq and its major cities.

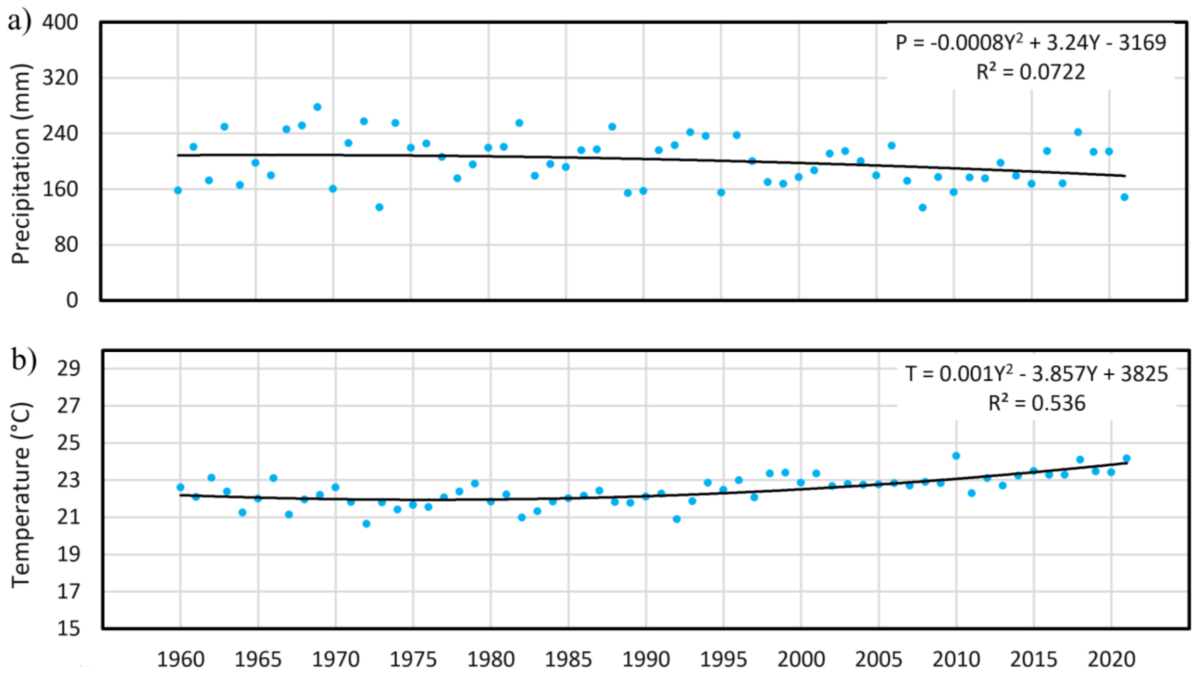

Figure 6. (a) Annual precipitation trend, (b) Average annual temperature trend over Iraq using monthly observations from 1960 to 2020.

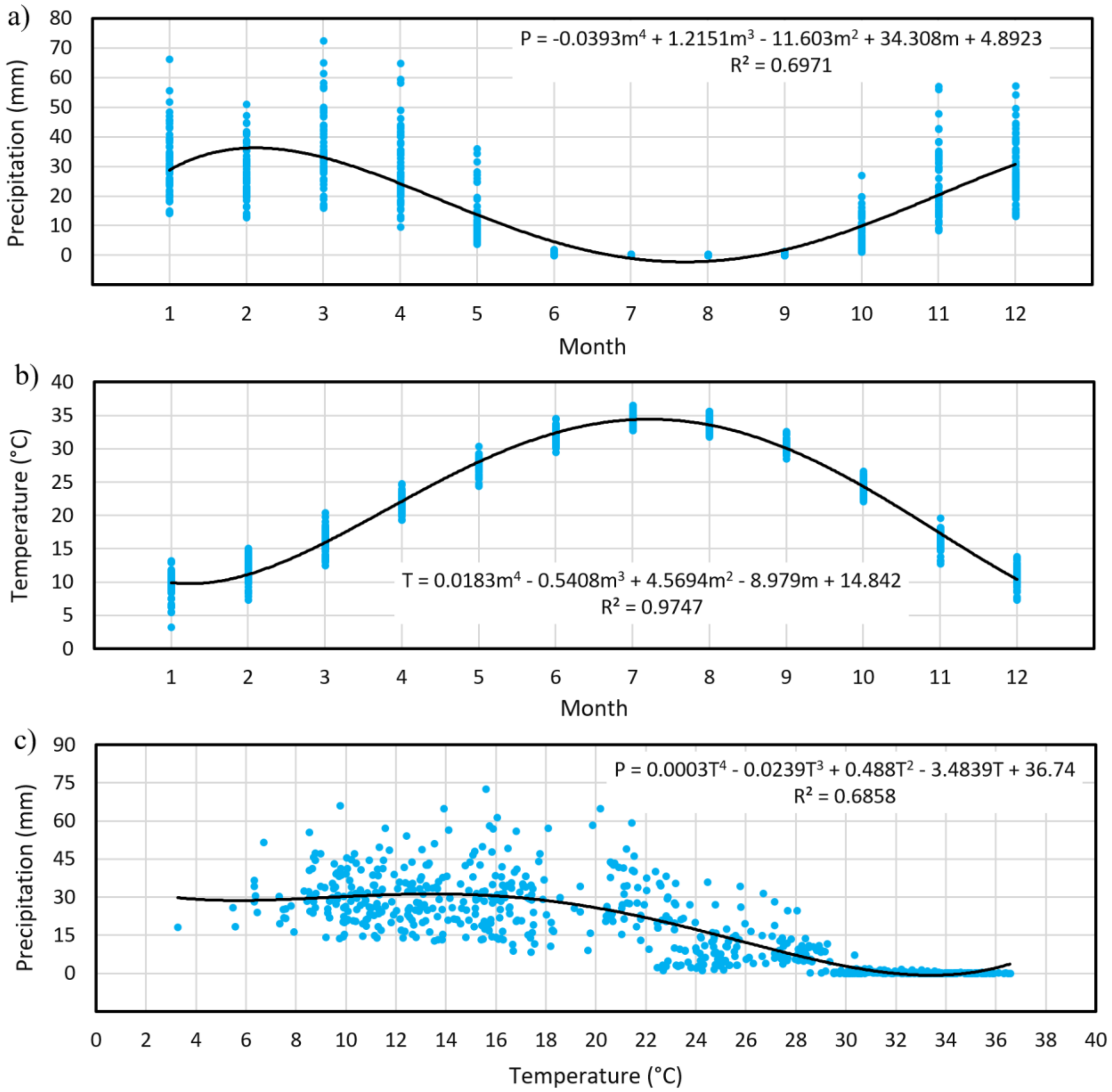

Figure 7. (a) seasonal variability of precipitation, (b) seasonal variability of temperature, and (c) the relationship between precipitation and temperature over Iraq using monthly observations from 1960 to 2020.

3.3.Model errors and validation

This section includes analyses of errors between the observed precipitation and calculated precipitation from best-fit equations. In addition, this section includes the validation of the best-fit equation for the precipitation versus temperature using different periods of data to see how well the calibration equations can fit different periods. First, the observed precipitation data (Figure 1b) is used to find the regression equation as a function of the latitude value (Figure 2c) as follows:

$$Pcs = 14.03 \times Lat^2 - 883.2 \times Lat + 14007 \quad \text{(Equation 3.1)}$$

Where Pcs is the calculated average annual precipitation (mm) for spatial analysis, Lat is the latitude value representing the distance from the equator. Only the equation between precipitation and latitude is used because it has the highest correlation, with a coefficient of determination (R2) of 0.9076 compared with the other parameters. The latitude value represents the distance from the equator and it is proportional to the amount of precipitation. Figure 8 shows the special distribution of the residual errors for the average monthly precipitation (mm) over Iraq. The average monthly precipitation error in figure 8 was calculated using the difference between the observed and the calculated precipitation. Calculated precipitation was created using equation (3.1) and divided the annual error by 12 to get the average monthly error. You can see that there is a positive error to the east (Figure 8) and a negative error to the west, this is because the western desert of Iraq has less average precipitation compared with other parts of Iraq.

Error of precipitation [mm].

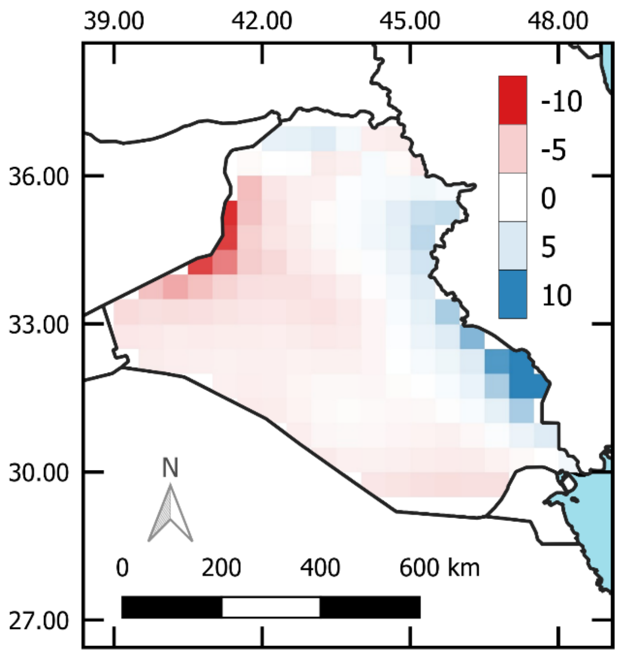

Figure 8. Spatial distribution of the average monthly precipitation error [mm]. Error is calculated as the difference between the observed precipitation and calculated precipitation.

The temporal distribution of error is monthly calculated to see which periods have extreme climate events. Extreme climate events cause a higher error from the correlated best-fit equation because the regression equation averages out the outliners that represent extreme climate events such as precipitation and temperature. Figure 9 shows the absolute value of errors, where errors are calculated as the absolute difference between observed precipitation [mm] and the calculated precipitation using the relationship equation between precipitation and temperature as specified previously (Figure 7c) using the following equation:

$$Pct = 0.0003 \times T^4 - 0.0239 \times T^3 + 0.488 \times T^2 - 3.4839 \times T + 36.74 \qquad \text{(Equation 3.2)}$$

Where *Pct* is the calculated average monthly precipitation (mm) for temporal analysis, and *T* is the observed monthly temperature (°C). Results show (Figure 9) that most of the precipitation errors occur during the winter season especially at the beginning of 2017 and 2019 when there are extreme precipitation events recorded.

Date: October 2023

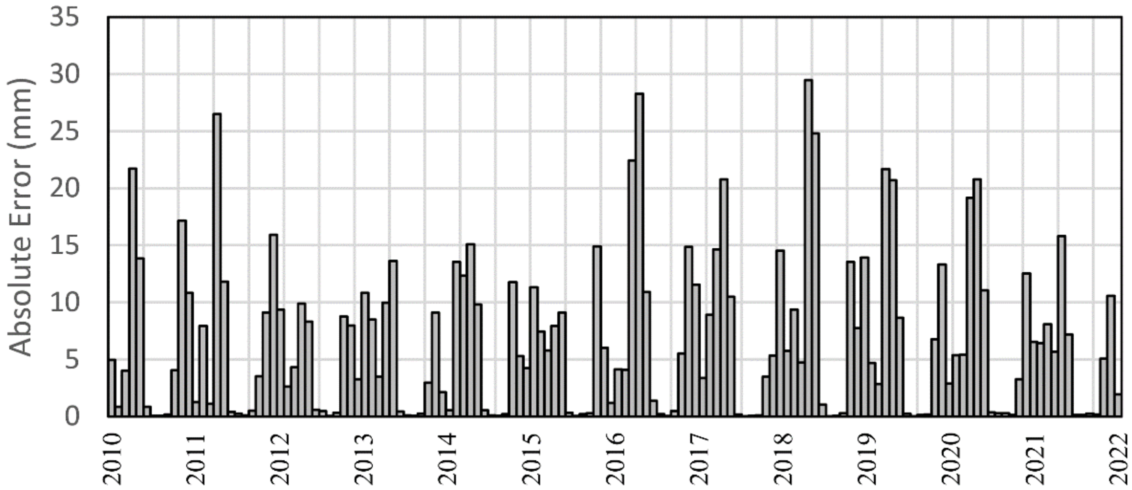

Figure 9. Monthly absolute error of precipitation in (mm) from January 2010 to December 2021.

Validation of best-fit equations calculated for the period between 1960 and 2020 on monthly time steps (Figure 10). First, the best-fit equation constants of seasonal precipitation variability were calculated for the first 50% of the monthly precipitation data, which is from 1960 to 1990. Then, the coefficient of determination (R^2) value of this calibration was calculated. This model was then validated by fitting the second 50% of the data, from 1991 to 2020 using the same equation and the same fitting constants to calculate the coefficient of determination (R^2) for validation (Figure 10a). The same procedure was repeated using the second 50% of the data for calibration and the first 50% of the data for validation (Figure 10b). The third and fourth sets of validations are used for the relationship between monthly precipitation and temperature. The same procedure was repeated using the first 50% of the data for calibration and the second 50% of the data for validation (Figure 10c); the second 50% of the data for calibration and the first 50% of the data for validation (Figure 10d). The monthly precipitation data has more extreme events and less correlation for the first 50% of the data and that reflects the reason why the calibration error is higher, with less R^2 value than the validation error (Figures 10a and 10c).

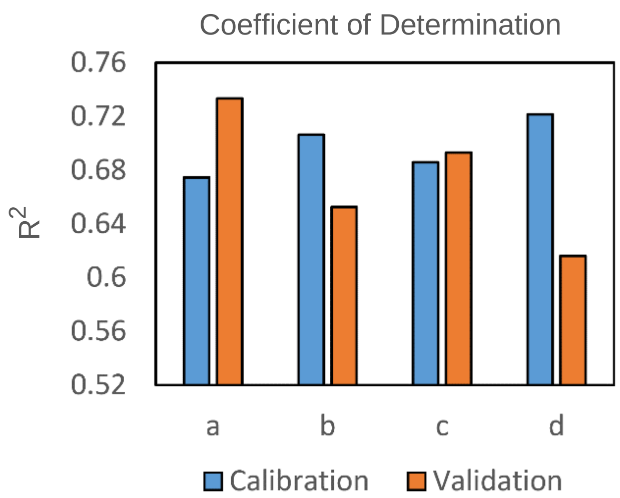

Figure 10. Coefficient of Determination, R^2, for the (a) calibration of the first 50% of the monthly precipitation seasonal variability per month for the period 1960 to 1990 and validation of the second 50% of the data for the period 1991 to 2020; (b) calibration of the second 50% of the monthly precipitation seasonal variability for the

period 1991 to 2020 and validation of the first 50% of the data for the period 1960 to 1990; (c) calibration of the first 50% of the monthly precipitation versus temperature for the period 1960 to 1990; and validation of the second 50% of data for the period 1991 to 2020; and (d) calibration of the second 50% of the monthly precipitation versus temperature for the period 1991 to 2020; and validation of the first 50% of data for the period 1960 to 1990.

4.Conclusion

This study includes the spatial relationship between precipitation and four other parameters: ground elevation, average temperature, longitude, and latitude across Iraq. In addition, this study includes the temporal correlation and validation for both precipitation and temperature with monthly time steps from 1960 to 2020. The spatial relationship between precipitation and both temperature and elevation is weak, coefficients of determination (R^2) are 0.32 and 0.018 respectively, especially for the western part of the country. This is because the western part of the country is a desert with a high elevation and relatively low precipitation, and this behaves differently than the other parts of the country where high elevation and low temperature result in higher average precipitation. Errors calculated for this spatial analysis show a gradual change from positive error east to negative error west, this occurs because the western desert of Iraq has less average precipitation compared with other parts of Iraq.

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Multivariate Statistical Methods Used in Determining the Hydrogeochemical Surfaces of Groundwater in Yusufiya District

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Abstract: For the importance of groundwater and being the second natural source of water after surface water, it is necessary to know the quality, features and hydrological surfaces of this water. For this reason, 15 wells were chosen in the Al Yusufiyah sub-district to study the quality of groundwater based on multivariate statistical methods as well as the Piper chart. These methods proved successful in characterizing the study of groundwater chemistry and can be relied upon for ground and surface water in other regions. The quality of the groundwater in Al Yousifiyah, according to Piper's scheme, the alkalinity increases with the presence of sulfate and chloride, depending on the type of soil. From the analysis of the correlation matrix, the totals were found to be Ca, Mg, and Cl. , Ca, Mg, Cl, and SO4, as well as Ca, Na, Mg, Cl, SO4, and HCO3. From the mass analysis, the first K, second Na, third Ca, fourth Mg, SO4 and fifth Cl, HCO3 were obtained. Finally, from the main component analysis, hydrogeochemical facies were found: Cl, SO4, Ca, HCO3, Mg, and Na, Respectively.

1. Introduction

Water is considered the artery that supports life on the globe. Water sources are either surface or groundwater, which is water formed in a permeable underground formation called an aquifer, used for all areas of life, Especially for areas where surface water is not available [1,2,3]. As a result of the increase in population, urbanization and factories increase, groundwater has become necessary and supportive of surface water, and sometimes it become the main water source. Therefore, the preservation of groundwater quality is necessary for the continuity of life and its well-being[4,5]. Municipal sewage and industrial waste are the main source of groundwater pollution, in addition to leachate resulting from solid waste and irrigation of agricultural lands [6], most of the pollutants are sulfates, chlorides, nitrates, viruses and bacteria, in addition to fertilizers and pesticides polluted from agricultural lands [6], groundwater quaility varies from One region to another according to the type of soil and the nature of the aquifer[7] . This water has been subjected to deterioration as a result of random withdrawals as a result of the lack of access to safe drinking water, also due to lack of sewage networks, the population has been forced to use sewage basins, which affects the rise pollutants of groundwater such as salts, organic and inorganic substances.

The Piper chart relies on the concentrations of major ions such as calcium, sodium, magnesium, potassium, bicarbonates, chlorides and sulfates in interpreting the hydrogeochemical characteristics, thus neglecting the actual concentration of dissolved solids [8]. This is considered a serious drawback on the Piper chart.[8] .

Multivariate statistical methods were used in many fields, as in groundwater, to interpret the hydrogeochemical aspects. There are several methods of factor analysis such as graphical methods [9]. Multivariate statistical methods have been used in groundwater to evaluate the hydrogeochemical features in many countries such as South Africa [10] USA [11] China [12]. It has been used in Iraq to evaluate groundwater in the Zuber area South of Iraq, Erbil [13], Baghdad [14], and others. Most research focused on climate change factors and water management, but few used multivariate

Date: October 2023

statistical methods with hydrogeochemical characteristics. The aim of this study is to use multivariate statistical methods to evaluate the hydrogeochemical characteristics of groundwater in the city of Yousifiya district.

2. Materials and Methods

2.1. study area

Yusufiyah district is an Iraqi sub-district of Al-Mahmudiyah. It is distinguished by its geographical location middle of Iraq, at a distance of 25 km in the southwest side of the capital, Baghdad, side of Al Karkh, between longitudes and latitudes 44 ° 08 ′ 52 "-44 ° 08 ′ 28" and 33 ° 13 ′ 58 "- 33 ° 01 ′ 15" respectively. It is characterized by the fertile agricultural character for passage Al Yusufiya River branching from the Euphrates River, addition to a commercial and economic location, which is the food provider for the Baghdad city . It is also characterized with livestock, poultry and fisheries. For these reasons, 15 wells were chosen in the study area as a case study, as shown in Figure (1) and (2).

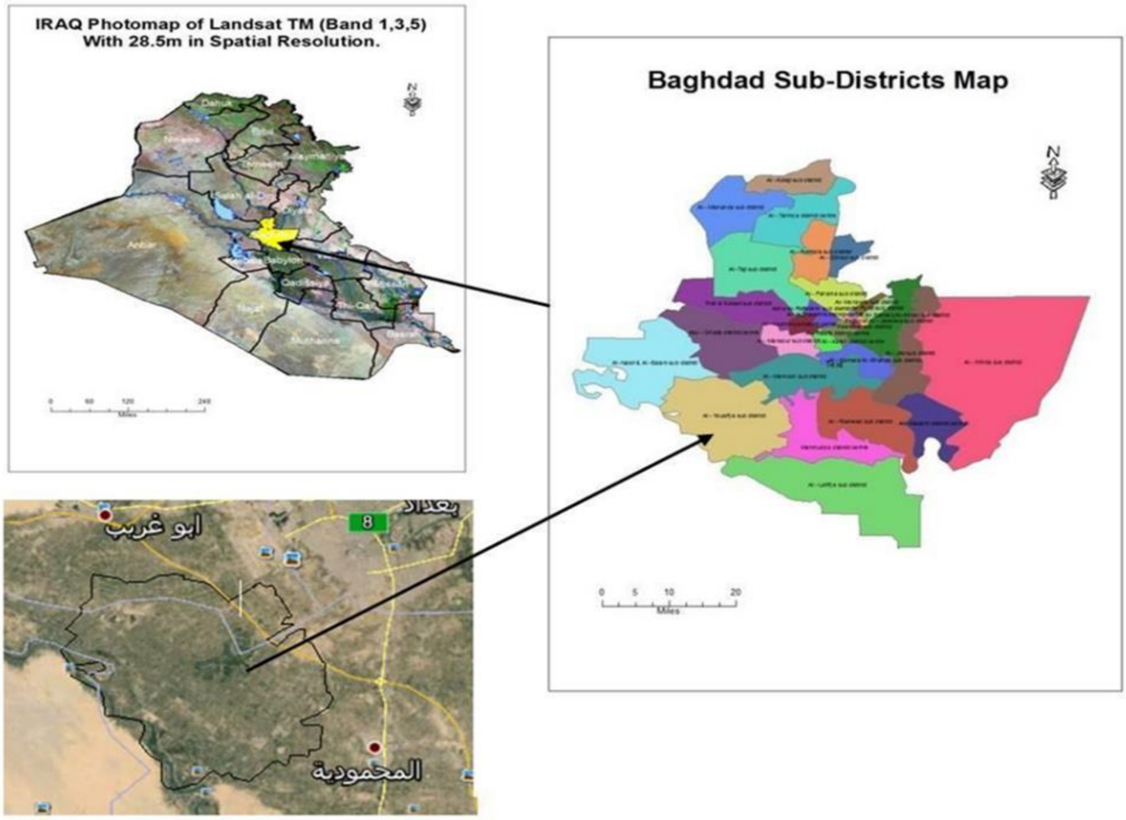

Figure 1. Al Yusufiya district location

2.2.Collection and Analysis Sampling

Fifteen wells in Al Yusufiya district area were selected to collect Groundwater samples during October 2020. Plastic bottles of 500mm capacity were used for this purpose. All samples were tested for the variables (pH, EC, TDS, TH, Ca, Mg, Na, k, HCO3, Cl, SO4, NO3. According to the specifications mentioned in the Standard Method, [15].

2.3. Statistical analysis of data result from Al Yusufiya groundwater wells

This study relied on statistical methods to analyze the results, where the correlation matrix, cluster analysis (CA) and principal components analysis (PCA) were used to analyze the main components of

Date: October 2023

groundwater in Yusufiyah district. By using the academic statistics software package STATISTICA - version 13.3 for Windows.

2.3.1. Correlation Matrix Analysis

A statistical method for evaluating variables linearly. The accuracy of the correlation depends on parameters and other variables [16]. Also named as effective factor analysis for multiplied variables that biased on chemical parameters they depend on their sources[17] . Interpreted of coefficient of correlation as in Table (1).

Table 1. interpreted of coefficient of correlation (**Pam et al., 2011**)

coefficient of correlation	**results**	**interpretation**
coefficient of correlation	Cf > 0.7	strong correlation
coefficient of correlation	Cf = 0.5-0.7	moderate correlation
coefficient of correlation	Cf < 0.5	low correlation

2.3.2. Cluster Analysis (CA)

The CA process is implemented before conducting data analysis, in order to remove the difficulties resulting from the process of collecting it. In this way, the data is collected in groups or nodulate data, and each cluster has an homogeneity internal interdependence and a large external heterogeneity[18].The data is then divided into groups, The analysis of the clusters is done one after the other until it becomes one group [19].

2.3.3. Principle Component Analysis (PCA)

It is an evaluation of observations which is expressed as a data matrix that depends on many dependent variables and is associated with each other[20] . The main purpose of this analysis is to obtain information that was previously inferred, used with the basic components, as well as on factors, eigenvectors, and shipments. Values for each variable are estimated according to the basic component [21]**.**

3. Results and Discussion

The results obtained by laboratory examination and shown in Table (2) were used in studying the effectiveness of multivariate statistics in knowing the interpretation of the hydrogeochemical surfaces of the groundwater of the Al Yusufiyah region. Figure (2) shows the places where samples were taken.

Date: October 2023

Table 2. Concentrations of anions and cations of groundwater in Al Yusufiyah district

No.	pH	EC (µs/cm)	TDS (ppm)	TH (ppm)	K (pm	Na (ppm)	Mg (ppm)	Ca (ppm)	Cl (ppm)	SO4 (ppm)	HCO3 (ppm)	CO3 (ppm)	NO3 (ppm)
1	7.2	2800	2000	325.5	12.1	424	36	71	362	510	270	0	9.4
2	7.26	2250	1850	947.8	3.8	214	112	195	471	420	393	0	10.46
3	7.42	1268	950	537.8	10	88	70	100	190	300	50	0	5.6
4	7.31	1268	950	548.8	5	88	68	108	182	379	51	0	4.06
5	7.11	1227	930	426.4	4.1	132	54	82	254	245	64	0	14.02
6	7.39	1570	1093	272.4	1.4	153	31	58	208	242	72	0	8.6
7	7.09	1570	1093	272.4	1.4	153	31	58	208	242	72	0	6.2
8	7.7	2190	1511	179.5	8.5	245	20	39	159	306	193	0	4.5
9	7.33	1457	1274	666.3	9.4	94	83	130	154	582	62	0	1.05
10	7.62	2310	1947	929.3	1.54	254	116	181	570	519	164	0	2.8
11	7.16	3860	2480	1357.3	2.48	248	166	270	445	1035	265	0	25.18
12	7.12	2840	1830	325.1	4.28	428	36	71	362	510	270	0	63.5
13	7.15	2800	2000	343.3	1.5	424	38	75	300	550	170	0	1
14	7.2	4530	3800	1223.7	5.36	332	157	232	716	1296	509	0	6.4
15	7.22	2250	1850	947.8	2.14	214	112	195	471	420	393	0	28.8
S.S*	6.5-8.5	1000-2000	500-1000	120 to 170	1.5	200	150	200	250-400	200-400	…….	…….	15

*** SS Standard Specification limit for drinking water (WHO, 2011)**

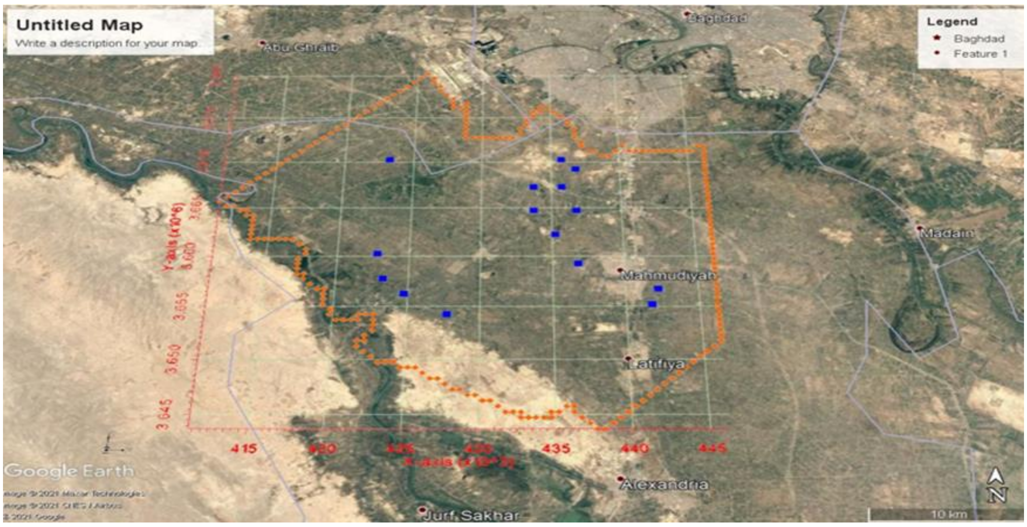

Figure 2. Selected wells in study area

Date: October 2023

3.1. Piper's classification

To describe the hydrochemical plains of groundwater samples in Yusufiyah, Piper charts were used, Rock Works software was used to build the Piper diagram and represent the different concentrations of the ions. which is a representative chart showing the type of groundwater. The Piper chart divides water into seven forms shown in Figure (3) and table (3). The results shown in Figure (4). The anions that appear are bicarbonate, carbonate, sulfate and chloride, the cations are calcium, magnesium or sodium and potassium cations. It was found that the wells in Yusufiyah fall within (class e) and (class g) hydrochemical destinations, which indicates the hydrochemical plains is alkaline ground water associated with sulfates, chlorides

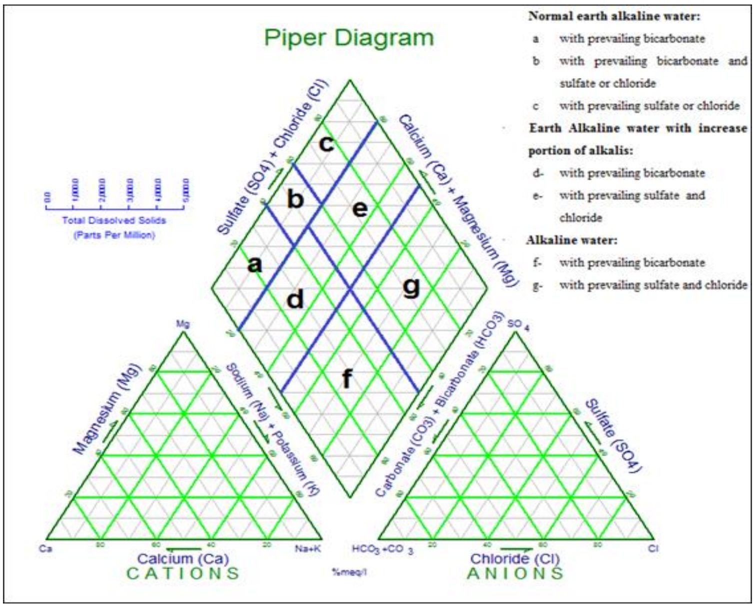

Figure 3. Standard Piper

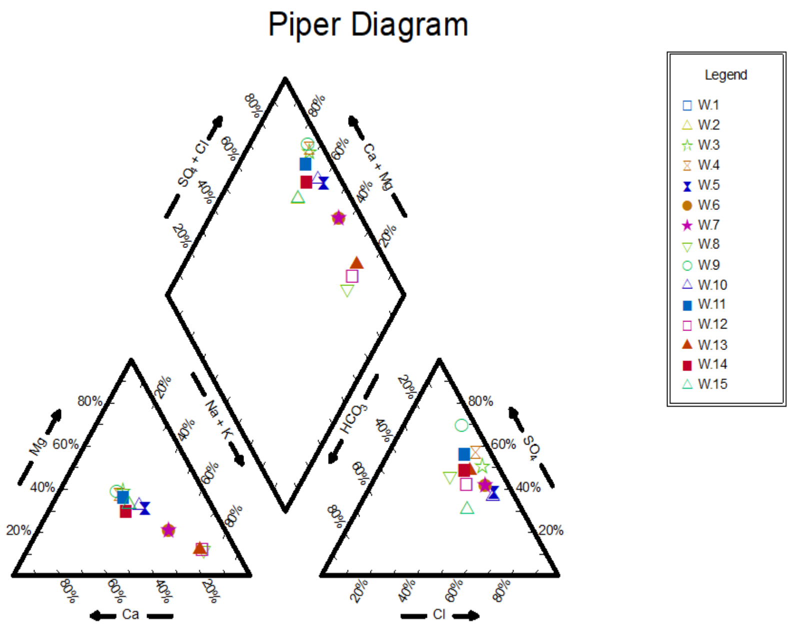

diagram **Langguth (1966)**
Figure 4. Piper diagram of Al Yusufiyah groundwater tests

Date: October 2023

Table 3. Classification of the Al Yusufiyah groundwater samples according to the Piper trilineadiagram

Primary title	**Secondary title**	**Class**
Normal earth alkaline water	With prevailing bicarbonate	a
	With prevailing bicarbonate and sulphate or chloride	b
	With prevailing sulphate or chloride	c
Earth alkaline water with increase portion of alkali	With prevailing bicarbonate	d
	With prevailing sulphate and chloride	e
Alkaline water	With prevailing bicarbonate	f
	With prevailing sulphate and chloride	g

3.2. Correlation Matrix Analysis

The relationship between two or more variables is measured statically by matrix correlation analysis, while the linear relationship between two variables is represented by the correlation coefficient in order to evaluate the correlation, which is known as the size and strength of the relationship at the level of importance, which shows the reliability of the correlation. The obtained results (correlation coefficient) were compared with the level of significance (p 0.05)[17];[22]. For example, the correlation coefficient (r) between sulfate, sodium, calcium, magnesium, total hardness, and bicarbonate was found to be 0.05 level (2-tailed). The other differences are a correlation coefficient of 0.01 level (2-tailed). These differences are considered insignificant and have no effect on the strength of the correlation. Comparing the results, it turns out that the highest correlation coefficient between the two variables is 0.998, which indicates the close correlation between total hardness and magnesium. According to the parameters in Table 1. depend on the main ions (cations - anions) Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, SO_4^{2-}, and Cl in meq/l. It turns out that the highest correlation coefficient for calcium is 991.

The results show that the positive correlation of cations and anions indicates a strong and medium bond, while the negative correlation indicates a weak bond. From here, the hydrogeochemical characteristics of the Yusufiyah region are shown in terms of cations and anions, depending on the correlation, as follows: (1)Ca, Mg, and Cl. (2) Ca, Mg , Cl, and SO_4 and (3) Ca, Na, Mg , Cl, SO4 and HCO_3 as in Table 4, These positive relationships that have been reached indicate the existence of more than one common origin as the source[21] **.**

Table 4. Correlation matrix analysis for Al Yusufiyah groundwater

	pH	EC	TDS	TH	Ca	Mg	Na	K	Cl	SO4	HCO3	NO3
pH	1											
EC	-.230	1										
TDS	-.167	.961**	1									
TH	-.091	.570*	.647**	1								
Ca	-.110	.579*	.648**	.997**	1							
Mg	-.074	.560*	.644**	.998**	.991**	1						
Na	-.243	.714**	.629*	-.025	.003	-.050	1					
K	.237	-.096	-.078	-.218	-.241	-.196	-.013	1				
Cl	-.141	.770**	.860**	.750**	.755**	.743**	.479	-.283	1			
SO4	-.223	.887**	.905**	.742**	.730**	.750**	.403	-.009	.708**	1		
HCO3	-.200	.794**	.847**	.589*	.612*	.565*	.567*	-.069	.831**	.637*	1	
NO3	-.395	.262	.128	.045	.073	.019	.386	-.175	.192	.085	.324	1

**. Correlation is significant at the 0.01 level (2-tailed).

Date: October 2023

*. Correlation is significant at the 0.05 level (2-tailed).

3.3. Cluster Analysis

Variables are classified into homogeneous groups by cluster analysis, using Ward's method on samples tested for Hierarchical Cluster Analysis (HCA). As shown in Figure (5) the hierarchical diagram of ions (cations and anions).

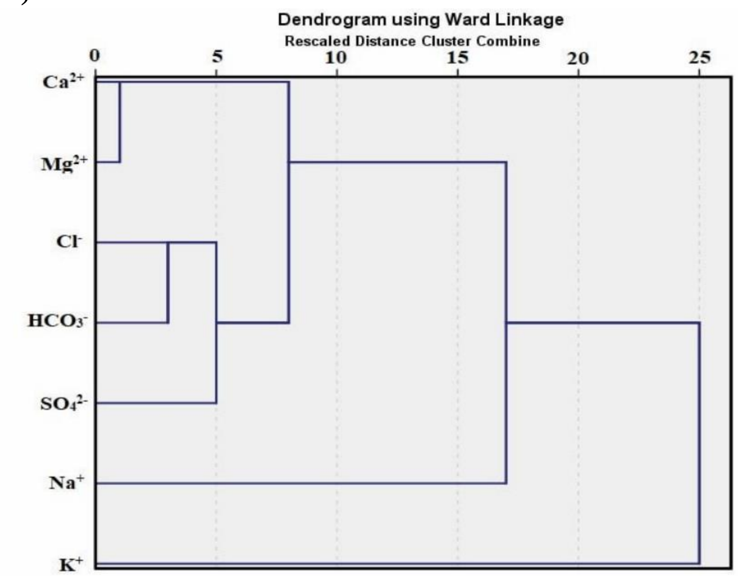

Figure 5. Dendrogram of the cluster analysis of Al Yusufiyah groundwater

The results showed the presence of compatible and overlapping groups between the dendrogram of ions (cations and anions), the results indicated that there are two compatible groups, the potassium group (K), the second group is includes two groups, the first one is single group (Na), while the second consists of two compatible groups, the first includes to calcium (Ca) and magnesium (Mg), while the second group includes two groups, the first one is sulfate (SO4-), and the second includes to chloride (Cl) and bicarbonates (HCO3-), these indicate to presence of positive relationships and indicate to the presence of only one source to groundwater, from this analysis it turns out that the hydrogeochemical characteristics of the Yusufiyah area consist of potassium, sodium, calcium, magnesium, bicarbonate, chlorides and sulfates.

3.4. Principle Component Analysis (PCA)

To determine the hydrogeochemical strain of groundwater in Yusufiyah, PCA was used by combining Varimax circulation with the Kaiser application. Table 5 shows the PCA results.From the results, it is clear that there are 3 extracted components, according to[23], the positive load has a value between (0.75-1.0), the moderate one is between (0.5-0.75), and the weak one (0.3-0.5).

From the results show that the positive load of ions (cations and anions) are Cl, SO4, Ca, HCO3, Mg, while the positive load in the second group is Na, and the third group lacks a positive group. Also, all aggregates lack medium loads. The ions may be cations and anions in the Youssifiya groundwater of two origins, according to PCA classification, either from Cl, SO4, Ca, HCO3, Mg or from Na.

Date: October 2023

Table 5. varimax rotation (Factor loadings) of ion (anions and cations) in Al Yusufiyah groundwater

	Component Matrixa		
	Component		
	1	2	3
pH	-.242	-.405	.587
EC	**.897**	.316	.186
TDS	**.934**	.182	.244
TH	**.848**	-.493	-.125
Ca	**.855**	-.465	-.150
Mg	**.839**	-.516	-.101
Na	.467	**.799**	.212
K	-.206	.049	.738
Cl	**.916**	.016	-.011
SO4	**.894**	-.021	.184
HCO3	**.850**	.242	.094
NO3	.235	.560	-.488

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

In Table 6 were shown a summary of the results of the correlation matrix analysis, the cluster analysis, and the basic compounds analysis of the Al Youssoufia groundwater samples, which show its hydrogeochemical surface.

Table 6. According to the multivariate statistics, hydrogeochemical faces of Al Youssoufia groundwater samples

	Hydro -geochemical Facies		
Class	**Correlation Analysis**	**Cluster Analysis**	**Principle Component Analysis**
1	Ca, Mg, Cl.	K	Cl, SO4, Ca, HCO3, Mg,
2	Ca, Mg , Cl, and SO4	Na,	Na,
3	Ca, Na, Mg , Cl, SO4, HCO3	Ca, Mg	
4		SO4	
5		Cl, HCO3	

4. Conclusion

The multivariate statistical method proved as hydraulic features in describing the quality of groundwater, especially in Yusufiyah, from the Piper chart showing that the alkalinity increases with the prevailing sulfate and chloride. This is due to the quality of the soil. Three hydrogeochemical facies were classified from the correlation matrix analysis, namely Ca, Mg, and Cl. and Ca, Mg, Cl, and SO4, as well as Ca, Na, Mg, Cl, SO4, and HCO3. It was concluded that (CA), the five surfaces

Date: October 2023

were found, the first K, second Na, third Ca, Mg fourth SO4 and Fifth Cl, HCO3 . Also, two hydrogeochemical facies were found: Cl, SO4, Ca, HCO3, Mg, and Na.

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Date: October 2023

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Date: October 2023

Determination of Radon Radiation Concentration in Groundwater for Some Wells of Baghdad City

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Abstract: The Radon level was measured in (17) groundwater samples collected from Baghdad city/ Iraq and two samples from Tigris and Dyala River. The measurements were performed by RAD7 an electronic radon detector manufactured by Durridge Company Inc. The concentrations of radon (226Ra) ranged from 0.3 to 2 (Bq/L). Radon concentrations from all the villages/towns were well below the was lower than WHO and EPA standard limits recommended by USEPA, UNSCEAR, EU Council and WHO. The total annual effective doses ranges from 1.64to10.95 μSv.y-1 were less than 0.1mSv.y-1which Recommended by the World Health Organization (WHO). The study also examined the relationship between the total dissolved solids (TDS) and the concentration of Radon-222 and it shows the absence of any linear relationship between the variables and concentrations Radon.

1. Introduction

There are three naturally radioactive isotopes of radon present in the environment (Radon Rn-222), Thoron (Rn-220), Action (Rn-219).The most abundant among the naturally occurring isotopes are R-222, an alpha emitter, with half-life of 3.8 day, while other isotopes Rn -220 and Rn -219 can be neglected due to their short half-life (5.66 - 3.92) minutes respectively[1].The half-life of radon isotope Rn-222 is long enough to allow it to migrate through the groundwater and soil and enter the air , therefore interring the human environment [2]. Natural radioactivity measurement is large importance to many researchers all over the world, which led to a worldwide national survey in the past two decades, measurement of natural radioactivity in the groundwater is very important to determine the amount of change of the natural background activity with time due or leakage radioactive [3,4]. Radon is formed as part of three radioactive decay chains that begin with (Uranium or Thorium). They are found in modest quantities in most soil, rocks and water. Radon gas released from rocks and soil can move to groundwater, surface water, and air; thusly, content radon-222 in groundwater is possibly a lot higher than surface water [5], usually less than 0.4 Bq/liter in surface water supplies and about 20 Bq/liter in groundwater depending on the geological nature of the area and the quality of the rocks. However, some wells had higher concentrations, up to 400 times the average [6]. The exposure of the population to high concentrations of radon and its daughters (218Po and 214Po) for a long period leads to pathological effects such as the respiratory the occurrence of lung cancer and functional changes. However, a very high level of radon in drinking water can lead to gastrointestinal cancer and significant risk of stomach [7].The present investigation aims to study the levels of radon in groundwater and compute annual effective doses for Baghdad (and some areas around it), to establish a database level of radon in groundwater in the study area, This information important in order to create an awareness about the health risk of radon in groundwater.

Date: October 2023

2. Materials and Methods

2.1. Location and Geology of the study area

Baghdad lies in the middle of Iraq within the Mesopotamian Plain. The Tigris River passes through the city dividing it into two parts; Karkh and Rasafa. The study area is restricted to latitudes (33º 10′ -33º 29′N) and longitudes (44º 09′- 44º33′E) with an area (Fig. 1). The quadruple period sediments cover the areas of Baghdad, which consist of sedimentary deposits (clay, sand, and gravel). The water-bearing layers are made of sand and gravel, while mud layers are permeable layers separating the layers of water. The distribution of these layers within the areas of the sedimentary plain may vary from one region to another. Within the areas west of Baghdad, it is thin and does not exceed the majority of (15 m), while within the basin of the Tigris it is thicker and up to (70 m) in areas close to the Tigris River, [8].

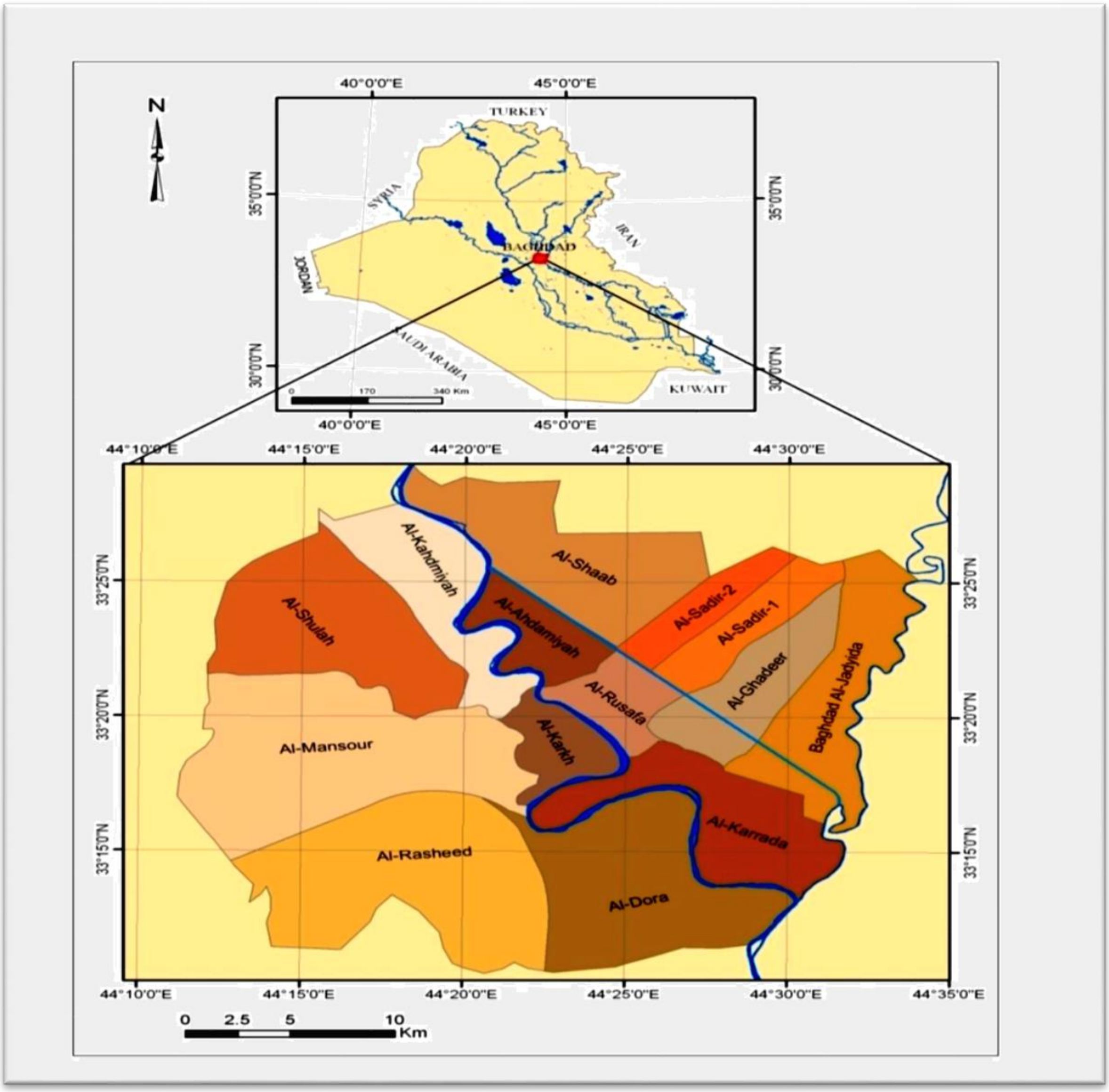

Figure1. Shows the study area

Date: October 2023

For data collection, 17 sampling stations were selected from Agricultural and residential areas where water was being used daily Fig. (2). The water samples were collected directly from a hand pump or submersible pump and stored in 250ml polyethylene bottles. Physical and chemical field measurements also cared out such as pH, Total Dissolved Solids (TDS) and EC were also carried out and Global Positioning System GPS device was used to determine the accuracy of coordinates (latitudes, longitudes and elevation) of sampling sites (Table 1). A Radon detector (RAD7) was used to measure radon concentration in water samples, Fig. (3) [9]. This detector has high accuracy and a wide range dedicated to measuring radon in water and soil.

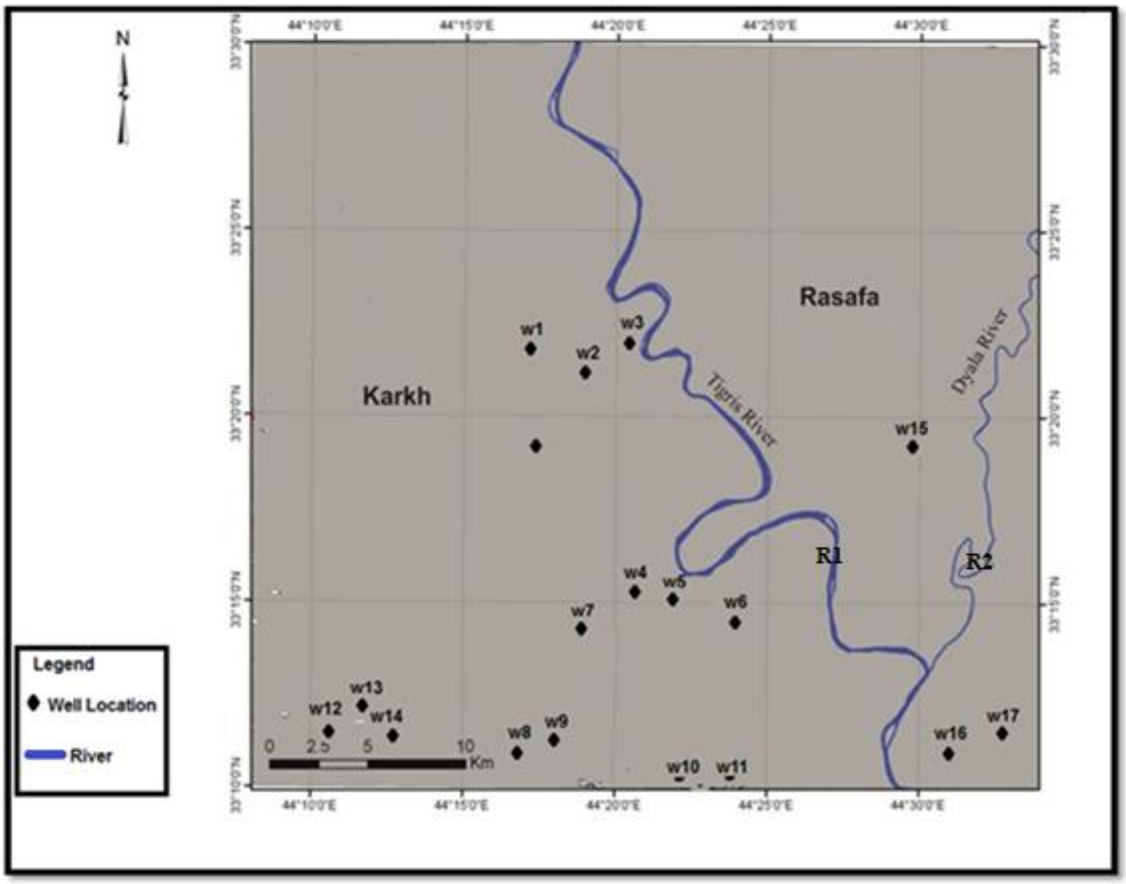

Figure 2. Map shows the study area and sampling stations.

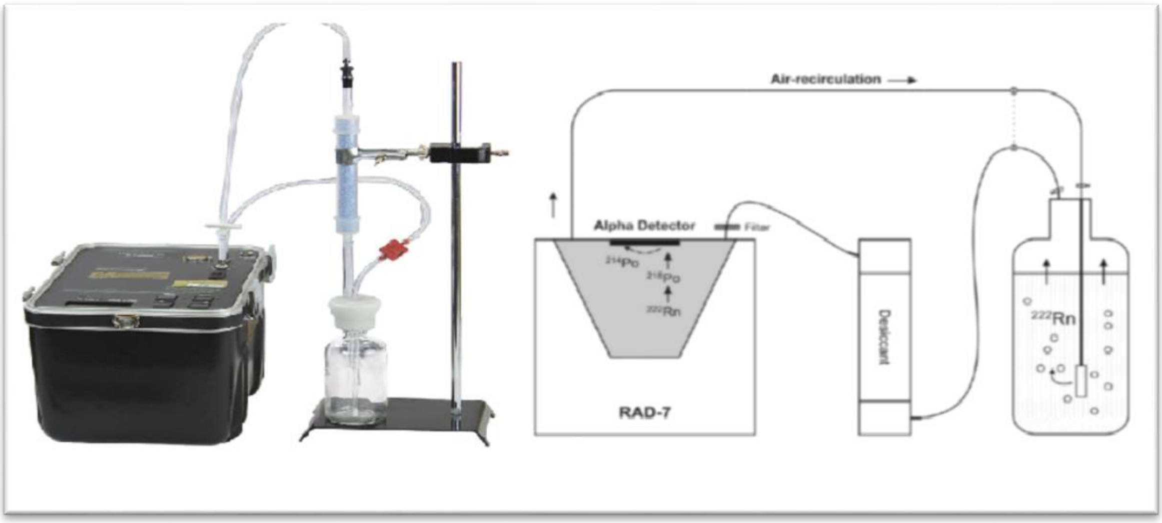

Figure3. Schematic diagram of RAD H2O

Date: October 2023

Table1.Coordinates of Well and samples sites.

	Locations	Type water	Well. No	Coordinates	land uses type
1	Al - Shuala	Groundwater	W_1	33°25'36.37"N , 44°10'59.17"E	Urbanized area
2	Al- Hurriya	Groundwater	W_2	33°21'37.9" N, 44°17'51.6" E	Urbanized area
3	Al-Kadhimiya	Groundwater	W_3	33°23'58.11" N, 44°18'33.1" E	Urbanized area
4	Al-Dora near the refinery	Groundwater	W4	33°15'33.29" N, 44°22'04.49" E	Urbanized area
5	Al- Dora near the electric station	Groundwater	W5	33°15'33.29" N, 44°24'04.49" E	Agricultural area
6	Al- Dora (Albuitha)	Groundwater	W6	33°14'58.5" N, 44°26'30.63" E	Agricultural area
7	Al-Saidiya	Groundwater	W7	33°15'15.4" N, 44°21'41.91"E	Urbanized area
8	Al- Yusufiya 1	Groundwater	W8	33°08'23.26" N, 44°18'32.5" E	Agricultural area
9	Al- Yusufiya 2	Groundwater	W9	33°07'23.26" N, 44°16'32.5" E	Agricultural area
10	Al- Mahmudiyah 1	Groundwater	W10	33^0 03'17.92"N $44^0$21'07.32"E	Urbanized area
11	Al- Mahmudiyah 2	Groundwater	W11	33^0 04'17.92"N $44^0$23'07.32"E	Agricultural area
12	Al- Radwaniyah 1	Groundwater	W12	33°07'46.71" N, 44°11'17.05" E	Agricultural area
13	Al- Radwaniyah 2	Groundwater	W13	33°08'46.71" N, 44°13'17.05" E	Agricultural area
14	Al- Radwaniyah 3	Groundwater	W14	33°10'46.71" N, 44°11'17.05" E	Agricultural area
15	Al-baladiat	Groundwater	W15	33°20'49.34" N, 44°28'03.84"E	Urbanized area
16	Al- Rustmieh 1	Groundwater	W16	33°16'31.01" N, 44°31'57.12"E	Urbanized area
17	Al- Rustmieh 2	Groundwater	W17	33°17'31.01" N, 44°33'57.12"E	Urbanized area
18	Tigris river	Surface water	R1	33°16'48.35"N 44°28'45.25"E	-
19	Diyala river	Surface water	R2	33°14'7.06"N 44°31'14.00"E	-

3. Results and Discussion

Results of the groundwater samples collected from some areas of Baghdad City and (2) samples from Tigris River and Diyala River are provided in Table 2.

Date: October 2023

Table 2. Concentration of Radon, TDS and Depth

No.	Well. No	pH	TDS (ppm)	Depth of wells (m)	^{222}Rn (Bq/L)	SD	Annual effective dose (μSv.y-1)
1	W1	7	2730	10	0.89	0.2	4.87
2	W2	7	4640	15	0.55	0.05	3.01
3	W3	6.9	1768	12	0.95	0.05	5.20
4	W4	7	1605	22	1.95	0.04	10.68
5	W5	7.1	1547	15	1.85	0.03	10.13
6	W6	7	1104	10	0.5	0.2	2.74
7	W7	6.9	1300	8	0.3	0.02	1.64
8	W8	6.9	1378	12	0.4	0.05	7.67
9	W9	6.9	1126	24	2	0.2	10.95
10	W10	6.9	1100	10	0.61	0.07	3.34
11	W11	6.8	1820	18	1.6	0.07	8.76
12	W12	7	3600	14	0.55	0.02	3.01
13	W13	7	3000	8	0.45	0.02	2.46
14	W14	7	1890	10	0.48	0.02	2.63
15	W15	6.9	1715	10	0.42	0.01	2.30
16	W16	8	3210	15	1.7	0.02	9.31
17	W17	6.87	3360	9	0.35	0.02	1.92
18	R1	7.4	538	-	0.028	0.01	0.154
19	R2	6.8	890	-	0.019	0.01	0.1

^{222}Rn (Bq/L): Radon-222 concentration in Becquerel per Liter, SD: Standard deviation, TDS: total dissolved solids

Radon concentrations ranged from 0.3 Bq /l in Al-Saidiya, which is an urbanized area to 2Bq/l in Al- Yusufiya 2 with an average value of 1.15 Bq/l Fig. (4). The difference in the depth of the wells is due to differences in the geological nature of each region and the environmental conditions and the movement and constant change of water, the study showed a higher concentration of radon in groundwater compared with surface water between radon concentration in surface water within the study area. Results show that the radon concentrations from all sampling sites well acceptable for drinking purposes since they are below the maximum contamination level of 11 Bq/l recommended by the United States Environmental Protection Agency (EPA), WHO and the European Commission.

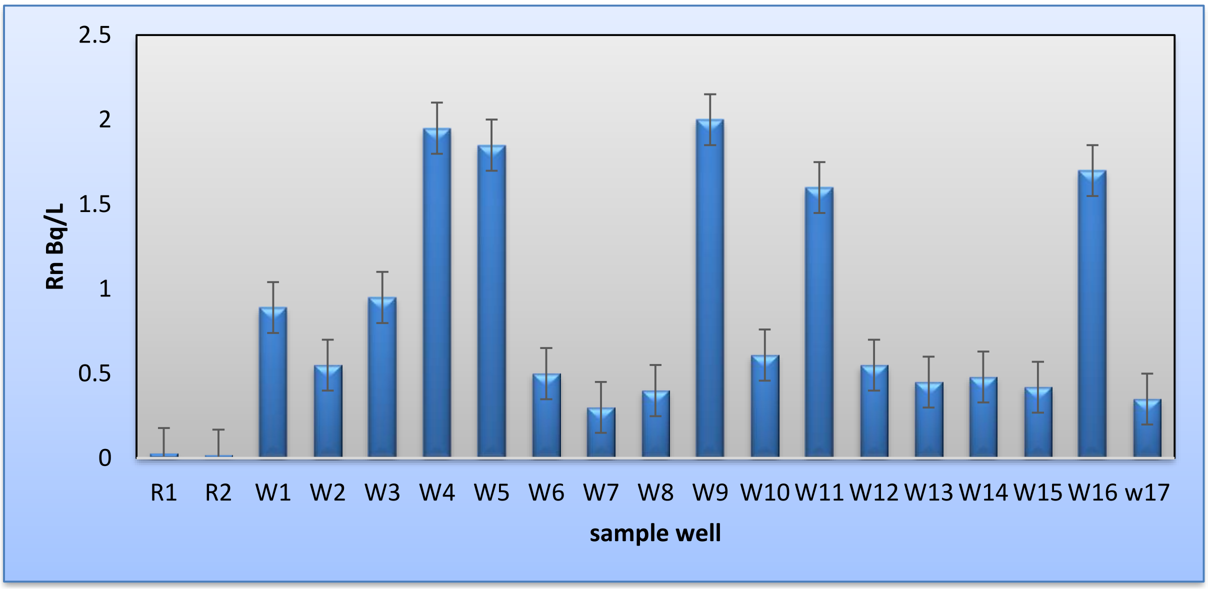

Figure 4. Variation in the Radon concentration of water samples

The range of radon concentrations were used to compare with those from other parts of the world. It was observed that the water samples in the present investigation are comparatively lower than those reported (China by Kedahet al. 11.41 Bq / L, Malaysia by Ahmad et al.4.7 Bq / L , Sakarya, Turkey by Yakut et al. 9.05 Bq / L, Pakistan by Khattak et al. 8.8 Bq / L.) [10,11].In the present investigation, the water samples were collected from different depths to find the relationship between radon concentration and depths of the well(groundwater)., Observed an increased in radon concentration level with increased depth the wells (maximum radon concentration (2 Bq/l) at the depth range of (24 m)The pH of water samples from study areas ranges between 6.8 and 8 its which is within the permissible limits recommended by US EPA [12], WHO [13], Fig.(5)The results show that there the variation the pH value don't affect radon concentration since there is (no significant correlation between the two.)

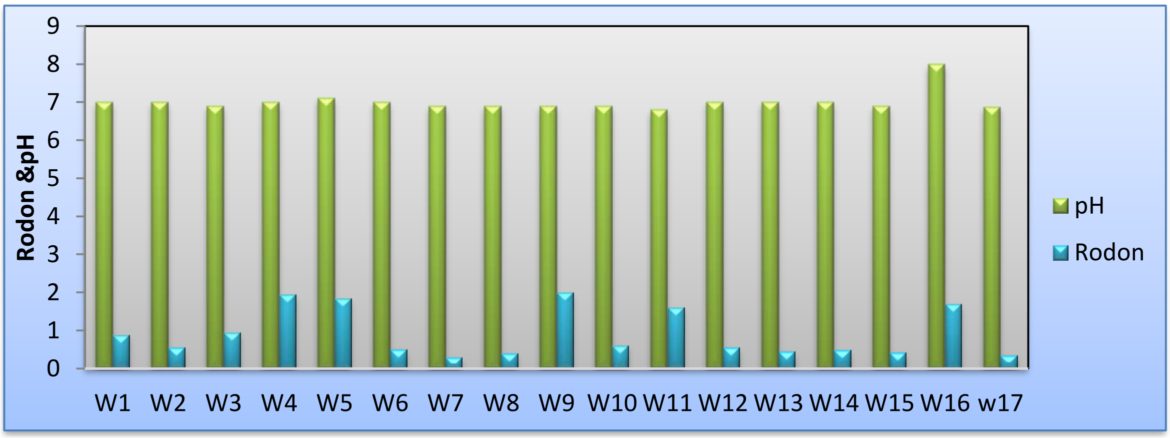

Figure 5. Radon concentration with pH in groundwater in the study area

The total dissolved solids (TDS) for the groundwater samples ranged from 1100 to 4640 ppm it which are high values in comparison the permissible limits of (1000 ppm for drinking purposes), However, The high salinity in groundwater models is due to its natural mineralization, Fig.(6) and which contributes to the high TDS values however it does not the difference values (TDS) don't affect radon concentrations (no significant correlation).

Date: October 2023

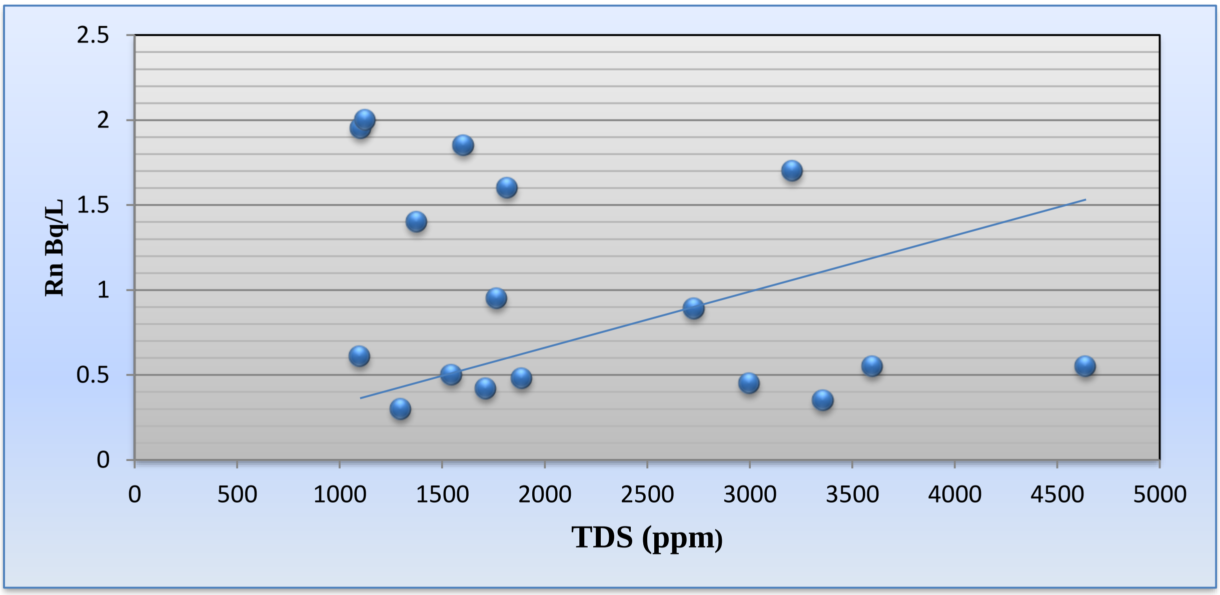

Figure 6. The Relationships between radon and TDS in water samples

The annual effective dose was calculated and the values ranged from 1.64 to 10.95 (µSv.y-1), which is less than the effective dose equal to 0.1 mSv/y recommended by WHO **Fig. (7)**. An annual effective dose for ingestion was accounted by Eq.1. [10]

AED = CR_n × Ai × Df Where: CR_n : Concentration of radon in water (Bq/ L), (1)

Ai: Consumption amount (1095 L. y-1) (general consumption rate).Df: is the ingesting dose conversion factor for radon (5 * 10-9Sv Bq-1).

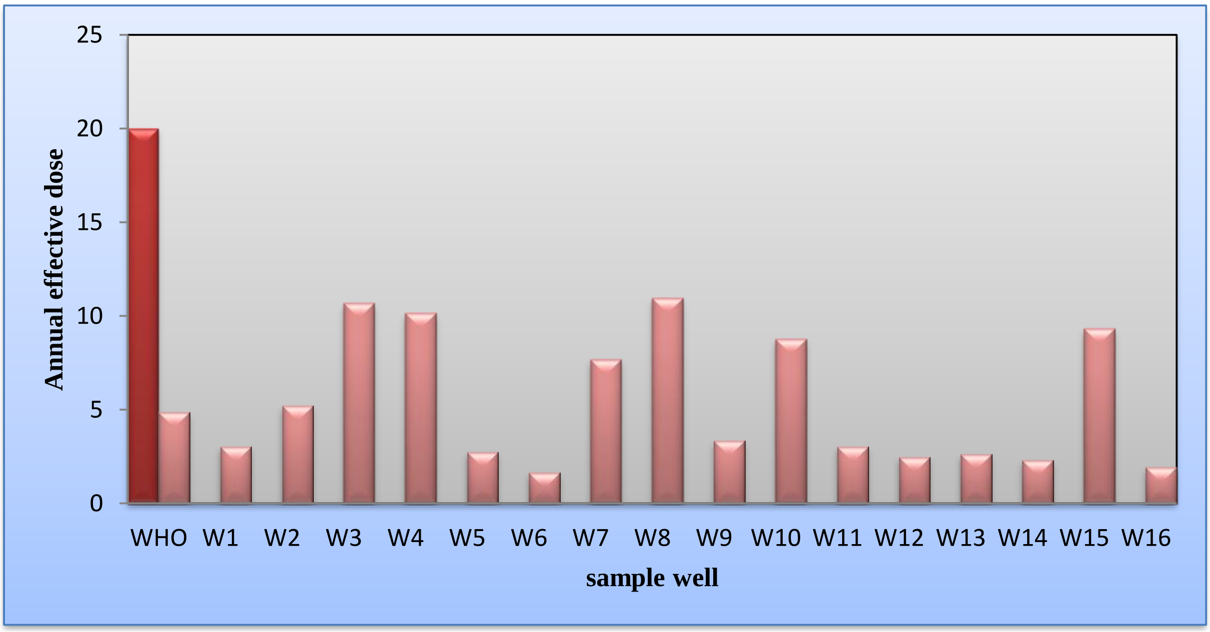

Figure 7. The relationships between the effective dose in the study area and WHO

Date: October 2023

4.Conclusion

The radon gas concentrations in the groundwater samples for the study area were (0.3 to 2) Bq/L which is higher than the concentrations of radon gas in surface waters (Tigris and Diyala)., But by comparing it with the concentration rates of radon gas for groundwater in general, which reach ((4-40000 Bq/L) are low, and we conclude from this that the groundwater in the study area is shallow type Results show that the radon concentrations from all sampling sites are well below 11 Bq/l. It is within the acceptable the below levels recommended by USEPA, UNSCEAR, EU Council and WHO. The TDS values are over the WHO permissible limits for consumption, however There is any significant correlation between pH and TDS values and concentration of Radon, this indicate that no effect to the radon concentrations. The annual effective dose for all the sampling sites was less than 0.1 Sv/y which is recommended by WHO.

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Date: October 2023

A Salt Tolerant Native plants as a Solution for Mobile Sand and Dust in Kuwait

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Abstract: In this study, a coastal research site north of Kuwait Bay faces sand encroachment, floods, and wave erosion. The plantation project's infrastructure was improved by fencing 1.2 km2 with barbed wire. The heavily deteriorated environment has coppice dunes of Nitraria retusa and Lycium shawii around single, double, or triple plants. To manage mobile sand and dust and protect the research centre, 21,500 Nitraria and Lycium were planted and irrigated with brackish water (around 7000 TDS). In order to aerodynamically shift and/or trap mobile aeolian sediments, the vegetation was planted in a V-shape facing the north-westerly wind. A closer gap (about 1m between plants) on the side facing the primary wind and widened toward the inner edges of the gated area controls mobile sand and dust. This projected design stabilizes the soil, protects against floods and wave erosion, enhances flora and animals, and controls aeolian activity. Mobile sand and dust yearly rates in the downwind traps were reduced by 94% and 64.5%, respectively. Native vegetation can control mobile sand and dust, according to this. Such systems can be more efficient with proper design and plant spacing.

1. Introduction

The aeolian activities have become more frequent in the past two decades because of fluctuations in climate and native vegetation cover (type and density) [1, 2]. Intensive aeolian activities cause major socioeconomic challenges locally, regionally, and globally [3 - 32]. In order to aeolian sediment transport, the interaction between the surface geomorphology and wind (direction and speed) should be entirely understood [33 - 46]. Native plants play an essential role in forming hummocky surfaces and coppice dunes and thereby reducing wind speed [47,48]. Once the sand drift starts to grow, its evolution process is controlled by the flow pattern that is directed by land geomorphology, vegetation gap ratio, and the form of the mobility of the aeolian particles [49 - 54]. Sand encroachment around the canopy is caused by plants disrupting the wind's behaviour with loaded sand; the larger the plant, the higher the volume of trapped sand and dust [55,56,57]. The influence of the plant morphology (size, shape, and gap ratio) is an important factor in controlling mobile sand and dust [58- 61]. Multiple studies recognized a strong association between aerodynamic and plant morphological properties and efficiency in trapping mobile sand. Consistently, the bulk volume of trapped aeolian sediments around 15 dominant native plant species in Kuwait was calculated. *Lycium* sp. and *Nitraria* sp. are efficient among all native vegetation in trapping the hugest volume of encroached sand and dust sediments up to 22 m^3 and 16 m^3, respectively, and branding them the most appropriate upcoming methods in trapping shifting sand and dust [62-67]. The applications of GIS (Geographic Information Systems) and RS (Remote Sensing) data, including Digital Elevation Models (DEM), have been well implemented for geomorphological analysis in the desert environments such as the case of Kuwait. Some of the geomorphic applications include the detection of geomorphological changes in sabkhas

Date: October 2023

using satellite image classification [68], identifying areas that are prone to sea level rise (SLR) scenarios, the environmental and economic impacts of SLR, and establishing a coastal vulnerability index for the coastline of Kuwait [69- 71], and to evaluate the spatial patterns of aeolian sand encroachment and its contributing factors [72]. Furthermore, geomorphological characteristics are usually integrated into GIS models as factors in environmental urban planning studies [73] and for suitability analysis for new urban site selection in the desert [74]. In addition, using DEM enabled geomorphologists to extract relevant geomorphic information, including the slope and the drainage system of an area for hydro-morphometric applications (Figure 2) [75], and to assess the sand dune movement and detect geomorphic changes in depression zones [76]. The northern part of Kuwait Bay consists of descending valley that slopes down from an escarpment at 3 km away toward Kuwait Bay, forming alluvial fan deposits (Figure 1). The alluvial fan deposits are occupied by *Nitraria retusa* and *Lycium shawii* as predominant native plants forming three main forms of coppice dunes (nabkhas) categorized by Al-Dousari et al. [33], namely: single, compound, and complex nabkhas, where the pilot area is situated within the mobile active aeolian passage. The study area is threatened by three main disasters that should be managed properly; namely: floods during winter, mobile sand and dust during summer, and coastal erosion. The native plant species play a key part in trapping mobile sand and dust in desert regions [48,77,78]. Nitraria and Lycium species were the furthermost efficient native vegetation in trapping the mobile sand during summer and flash floods in winter and springtime [55]. The study aims to assess and manage the aeolian activities in the study area using massive native plantations landscape strategy grounded on a scientific foundation; this enhancement in the vegetation cover, with native plant species, will improve available nutrients, retention, and soil texture, also provide a healthy ecological environment for wildlife in the area, and to safeguard any future urban infrastructure that is constructed in the area as well.

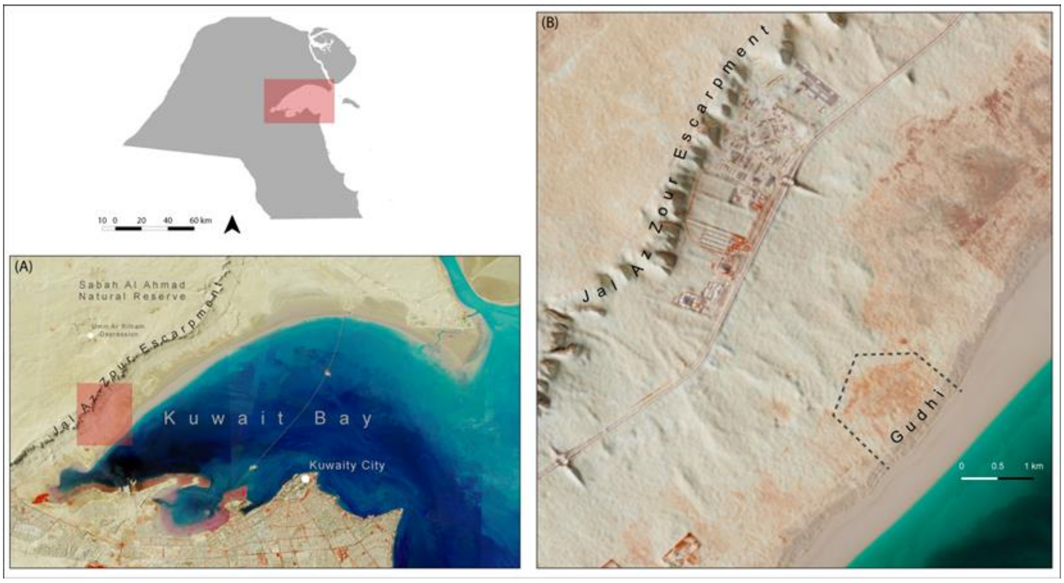

Figure 1. The study area location map, the implemented massive plantation was within the shaded area.

Date: October 2023

2.Materials and Methods

With the intention to diminish the effect of mobile sand and dust sand in order to protect land and prospect substructure in the pilot area, a groundbreaking strategy depending on a massive plantation of *Nitraria* and *Lycium* as effective native plants in controlling all threats mentioned before. A massive native plantation with special scientific tactics should be carried out in order to manage predictable hazards accompanying aeolian activities, coastal erosion, and flashy floods. Therefore, a 25 m in-depth water well was drilled. The water table is at a 4m depth with around 7000 ppm total dissolved solids, which are suitable enough to establish a massive plantation project. Subsequently, a native plantation design was done and implemented via a massive plantation for around 21,500 *Nitraria* and *Lycium* plants as the main step to managing flash floods, mobile dust and sand, and seaside erosion. Around 21,500 *Nitraria* and *Lycium* plants were planted with public awareness for schools and public environmental authorities within open days and workshops during plantation seasons. The massive plantation plan was designed by an artistic engineer in order to approach characteristically used in these arid conditions for the controlling of such environmental hazards. The irrigation was only during summer once a week, and no irrigation during rainy seasons (winter and springtime) for only 3 years. The sand accumulation around plants forming newly formed nabkhas was greater on the upwind side of the study area [79,80,81]. The growth rate of flourishing was faster in areas with higher mud and very fine fractions percentages within surface sediments. Particle size analysis and statistical parameters for all samples were done according to Folk and Ward method [82] using Blott and Pye software [83]. A databank contained by the program of Crisis Decision Support (CDS) was established for the study area counting data concerning risks, sedimentation, geomorphology, and native life (flora and fauna). Dust and sand collectors (6 each) were established up and downwind of the plantation as well as in a control area (monitored for 4 years). In order to quantify the site's existing flora and fauna, there were an assessment and analysis of the study area using available aerial photos using infra-red images. Inventory assessment of surface and a meter depth sediment around the roots of Nitraria and Lycium were collected. Vegetation and fauna surveys and assessments were started to form enough reference data. Satellite images for the study area and surroundings were prepared (with a total area of about 4.5 km2) after and before the establishment of management measures. Drainage patterns, wadis, valleys, and alluvial fans were closely outlined for the study area. In imperative to attain comparatively fast and better plantation, two different forms of bowl-grownup nursery systems (regular root and elongated root systems) jabbed with fungi AM (Arbuscular Mycorrhizal) were used to enhance the vegetation growth rates. The coppice dunes (nabkha) are forming in three patterns (compound, complex, and isolated coppice dunes) to control salt pressure and nutrient obtainability as they are the main restraint to vegetation development and production in the study area [33].

3. Results and Discussion

The study area altitude is varying between 0-20m ASL (Above Sea Level). It is situated downstream the Jal Al-Zour parallel escarpment which acts as a watershed area 6 km 125 m ASL. The drainage streamlines descending from the escarpment area hit the plantation area with two main streams and 14 minor attributes mainly from the north and the west (Figure 2). The northwesterly wind is the dominant direction. A massive plantation was shared with public awareness (school students and public environmental authorities) of two main native plants (*Nitraria retusa*, and *Lycium shawii*) in the study area (Figure 3). Around 5 open days and workshops were done up to date as a public awareness. The irrigated water from the drilled water well shows the ground water table is at a 3.5m depth with 7250 mg/L as total dissolved solids (Table 1). which are fit enough to start a massive vegetation project, consequently, the sand accumulates nearby *Nitraria retusa,* and *Lycium shawii* creating coppice dunes or newly formed nabkhas and was noted greater coppice dunes on the upwind sideways of the pilot area. The irrigation of such brackish causes slow growth rates for the vegetated plants but makes the plants high adaptability to the harsh environment. The growth rate of flourishing was faster in areas with larger size fraction percentages within surface sediments (Figure 4). Surface sediment (Table 2) and Aeolian (dust and, sand) samples (about 250 samples) were analyzed using a centrifugal particle analyzer for grain size distribution. Mobile sand (Figure 5a) and dust (Figure 5b) annual rates in the downwind compared to upwind sand and dust traps decreased by 94%, and 64.5%, respectively.

Date: October 2023

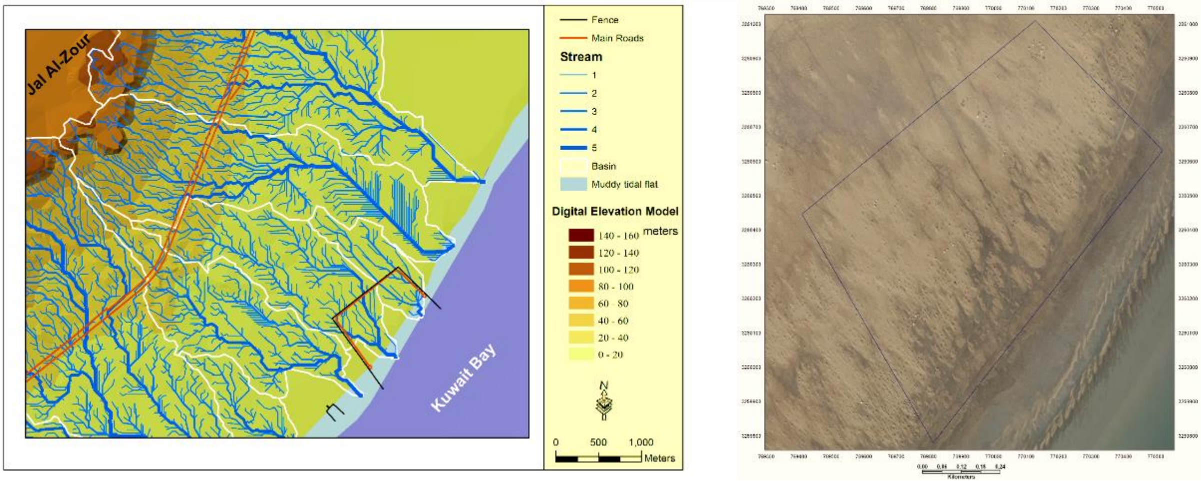

Figure 2. The DEM elevation model and drainage system maps (left) and a close satellite 2013 image with a high resolution before the massive plantation for the pilot area.

Figure. 3. Arial photo 2022 by a drone for the study area attacked by tongues of mobile sand corridors forming a unique field of coppice dunes around vegetation (left) and a single plant of *Nitraria retusa* trapping around 21 m^3 of sand and dust (right).

Table 1. Chemical parameters of the water in the drilled well used in irrigation for planted halophytes within the study area.

Parameter	**Result**
pH (Alkalinity/acidity)	7.56
Conductivity level (µS/cm)	10250
Total Dissolved Solids (mg/L)	7250
Na-Sodium (mg/L)	1384
K-Potassium (mg/L)	23
Ca-Calcium (mg/L)	733
Mg-Magnesium (mg/L)	212
Cl-Chloride (mg/L)	3023
SO_4-Sulphate (mg/L)	1634
NO_3-Nitrate (mg/L)	124
Br-Bromide (mg/L)	2.79

Table 2. Statistical parameters for surface and root (1 m depth) sediments formed around *Nitraria retusa* and *Lycium shawii* in the study area.

vegetation type	Mean (phi)		Sorting		Skewness		Kurtosis	
	Surface	1 m	Surface	1 m	Surface	1 m	Surface	1 m
Lycium shawii	1.61	1.54	1.05	1.01	0.18	0.17	0.94	0.94
Nitraria retusa	1.72	1.53	0.95	0.93	0.11	0.07	1.17	1.24
Average	1.67	1.54	1.00	0.97	0.15	0.12	1.06	1.09

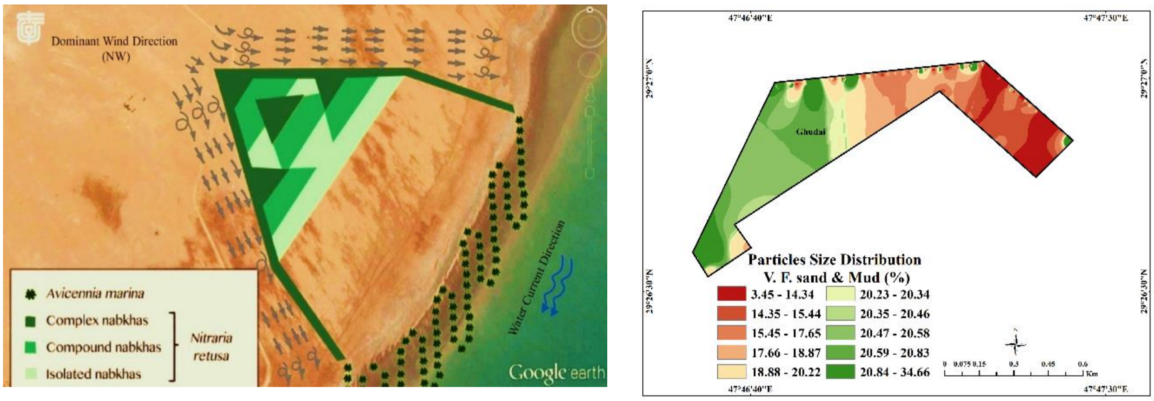

Figure. 4. The massive plantation design for native plants proposed in the study area (left), and very fine sand and mud percentages in the plantation area (right).

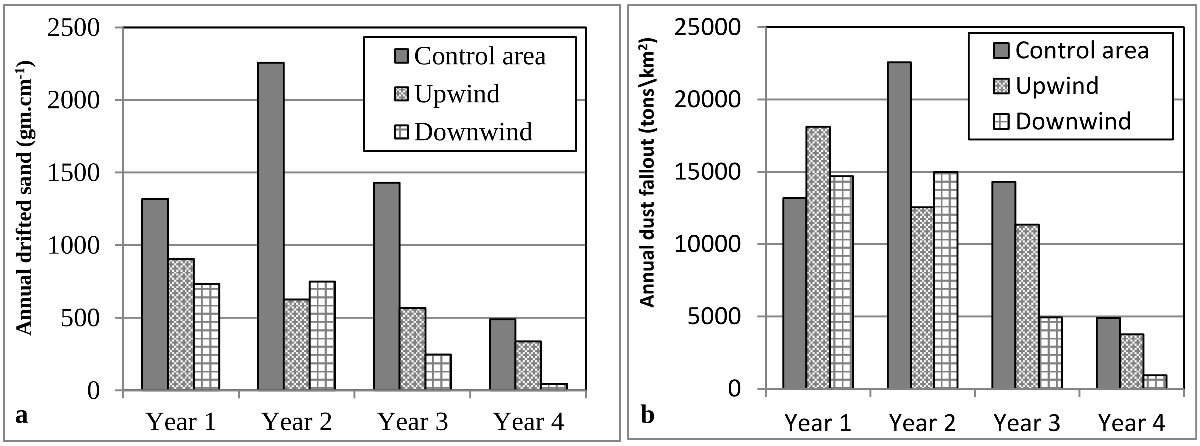

Figure.5. Mean deposited sand (a) and dust (b) for sand and dust traps located at upwind, downwind, and control areas within the study area.

3.1. Assessment for Fauna and Flora

The fauna and flora monitoring and assessment establish basic information on present flora and soil properties, that are considered to be important for putting a figure on ecological settings before the actual launch of massive native restoration or plantations hard work.

Figure 6 shows the vegetation health map in reference to the RGB detector that pinpoints the colour red as unhealthy, indicating a chlorophyll content deficiency and decreasing the photosynthesis process in that zone; any other colour would mean healthy vegetation. There were 76 bird species detected within the study area for the last 4 years (2019-2022). The bird's watcher site in the study area (https://ebird.org/region/KW/hotspots), the birds were classified into three parts in accordance with their number in the world; namely endangered, vulnerable, and near threatened. In the study area, there were two as vulnerable (Houbara Bustard and Imperial Eagle) detected three times, one classified as endangered (Steppe Eagle) detected one time, and four were near threatened (Eurasian Oystercatcher, Eurasian Curlew, Pallid Harrier, and Cinereous Bunting) detected 12 times. The number of birds detected increased by 32% and 31% in 2021 and 2022, respectively, compared to the

Date: October 2023

counts in 2019. Also, the bird species (diversity) increased by 64% and 49% compared to 2019 (Fig. 7a and b). There are a number of animal and insect increases indicated by the number of holes of beetles and ants, lizards, agamid lizards, and foxes in the pilot area.

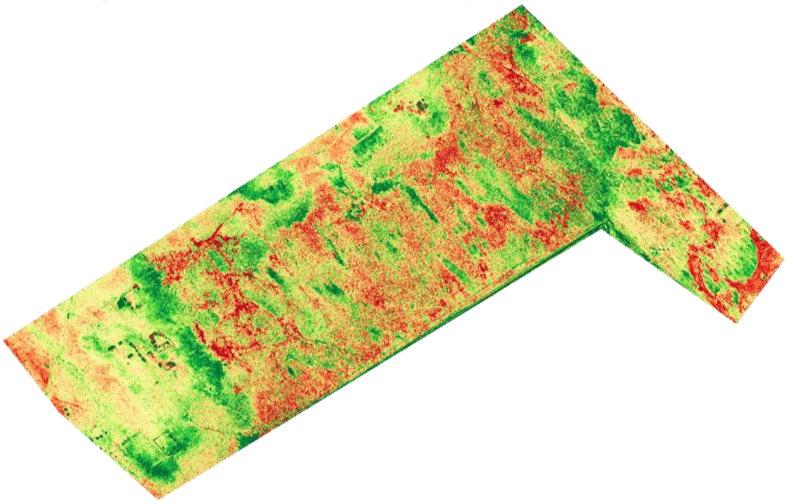

Figure. 6. Flora flourishing map (red represents low while green is high).

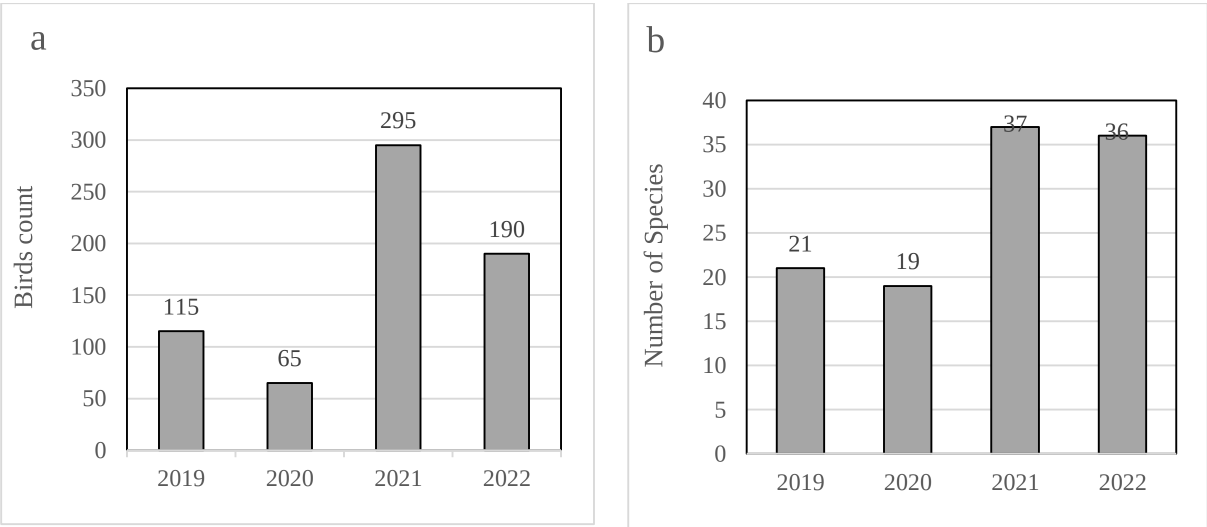

Figure.7. Variations within bird counts (a) and counts for species (b) in the study area.

4. Conclusion

Native vegetation type, size, density, horizontal space, or distribution play a crucial role in trapping aeolian sedimnts. The highly efficient native plants are the most appropriate solution for controlling aeolian activity. This study shows that plant effectiveness in reducing Aeolian activities (dust and sand). The Nitraria and Lycium massive plantation using aero-dynamic response to airflow away can act as an adaptation method to control mobile sand and dust, floods, and erosion. Also, the ecological system in the study area healed very fast. The growth rate of the plants was higher with a coarser size fraction, mainly in the eastern corner of the study area. The research demonstrates an improvement in the study area's vegetation cover, growth in the number of nabkhas, and a thriving proliferation of native species, compared to before the commencement of the research. Additionally, a considerable increase in bird species was observed, and the number of birds discovered rose as a result of the study procedures. That signifies a healthy ecological system has developed in the region. Future studies should concentrate on aerodynamically shifting the mobile sand and dust from future urban areas within severely affected areas in desert regions.

Date: October 2023

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Investigations of Groundwater and Soil Specification at AL-Warrar Canal Reach, Ramadi City-Iraq

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Abstract: The study area is located in Anbar Governorate, western Iraq, within the city of Ramadi, in the area adjacent to Al-Warrar Canal. The study area suffers from a lack of previous hydraulically studies, hydrological, the geological, and topographical characteristic and the soil characteristics, also suffers from a significant increasing in levels of groundwater. Three wells were drilled in area adjacent of the Al-Warrar canal with a diameter of 0.1524m, 10m in depth and 100 m the distance between each well, to observe water level of the groundwater with the change in the levels in Al-Warrar canal. The physical properties of soil, as well as their chemical properties, were studied in order to straighten. According to these tests, the soil of the study area was found to have a high concentration of sulfite, gypsum, salts and moisture content in the upper layers of clayey sand and clay, with low plasticity. As well as the increase of level in Al Warrar Canal water leading to an increase the hydraulic heads in the groundwater level in the area of study. Depending on the two possibilities were taken for the movement and transmission of groundwater, one of which is the movement of groundwater from the study area to Al Warrar Canal and the other is groundwater movement from the canal to the study area depending on the increase and decrease in the water level of Al Warrar Canal.

1. Introduction

The aquifer is defined as an underground layer of water-bearing permeable rock, rock, or unconsolidated materials (sand, gravel, or silt). The groundwater is abstracted from the aquifer by drilling wells [1]. Therefore, it is necessary to determine groundwater levels, especially in the layers those close to the ground surface to know the properties of soils and the effect of the groundwater on it before creating for any construction or service project. [2], showed that, field and laboratory tests were carried for three great water projects in Basra. Thirty-nine boreholes were drilled at a depth of 30 m. The results were observed the soil of Basra forms mainly sand, clay, silt, clayey silt, and silty clay, with plasticity low for this soil. The study area in Al-Ta'meem, Al-Ramadi suffered lacks sanitation and storm sewer networks. Therefore, excess water penetrates into the soil and groundwater, which increases its levels. Which accelerates the water penetration is that the soil is clayey-sandy and clayey-gravel in some areas in the study region. As well as this area is close to septic tanks that seep into the groundwater, causing water pollution. This region was in ancient times an agricultural area, led to storing large quantities of irrigation water, this case increase the percentage of groundwater and maintain its high level until the present time. Also, one of the main problems in this area is the lack of previous hydraulically studies on groundwater information and the percentage of its pollution, as these were real obstacles to determining the geological and hydrological characteristics of the area [3]. Therefor the distribution for soil layers estimating hydraulic heads of the aquifer system, and finding the soil characteristics, hydrological, the geological, and topographical characteristic in the study area,

Date: October 2023

the study was conducted. The main purpose of three wells were drilled in this area to observe water level of the groundwater with the change in the levels in Al-Warrar Canal. And also the soil investigation was to identify the subsoil engineering, physical and chemical properties up to 10m depth.

2. Materials and Methods

2.1. Soil Testing and Groundwater Investigations

2.1.1. The Field Works Study

The location of the study area was specified after some investigations for the suitable locations for well drilling. The survey works were conducted to specify the drilling locations by using the Total Station device and the (GPS) to specify the path between the locations and with Al-Warrar Canal and to specify the coordinates for these locations. Three locations were drilled at 10m depths, 0.1524m diameter and 100 m the distance between each location, specified as right-angled triangle in the study location. To check the movement of groundwater, it parallel to Al Warrar canal or perpendicular to this canal.

In 13/10/2020, the trucks reached the study area to start the work. The drilling started in rotary drilling according to the American Standard (ASTM D-1452 – D5783), [4-6] using a mechanical drill (Flight Augers) with 0.1524 m diameter. The pipe with a diameter of 0.1016 m installed graduated filter with a diameter (0.005-0.019) m to every observation well to fill the remaining diameter from the observation well (0.0508 m).

2.1.2. The Location of wells drilling

Three drilled observation wells were located on the right bank of the Al Warrar canal between Al Haouz Bridge and Al Qasim Bridge, Al-Ta'meem district, between the 33 ° 25' 09 "N to 33 ° 24'14" N Latitude and 43 °17'15 "E to 43 ° 17' 54" E longitude, figure (1). Al-Ta'meem district is one of the largest areas in the Ramadi city, which is the center of Anbar Province, about 100 km west of the Iraqi capital moreover, it has an area of about 14 km^2.

The settlement problem had been seen for the first observation well at a depth 1.5m due to the brittle type of soil, which was usually clayey sand soil. Therefore, the first attempt was not successful. In the second attempt, the pipe was sucked, and then the re-drilling of the observation well succeeded. Then the pipe was dropped to a depth of 10m from the ground level. On the other hand, the first attempt to drilling the second and the third observation wells was succeeded and the pipe is dropped to 10m from the ground level. During the fieldwork, the distributed Samples (Ds) were broken down and obtained during the drilling for every 1.5m from the boreholes, and were put in a plastic pocket, were transferred to the laboratory to do the required laboratory testing according to the American Standard (ASTM D-1586) DAS, [4-6].

Figure 1. Sites of the observation boreholes in the study area [3].

Date: October 2023

2.1.3. The Groundwater Levels

Since the completion of the drilling of each observed wells finished after 24 hours, the groundwater has reached nearly a steady state. It has been observed that the groundwater level rises and reaches approximately the natural ground level, and it can be calculated as about 1.5 meters from the natural ground level.

2.1.4. Laboratory Tests for Soil

Tests were executed to determine some of the physical and chemical properties regarding classification of soils at Soil Laboratory of Engineering Consulting in the University of Al-Anbar. The results from these tests have been used to assess soil quality and its ability to transport groundwater, in addition to specifying its type. As per specification in Table (1).

Table 1. Standards for laboratory testing, (American Standards for Testing and Materials (ASTM) [7], and American Standards for Testing and Materials (ASTM), [8].

laboratory testing to distributed Samples (DS)	Standards for laboratory testing
Grain Size Distribution and Hydrometer Analysis	ASTM D 422
Moisture Content MC%	ASTM D 2216
Specific Gravity (G_S)	ASTM D 854-00
Atterberg Limits (L.L, P.L, P.I)	ASTM D 4318
Moisture-Density Relationship (Compaction)	ASTM D 698
	ASTM D 1557
Sulfite Content (SO_3^{-2})	BS 1377
Gypsum Content (GC)	BS 1377

3. Results and Discussion

The groundwater with the soil plays a significant role in the formation and behavior of condition surrounding the foundation where the structural elements in contact with the soil located near or under the water table are exposed to various damages due to the chemical effect of moisture and salts therein or in the soil.

3.1. Groundwater levels results

The process of fluctuation in groundwater levels in the region is affected by the increase and decrease in the water levels in Al-Warrar canal, in addition to the amount of rain falling in the region with the increase and decrease the amount of water coming from the aquifers surrounding the study area as shown in Figure (2). Therefore two possibilities were taken for the movement and transmission of groundwater, one of which is the movement of groundwater from the study area to Al Warrar Canal and the other is groundwater movement from the canal to the study area depending on the increase and decrease in the water level of Al Warrar Canal.

Date: October 2023

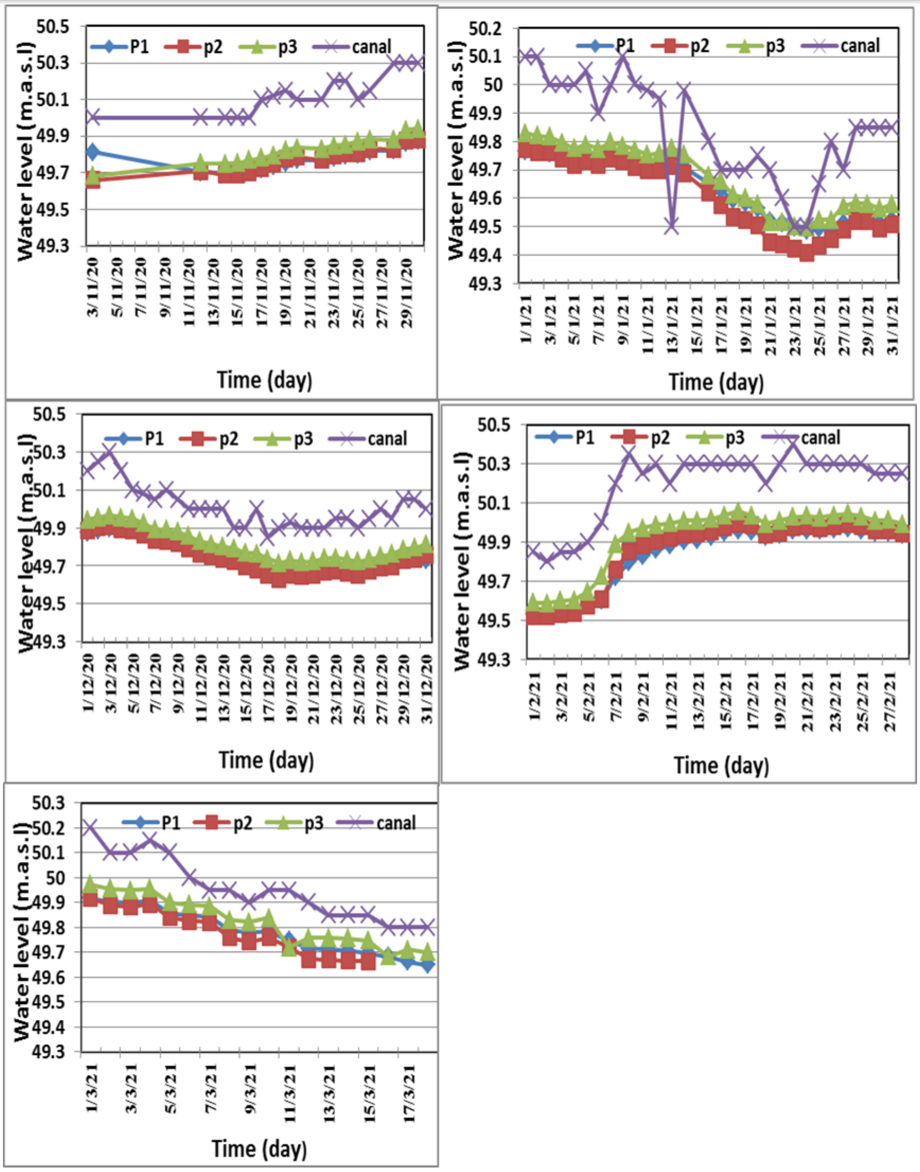

Figure 2. The groundwater level fluctuated in the three wells compared to the water level in Al Warrar canal during the five months period [3].

3.2. Geotechnical investigations

This study includes the analysis of Al-Ta'meem district soil for seven geotechnical properties. Where during the fieldwork, the distributed Samples (Ds) were broken down and obtained during the drilling for every 1.5m from the boreholes, and were put in a plastic pocket, were transferred to the laboratory to do the required laboratory testing according to the American Standard. These results contained the physical properties, the granular gradient which is the basis of soil classification systems, the indicative properties of the soil, including the plasticity limit, the liquidity limit, and the plasticity index. As well as knowing the chemical properties of soil that help with the type of materials and treatments that are used in the foundations if a facility was established in the study area, including sulfate ions and the percentage of salts in the soil. The soil of the study area is a high concentration of sulphates, gypsum, salts, and moisture content in the upper layers, with low plasticity. Atterberg's limits and their corresponding base theories are giving very useful indication to classify the soil and define the swelling properties of the clayey soils. It also helps to show soil susceptibility to liquefaction. It was discovered three layers of soil in this area. The results of the tests showed that the

Date: October 2023

results of the tests indicated that the liquid limit (L.L) values ranged from (24-30) % minimum, and (38-49) % maximum. The values for plastic limit (P.L) ranged from (4-10) % minimum, (15-25) %, maximum. Type of soil layers in three boreholes are shown in Tables (2, 3).

Table 2. The soil layers in three wells

The soil type	Layer1	Layer2	Layer3
First well	a package of clayey sand-Poorly graded, (from 0 m to 1.5 m)	clay, (from 1.5m to 6 m) depth	clayey gravel, (from 6 m to 10 m)
Second well	consists of one layer	only from clay at a	depth of 10 m
Third well	Clay, (from 0 m to 4.5 m) depth	a package of clayey sand, (from4.5m to 6m) depth	clayey gravel, (from 6 m to 10 m) depth

Table 3. The results of soil chemical and physical properties

Parameters	First well		Second well		Third well	
	Max %	Min %	Max %	Min %	Max %	Min %
Gravel	52	0	4.82	0	60.43	0
Sand	69.8	13	35.49	7.9	64.83	4.71
Passing #200	93.3	8.9	89.2	59.69	94.1	12.9
L. L	43	30	38	26	38	26
P. L	29	16	23	19	24	14
P.I	20	4	15	5	25	10
M C	31.01	18	34.47	20.76	32.72	10.87
SO_3	5.013	0.832	1.368	0.53	0.933	0.137
GC	10.118	1.788	2.942	1.139	2.006	0.295

3.3. Permeability Test

The soils permeability is one of the most important factors in soil classification. The permeability of clayey sand soil has computed depending on the sieve analysis as shown in equation (1) [9]. Table 4 shows the results of the sieve analysis for the soil of the study area. The results showed that the permeability of the soil was 2.883 x 10^{-4} cm ⁄s. Figure (3) shows the distribution of the grain size for the soil in the study area.

Whereas the permeability for the clay soil and clayey gravel soil were determines by equation. 2 depends on the plasticity index [10]. The results showed that the hydraulic conductivity of the clayey gravel soil is 2.709 x10^{-4} cm/s, and for the clay was 3.108x10^{-7} cm/s. Also table (5) shows the specific gravity was 2.65 for the clay and 2.67 for the clayey gravel soil, and shown the voids ratio, porosity, and hydraulic conductivity of soil. The results showed that the soil permeability in the area is very high in the study area.

Date: October 2023

Table 4. The sieve analysis for the soils of the study area

4. Sieve	5. Diameter (mm)	6. Passing%
7. 4	8. 4.75	9. 91.91
10. 8	11. 2.36	12. 86.53
13. 16	14. 1.81	15. 83.34
16. 30	17. 0.6	18. 81.6
19. 50	20. 0.3	21. 74.7
22. 100	23. 0.15	24. 41.34
25. 200	26. 0.075	27. 27.08
28.	29. 0.054	30. 19.83
31.	32. 0.038	33. 16.94
34.	35. 0.027	36. 14.19
37.	38. 0.020	39. 11.45
40.	41. 0.014	42. 9.61
43.	44. 0.011	45. 6.87
46.	47. 0.008	48. 5.04
49.	50. 0.006	51. 3.20
52.	53. 0.004	54. 2.29

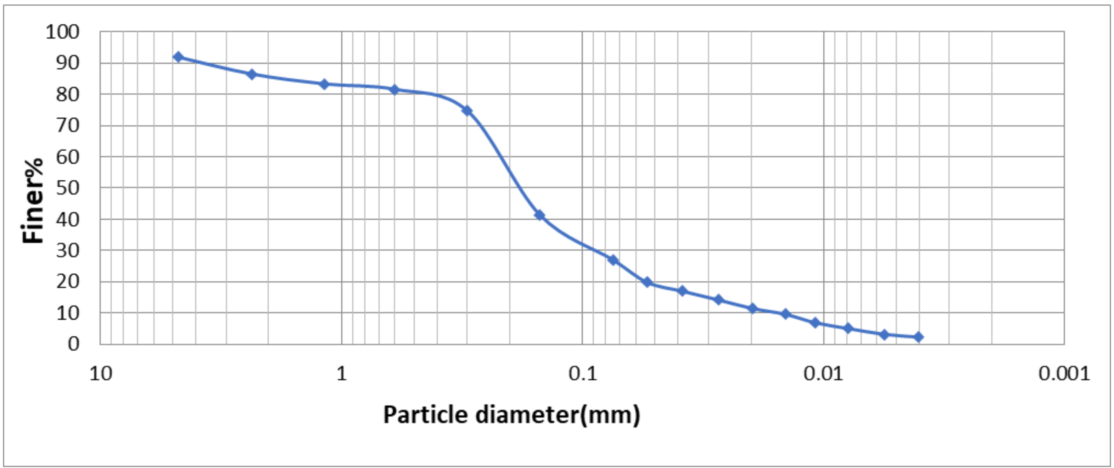

Figure 3. The distribution of the grain size passing from sieve #200 for the soil in the study area [3].

$D_{60} = 0.2339$

Date: October 2023

$D_{30} = 0.0904$

$D_{10} = 0.0155$

$D_5 = 0.0079$

D_{10} = Effective size (mm)

$K_{cm/sec} = c\ {D_{10}}^2$ For clayey sand soil (1)

c = a constant from (1 to 1.5)

$K_{cm/sec}$ = (1.25) 0.0155^2 = 2.883x10^{-4} cm/s

$$K = \frac{0.0174\ I_p^{-4.29}}{1+e}\ \left[e - 0.027\left(w_p - 0.242\ I_p\right)\right]$$

for clay soil and clayey gravel soil (2)

I_p (Plasticity index %), w_p (Plastic limit %), K (Permeability m/day)

$$\gamma_d = \frac{G_S\ \ \gamma_w}{1+e}$$

Table 5. The results of the voids ratio, Porosity and permeability for the study area

55. **Parameters**	56. **Clay**	57. **Clayey gravel**	58. **Clayey Sand**
59. G_S	60. 2.65	61. 2.67	62.
63. ρ_d g/cm^3	64. 1.78	65. 1.73	66.
67. γ_d KN/m^3	68. 17.456	69. 16.966	70.
71. γ_w KN/m^3	72. 10	73. 10	74.
75. **Voids ratio (e)**	76. 0.518	77. 0.574	78.
79. **Porosity (n)**	80. 0.341	81. 0.365	82.
83. **K** cm/sec	84. 3.108x10^{-7}	85. 2.709x10^{-4}	86. 2.883x10^{-4}
87. **K** m/day	88. 0.0002685	89. 0.2341	90. 0.2491

4. Conclusion

The results were evaluated of the study area, based on the data gathered by the drilling wells in this area. According to these tests, the soil of the study area was found to have a high concentration of sulfite, gypsum, salts and moisture content in the upper layers of clayey sand and clay, with low plasticity. And it showed that the soil permeability in the area is very high, it ranged between (3.108 * 10^{-7} - 3 * 10^{-4}) cm/sec in three layers. The results of the tests indicated that the liquid limit (L.L) values ranged from (24-30) % minimum, and (38-49) % maximum. The values for plastic limit (P.L) ranged from (4-10) % minimum, (15-25) %, maximum. The increase of level in Al Warrar canal water

Date: October 2023

leads to an increase the hydraulic heads in the groundwater level in the area of study. Depending on the two possibilities were taken for the movement and transmission of groundwater, one of which is the movement of groundwater from the study area to Al Warrar Canal and the other is groundwater movement from the canal to the study area depending on the increase and decrease in the water level of Al Warrar Canal.

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Using Native Plants as Sustainable Solution for Controlling Aeolian Activities

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Abstract: Kuwait is experimenting with the restoration of severely degraded terrestrial regions in its northern region, center for the development of wildlife habitats. The re-implantation and reproduction of native plants project, which will run from June 2003 to May 2019, is the main part of the restoration of the degraded zones. The most effective plants for reducing aeolian mobile sediments were highlighted, along with the most endangered plant species in the area, including *Lycium shawii, Haloxylon salicornicum*, *Rhanterium epapposum, Panicum turgidum and, Calligonum polygonoides*. The irrigation of these plants was kept up for around one to two years using brackish water from a productive well that produced 20 to 26 m^3 per hour (TDS=4, 900 ml/l) and was hydrogen sulfide-free. Maximum mobile aeolian sediments were captured in *Nitraria, Haloxylon, Tamarix, Lycium, Panicum,* and *Citrullus* at 11.17, 6.29, 6.09, 5.77, 5.60, and 5.51m^3, respectively. Their relative economic values were 14.74, 8.3, 8.04, 7.62, 7.39 and 7.27 $, making them the most effective controls for aeolian processes in both current and upcoming applications.

Article I. 1. Introduction

Nearly 80% of Kuwait is made up of the desert environment, which covers roughly 14.240 km^2 [1]. Such a system is extremely fragile, produces little biomass, and is vulnerable to extensive degradation from both natural and artificial sources. The extension of degraded lands has social and economic consequences [2-5]. Because of this, Kuwait has started to develop a national biodiversity policy to protect Kuwait's biological diversity, ecological systems, and sustain the health of the land. Additionally, emphasis has been placed on the rehabilitation of degraded lands using sustainable, environmentally friendly methods, particularly the cultivation of native plants.

The soil is protected from erosion by wind and water by vegetation [6-8]. Soil erosion can be significantly decreased by the presence of vegetation coverings such standing vegetation and vegetation that is in line with the ground. collecting raindrops and releasing their kinetic energy before they hit the ground. The establishment of green cover improves the quality of our lives and the circumstances for urban living bypurifying the air, regulating temperature, reducing soil erosion, improving the water and soil quality, and enhancing the aesthetics and biodiversity of our city [9-16].

Kuwait is experimenting with the rehabilitation of seriously deteriorated terrestrial areas in its northern region (Liyah), center for the development of wildlife habitats. Due to overgrazing, various military activities, excessive exploitation of the sand and gravel resources, and other factors, this area has experienced severe environmental pressures over the past 40 years [17-21]. As a result, the soil properties have deteriorated and the

Date: October 2023

vegetation surrounding the areas where gravel is extracted and in its immediate surroundings has totally disappeared. In order to coordinate quarrying activities and preserve Kuwait's natural resources, the Environmental Public Authority (EPA) Committee issued Decision No. 973/1997 in October 1997. Another Council of Ministers resolution was made in August 2001 to fill in quarries sites and level off surface irregularities in order to restore the natural vegetation and wildlife to their which was before condition. The ecosystem of center will be restored using both natural and artificial means. In order to enable the degraded soil to rebuild itself without needing direct human involvement, natural rehabilitation depends on generating the right environmental conditions for the recovered region. In order to do this, the region is protected and harmful human activities like grazing, camping, and hunting are outlawed. Most degraded areas require human intervention to develop plans, strategies, and studied programs to restore the area. Artificial rehabilitation is used in these cases. Examples include planting suitable native plants and using sustainable, environmentally friendly applications to restore the degraded soil [22-28]. The primary component of rehabilitation of the degraded zones is the re-implantation and reproduction of native plants. Planting oases in deteriorated playas and wadies with the best plants for regulating aeolian mobile sediments and protecting the most endangered plant species in the area, including *Lycium shawii, Haloxylon salicornicum, Acacia pachyceras, Cenchrus ciliaris, Rhanterium epapposum, Panicum turgidum, Calligonum polygonoides and Vochilla tortilis*. The water utilized for irrigation was brackish, free of hydrogen sulfide, and produced by a well with a capacity of 20–26 m^3/h (TDS = 4, 900 ml/l). These plants received continuous irrigation for almost two years using a variety of experimental techniques, after which they became accustomed to the weather (with 110 mm average rainfall) [21]. This study expands on earlier research that examined the economic value of native plants [29]. Therefore, the goal of this study is to determine how effective native plantsare at capturing sand and dust.

Article II. 2. Materials and Methods

Study area Al-Jahra is 40 kilometers to the north of the research area. Around 149.7 km^2 (1.12% of the total area of the state of Kuwait) is the size of a center for the development of wildlife habitats. A collection of hills, notably Liyah Ridge (approximately 100 meters above sea level), dry valleys, and depressions break up the nearly level terrain (playas) [30‹31]. The early 1960s of the last century saw the beginning of gravel extraction due to the availability of aeolian and gravel deposits [32]. The soil in the north is rich in calcium carbonate build-up and is eroded with coarse sand or granules. Due to the significant gravel extraction, the research region experiences soil crusting, compaction, exposed bedrocks, the disappearance of soil silt, low density of plant coverings, and loss of biodiversity [33]. The area's highest point is 134 meters above mean sea level (MSL). The surface topography of Liyah is somewhat undulating or descends gradually in a northeasterly direction with an average gradient of 2.5 m km^{-1}. Within the study area, there are two important wadis: Wadi Al-Aujah and Wadi Huban, both of which have an east-west trend that is only somewhat different from the regional trend. Different playas have formed in the study region as a result of surrounding ridges and artificial features. It is dominated by scant vegetation, primarily *Astragalus spinosus*.

research examined the morphological and sedimentological features of the several perennial plantscultivated in Kuwait's desert [34‹35]. Within a total of 220 nabkhas, the length, height, and width of the sand body of the various vegetated nabkhas were measured.

$$\text{The volume of nabkha} = (1/3 \times \pi) \times a \times b \times c$$

(1)Where a=nabkha width, b=nabkha length, and c=nabkha height

Date: October 2023

In Kuwait, it was estimated that removing aeolian encroachments from the vicinity of desert facilitieswould cost around 1.32 USD per cubic meter [36].

The saved cost ($) of sand stabilization = volume of nabkha X cost ($) (2)

The average and maximum sand volume value for 14 perennial native plants in Kuwait was calculated to estimated sand volume m^3 and economic cost as following:

Estimated sand volume m^3= (average or maximum value) of sand volume for nativeplants X the number of plants grown during a specified period.(3)

Estimated economic cost = (average or maximum value) economic cost of native plants(US dollars) X the number of plants grown over a specified time period. (4)

Article III. 3. Results and Discussion

Following vegetation maps created by Halwagy & Halwagy [37] and Omar, there are 15 major native desert plants in Kuwait (2000) [38-39]. They are *Cyperus conglomeratus, Haloxylon salicornicum, Rhanterium epapposum, Astragalus spinosus, Lycium shawii, Citrullus colocynthis, Panicum turgidum, Calligonum polygonoides, Nitraria retusa, Tamarix aucheriana, Halocnemum strobilaceum, Salicornia europaea, Heliotropium bacciferum, Arnebia decumbens*, and *Convolvulus oxyphyllus*. The average and maximum volumes of sand accumulation for 14 native plant species were taken into account in this study, which focuses on how effectively plants may control aeolian accumulations. As can be seen in (Table 1), the volume of the encroaching sand around native plants was determined. The cost to remove one cubic meter of sand (USD 1.32) multiplied by the total volume of nabkha (m^3) equals the economic value of native plants.

Comparatively, the size of the nabkhas formed under *Nitraria, Lycium Haloxylon, Tamarix, Panicum,* and *Citrulus* is much more than that of the nabkhas formed around *Halocnemum, Salicornia* and *Convolvolus* which are smaller. *Astragalus, Calligonum, Cyperus* and *Rhanterium* are examples of plants where medium-sized nabkhas can develop (Table 1). The average volumes of nabkha deposits created by the native plants, primarily *Nitraria, Haloxylon, Tamarix, Lycium, Panicum,* and *Citrullus*, were up to 11.17, 6.29, 6.09, 5.77, 5.60, and 5.51m^3. Their relative economic values were 14.74, 8.3,
8.04, 7.62, 7.39 and 7.27 $.

Table1. Measurement of volume and mass of nabkha of 14 native plant, and economic value of each native plantin $ and Kuwait Dinar.

No	Plant	Volume (m^3)	Mass (Ton)	Saved $
1	*Haloxylon*	6.29	15.73	8.30
2	*Convolvulus*	0.36	0.91	0.48
3	*calligonum*	0.50	1.25	0.66
4	*Lycium*	5.77	14.43	7.62
5	*Haloceneum*	0.30	0.76	0.40
6	*Rhanterium*	0.93	2.32	1.23
7	*Cyperus*	0.77	1.93	1.02
8	*Nitraria*	11.17	27.92	14.74
9	*Astragalus*	0.98	2.44	1.29
10	*Citrullus*	5.51	13.76	7.27
11	*Panicum*	5.60	14.00	7.39
12	*Tamarix*	6.09	15.23	8.04
13	*Heliotropium*	0.54	1.36	0.72
14	*Salicornia*	0.23	0.57	0.30
	Average	3.22	8.04	4.25
	Max	11.17	27.92	14.74

Date: October 2023

The key component of the restoration of the degraded areas in the Liyah protected area is the preimplantation and reproduction of native plants. From April 2003 to May 2019, hundreds of thousands of native plants were grown for the purpose of restoring the damaged areas (Figures 1and 2). The maximum amount of sand that was anticipated to be captured by native plants was 1454165 m^3, saving 1919498 $. Aeolian deposits have accumulated on the entire agricultural oasis area as a result of the native plants' 3-m close proximity to one another. It was estimated that between 2011 and 2015, native plants were predicted to trap a maximum of 670071 m^3 of sand, saving an estimated USD 884493 on sand removal costs.

Table 2. The estimated volume of sand that will be deposited around native plants (in cubic meters) for the years 2003 through 2019 as well as the expected economic return in US dollars of each native plants.

Period	Project	Plant number	Mass (tones)		Sand volume (m^3)		Saved cost ($) from sand	
			Average	Max	Average	Max	Average	Max
2003-2008	Liyah-1	40000	321711	1116784	128684	446714	169863	589662
2011-2015	Liyah-2	60000	482566	1675176	193026	670071	254795	884493
2016-2019	Liyah-3	30210	242972	843451	97189	337381	128289	445342
expected	sum	130210	1047248	3635412	418899	1454165	552947	1919498

Figure 1. Native plants planted in Liyah protected area 2015

Figure 2. Agricultural oasis area in Liyah protected area 2016

Date: October 2023

Article IV. 4. Conclusion

Controlling aeolian activities in Kuwait and the adjacent areas can be done sustainably by using native plants [40]. Only one to two years of irrigation are needed for native plants before they are able to adapt to the weather with 110 mm average rainfall. As a consistent source of plant seeds,aeolian sand and dust, which are a component of the desert eco-system, work to restore degraded regions. *Nitraria, Lycium Haloxylon, Tamarix, Panicum,* and *Citrulus* were shown to accumulate the maximum amounts of sand, making them the most effective native plants for controlling aeolian sediments. The use of native plants was shown to be a cost-effective method of reducing aeolian accumulations and a realistic option.

Article V.
Article VI. References
Article VII.

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Evaluation of the Efficiency of the Wastewater Treatment Plant in the Women's and Children's Hospital in Ramadi, Anbar, Iraq

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Abstract: The current study was conducted to evaluate the efficiency of the wastewater treatment station in the Women's and Children's Hospital in the city of Ramadi. Samples were collected from the treatment plant (water entering the station and treated water) during the two study seasons (summer and winter). As some physical, chemical and biological characteristics of the water entering the station and the treated water were studied to find out the efficiency of this station. It included the physical properties (temperature and conductivity), while the chemical properties included (pH, chloride, total hardness, nitrates, and COD ,Oils, greases and dissolved oxygen). Biological characteristics include the biological requirement for oxygen. As it was noted that the efficiency of the station in getting rid of the conductivity is 18.38the chloride is 6.79%, the total hardness is 55.58%, the nitrates are 26.3%, and the COD is 30.6%, while the efficiency of the station for the disposal of oils and greases was 40.5 % and BOD 49.23 %,. The results of the study showed that the use of the water coming out of the station for irrigation and drinking purposes is not valid because some of the determinants exceeded the permissible limit

1. Introduction

The use of water by humans in homes, public shops, and health institutions, and as a result of these different uses, the water acquires many impurities and microorganisms, as this water is called waste water, and this water poses a threat to public health and distorts the beauty of nature [1]. And the discharge of this water into the river without treatment or with inefficient treatment by sewage treatment plants causes damage to the water environment, as this water contains high concentrations of harmful environmental pollutants, and Wastewater constitutes 80% of the fresh water consumed in cities and consists of 1 % of impurities and harmful pollutants and 99 % of water [2]. The stages of purification of sewage water in the women's and children's station are carried out by a set of physical, chemical and biological processes to reduce or remove the percentage of these pollutants. Secondary treatment, uses microorganisms to remove organics matter in presence of air, and advanced treatment, its aim is to improve water quality by removing some substances such as nitrates, phosphates, and bacteria [3,4]. The women's and children's hospital station is evaluated through the following:

Station efficiency = the average during the two study seasons (winter and summer) of the determined concentration in the incoming water - the average during the two study seasons (winter and summer) of the determined concentration in the treated water) / the average during the two study seasons of the determined concentration of the incoming water × 100. There are some previous studies conducted by researchers in evaluating the efficiency of treatment plants : The research conducted by [5] in evaluating the performance of some sewage plants, as the research included studying some chemical characteristics of three plants in the city of Kirkuk, as it included chemical tests (pH, BOD, DO, TSS, COD, sulfates, nitrates , phosphates) As it was concluded that the treated water from sewage plants is not suitable for irrigation and drinking water purposes, because the concentrations of some of these determinants exceeded the permissible limit of the Iraqi standard specifications and international specifications, as the efficiency of these stations was good in

Date: October 2023

reducing some pollutants. Another research was conducted [6], which included an evaluation of the efficiency of the wastewater treatment unit in the residential complex in Al-Dur - Salah Al-Din, as some physical and chemical aspects were measured , The results showed that the characteristics of the water ejected from the river from the treatment station were with a temperature of 19.840 C○, a pH of 7.76, a BOD of 40.3 mg/l, a conductivity of 544.2 us/cm, and a chloride of 209.16 mg/l, as the station was characterized by a good removal of both total hardness and magnesium hardness. It amounted to (396.8, 94.3) mg / liter, respectively, the cloudiness was (7.9), and the total alkalinity was 345.2 mg / L. Another researcher conducted by [7] where the physical and chemical properties of wastewater in Al Barakiya were studied, including pH, electrical conductivity, total dissolved salts, total suspended matter, COD, DO, chloride, nitrates, temperature, phosphates, oils and greases, where the main results were measured. Wastewater pH before and after treatment It was noted that the oxidized water had a pH of about 7.3, while the electrical conductivity ranged from cm us ⁄ (4460-3512), while the percentage of dissolved substances was (17560-262000) mg / liter, and the suspended matter ranged from (3700-15600) mg / liter and the percentage of oxygen chemical range between (45-600) mg/l, Biological requirement of oxygen (0.48-7.2) mg/l, chloride (289.9-424.5) mg/l, nitrates (7.7-41) mg/l, and the percentage of oils and fats ranged between (1.6-61.8) mg/l liters, while the temperature ranged between (18.9-29.7) and phosphate ranged between (0.4-6.2) mg⁄l. Another research was conducted by [8] to assess the efficiency of the wastewater treatment plant in Najaf, where the determinants of environmental pollution were studied for the incoming water to the station and the treated water and it was said that it is discharged to the river, as these included BOD, COD and TSS, pH, temperature and concentration of phosphates, sulfates, nitrates, chlorides, oils and greases. It was found that the efficiency of the station in getting rid of BOD reaches 81.5%, from COD to 76% and from TSS up to 66%. The current study aimed to Study some physical, chemical, and biological properties of wastewater to evaluate the efficiency of the wastewater treatment station in the Women's and Children's Hospital in the city of Ramadi.

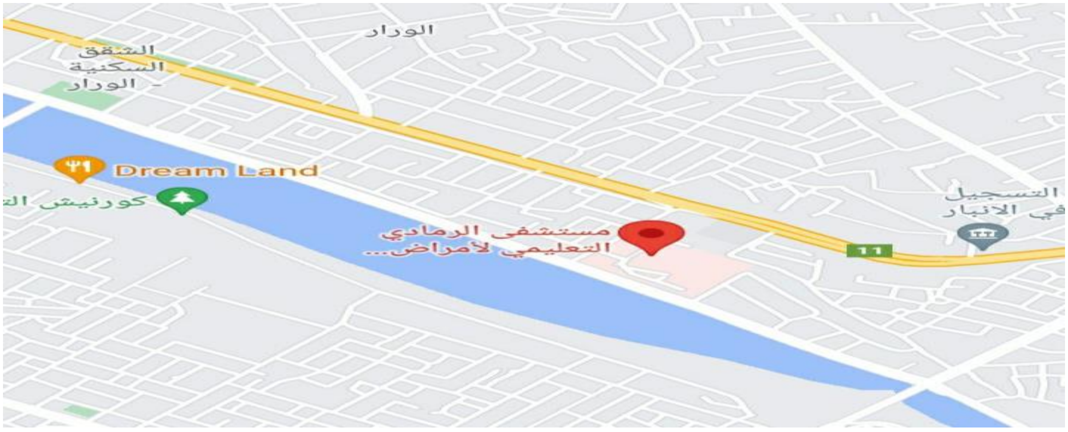


Figure 1. shows the location of the wastewater treatment plant in the Women's and Children's Hospital in Ramadi.

Date: October 2023

2. Materials and Methods

The samples were collected using polyethylene containers washed with dilute nitric acid (0.1 N) and then with distilled water. The samples for physical, chemical and biological tests were collected in one-liter bottles. air and kept at 4°C.

2.1. Physical properties

2.1.1. Water temperature: The water temperature was measured directly at the sampling sites using a mercury thermometer ranging from (0-100) degrees Celsius**.**

2.1.2. Electrical Conductivity: Use the Electric Conductivity ⁄ TDS meter which measures the electrical conductivity in us/cm and TDS is estimated in mg/l.

2.2. Chemical properties

2.2.1. pH: The pH was measured using a field pH-meter after calibrating the device on standard buffer solutions [4, 7, 9].

3.2.2. Chloride: The spectrophotometric method was used to determine the chloride ion at a wavelength of 530 nm using the Silver nitrate turbid method [9].

3.2.3. Total hardness: It was estimated by the method adopted by the World Health Organization [10].

2.2.4. Nitrates: The reduction method was used by means of a cadmium column, as nitrate was reduced to nitrite, and then the absorbance was measured at the wavelength of 543nm, after adding 2ml of the colored solution to 50ml of the sample that was passed through the cadmium column, and the results were expressed in micrograms / liter.

2.2.5. Chemical oxygen demand: been used the open reflux method described by the American Public Health Association to measure the chemical oxygen demand.

2.2.6. Oils and greases: Oils and greases were extracted from water samples using chloroform as a solvent. It is calculated through the following equation:

Oil and grease as PPm = (W2 – W1) 1000 / Vol. of sample

2.2.7. Dissolved oxygen: The electrode method was used to measure dissolved oxygen using a device (Do oxygen meter).

2.3. Biological properties:
2.3.1. Biochemical oxygen demand: The vital oxygen requirement was measured according to the method described by the World Health Organization, as the darkened Winkler bottles were incubated in an incubator at (20) degrees Celsius for a period of 5 days, after which the dissolved oxygen was fixed in the same way. [10]. It is calculated from the following equation

BOD : The amount of dissolved oxygen before incubation - The amount of dissolved oxygen after incubation.

Date: October 2023

3. Results and Discussion

3.1. physical examinations:

3.1.1. Temperature

The temperature of the incoming water to the station was recorded during the winter season (19C○) and summer (38C○). As for the treated water, the temperature value during the winter season was (17C○) and summer (34C○)., as the Iraqi specifications were (35C°), and the efficiency of reducing the water temperature was 10.5 %. As shown in Figure (2). R1= It represents the incoming water to the station , R2= It represents the treated water from the station , % = removal efficiency

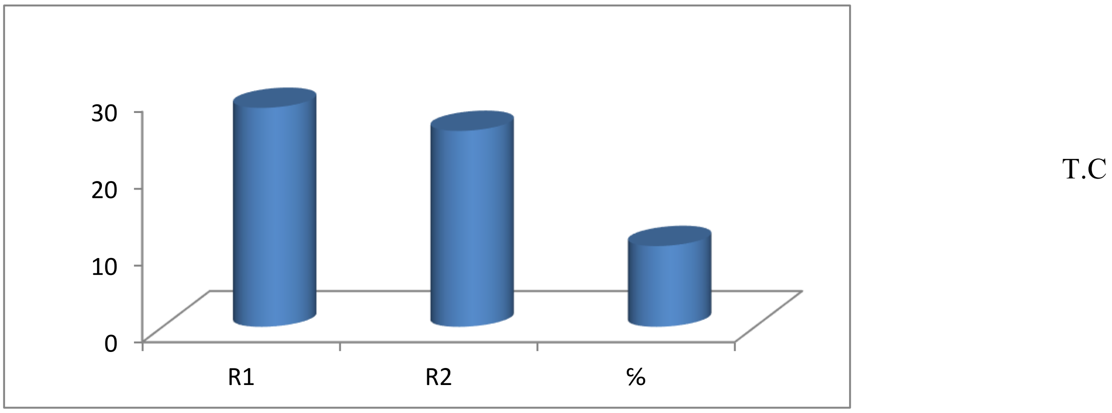


Figure 2. shows the average temperature of the incoming water and the treated water and the reduction efficiency in the treatment plant.

It turns out that there is a difference between the temperatures of the incoming water and the treated water during the winter and summer seasons as a result of the climatic conditions. Summer, and the water of sewage units is characterized by the fact that it contains organic materials, and these materials are highly concentrated, and this leads to an increase in the processes of organic decay and decomposition by microorganisms and large numbers of bacteria, and this leads to an increase in the energy emitted [6].

3.1.2. Electrical conductivity

The electrical conductivity of the incoming water to the station during the winter and summer seasons recorded a rate of 14867.5 us⁄ cm), while the electrical conductivity of the treated water from the station during the two study seasons recorded an average of (12133.5 us⁄cm), and the permissible limit was (1000 us ⁄ cm). Figure 3 illustrates this.

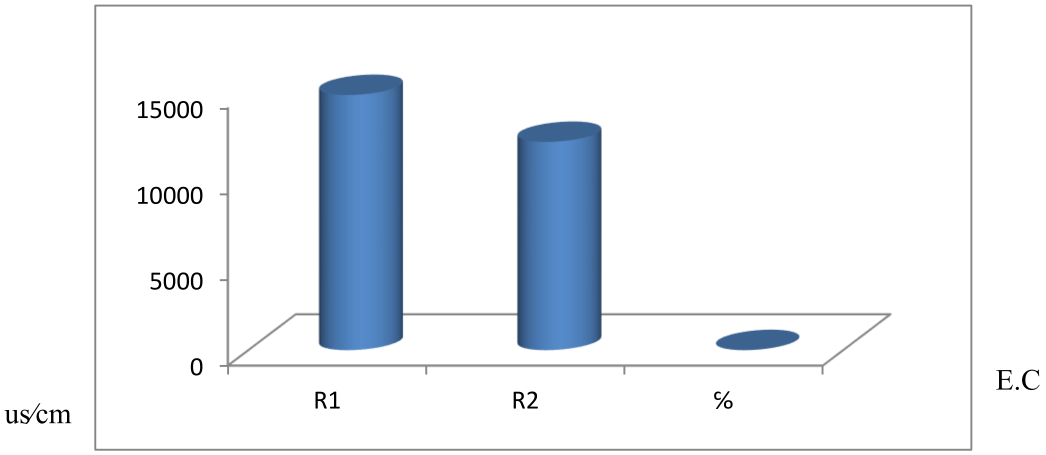


Figure 3. shows the conductivity rate of the incoming water and the treated water and the reduction efficiency in the treatment plant.

Date: October 2023

The reason for the high rate of conductivity in the incoming water to the station is that the water is untreated and contains large quantities of salts. The rate of conductivity of the treated water from the station is relatively high and exceeds the standard specifications. This is due to the fact that the water represents the water of household waste, which is loaded with quantities of salts, in addition to being A major source of negative and positive ions [11].

3.2. Chemical tests:

3.2.1. pH

The pH recorded during the winter season in the incoming water was (7.9), while the treated water was (8.2). The pH was recorded during the summer season in the incoming water (8.1), while the treated water was (8.4).and the permissible limit was (9.5). The figure 4 below shows this.

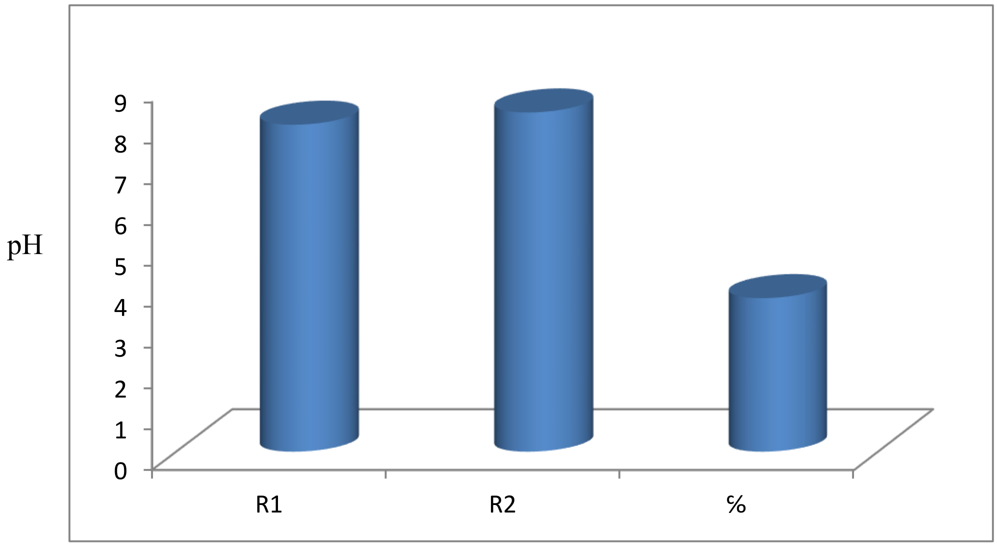


Figure 4. shows the average pH of the incoming water and the treated water and the reduction efficiency in the treatment plant.

From the results that were reached, it was found that the incoming and treated (exiting) water from the sewage water plants did not exceed the Iraqi standard limits, and although there is a rise in the pH of the treated water, it did not exceed the permissible limit, as we note that there are changes in the acidity function, as the water The treatment was higher in alkalinity than the water coming into the station. This is due to the increase of some determinants that increase the alkalinity during treatment, such as nitrates, or because of the increase in bacterial activity and the increase in organic waste, which constitutes a burden on the biological treatment unit, in addition to the low percentage of oxygen in the aeration ponds needed for digestion. organic matter and thus removed [8].

3.2.2. Chloride:

The chloride ion recorded in the incoming water to the station during the winter and summer seasons averaged (342 mg ⁄L), and the chloride ion recorded in the treated water from the station during the two study seasons averaged (322.5 mg ⁄ L) and the allowable limit was (600 mg ⁄ L), and the reduction efficiency of the ion was Chloride 6.79 %. Figure (5) illustrates this.

Date: October 2023

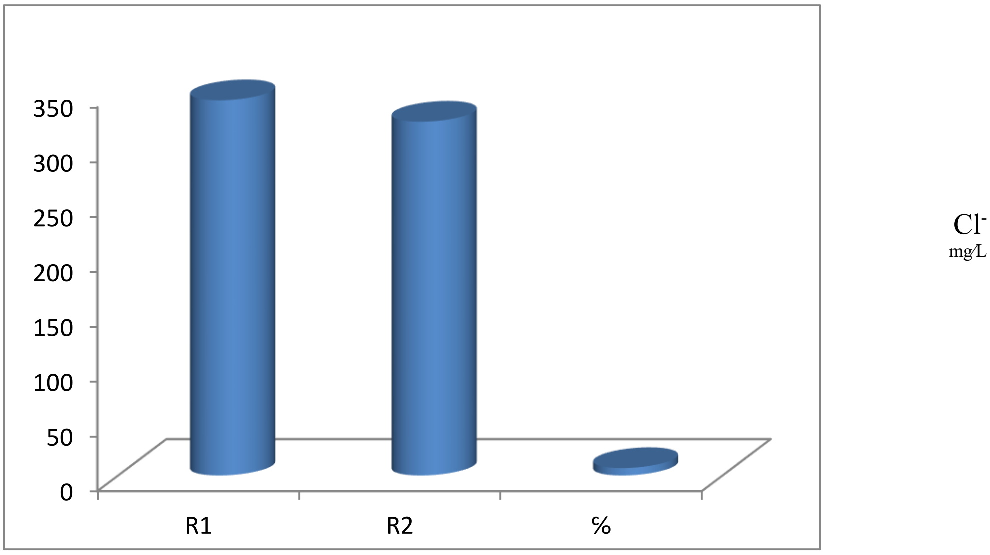


Figure 5. shows the chloride ion rate of the incoming water and the treated water and the reduction efficiency in the treatment station.

From the above results, it was found that the rate of chloride in the incoming and outgoing water from the station did not exceed Iraqi specifications, but there has been a noticeable uptick, and the reason for the high values of the chloride rate in the treated water is due to the decomposition of organic materials and the complexes contained in sewage waste, in addition to what human excretion adds. of chloride, as it reaches 6 g / day [12].

3.2.3. Total Hardness:

The total hardness of the incoming water to the station during the winter and summer seasons was recorded as (1186.5m g/L), and the total hardness of the treated water from the station during the two study seasons was recorded as (527 mg/l), and the reduction efficiency for the total hardness was 55.58 %. The figure 6 below shows this.

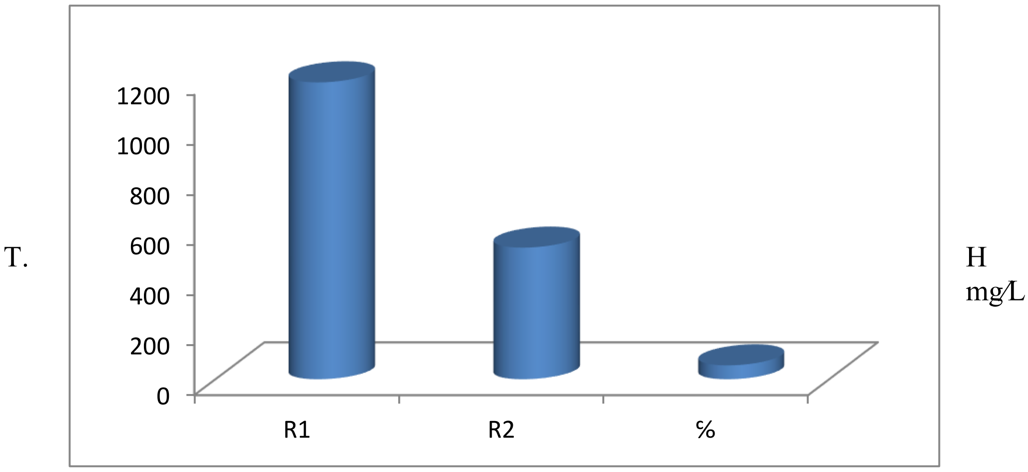


Figure 6. shows the total hardness rate of incoming water, treated water and reduction efficiency at the treatment plant.

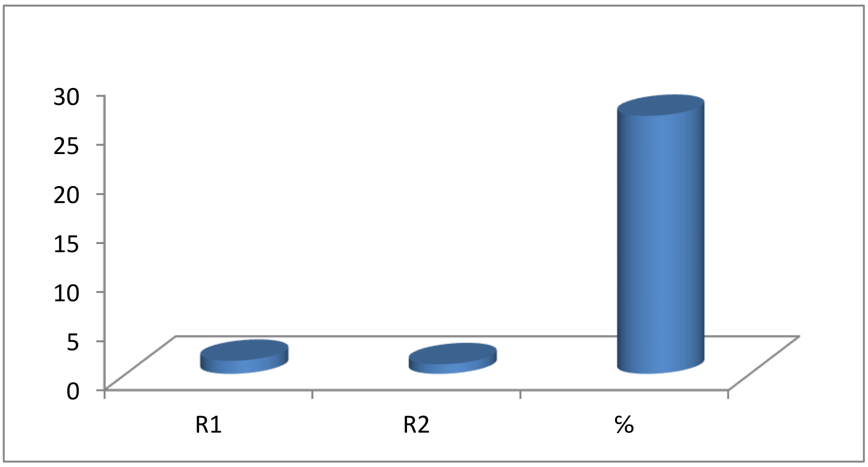
The high values of the total hardness of the incoming water and the treated water that exceeded the permissible limits are caused by the sewage water as a result of the high concentrations of dissolved ions and salts. Among these dissolved ions are the magnesium and calcium ions, in addition to the activity of microorganisms with the high temperature that causes the decomposition of organic matter. The decomposition of organic matter produces precipitated, dissolved or suspended ions and elements [6].

Date: October 2023

3.2.4. Nitrates:

The nitrate ion in the incoming water to the station during the winter and summer seasons recorded an average of (1.33 mg / L), and the nitrate ion in the treated water of the station during the two study seasons recorded an average of (0.98 mg / L) and the allowable limit was (1 mg / L), and the reduction efficiency of the ion was Nitrates 26.3 %. The figure 7 below shows this.

NO_3^-



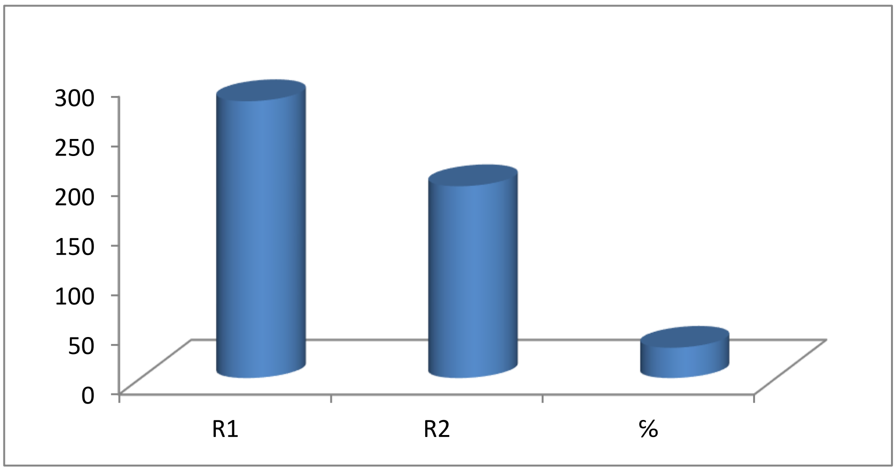
mg/L

Figure 7. shows the nitrate ion rate of the incoming water and the treated water and the reduction efficiency in the treatment plant.

From the results that were reached, since the treated water for the rate of nitrates was within the Iraqi specifications for river maintenance, but there is a noticeable increase in the incoming water due to the oxidation of nitrogenous compounds, which causes the nitrification process [13].

3.2.5. Chemical Oxygen Demand:

The COD recorded in the incoming water to the station during the winter and summer seasons was an average of (279 mg / L), and the nitrate ion in the treated water of the station during the two study seasons recorded an average of (193.5 mg / L) and the permissible limit 30 mg / l and the COD reduction efficiency was 30.6 % . The figure 8 below shows this.



COD mg/L

Figure 8. shows the COD rate of incoming water, treated water and reduction efficiency in the treatment plant.

It was found that there was a noticeable increase in the rate of treated water from the plant, and the reason for the low efficiency of the station is due to the station loading pollutants beyond its absorptive capacity in wastewater treatment [14]. Water subject to decomposition, as the greater the amount of oxygen that is consumed vitally, the greater the polluted water, as it constitutes a burden on the biological treatment unit in the wastewater treatment plants [15].

3.3. Biological tests:

3.3.1. Biochemical Oxygen Demand

The BOD recorded in the incoming water to the station during the winter and summer seasons was an average of (230 mg / L), and the nitrate ion in the treated water of the station during the two study seasons recorded an average of (116.75 mg / L) and the standard specifications (20 mg / L), and the reduction efficiency was BOD 49.23 %. The figure 9 below shows this.

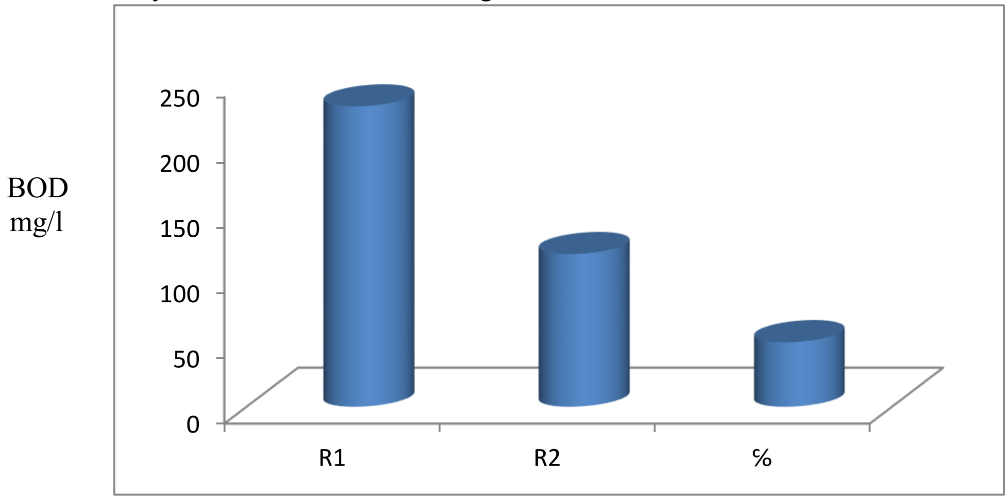


Figure 9. shows the BOD rate of incoming water, treated water and reduction efficiency at the treatment plant.

It showed that the results of the BOD of the incoming water exceeded the Iraqi specifications, and the reason for this is due to the increase in the daily discharge of sewage water and thus an increase in organic waste, as the oxygenic and bacterial activity is increased, as it constitutes a load on the biological treatment units, As there is an increase in the rate of treated water due to the decrease in the proportion of dissolved oxygen in the aeration ponds, which is necessary for the digestion and removal of organic materials [15].

3.3.2. Oils and greases:

Oils and greases in the incoming water to the station during the winter and summer seasons recorded a rate of (429.5 mg / L), oils and greases in the treated water station during the two study seasons registered a rate of (255.5 mg / L), and the reduction efficiency of oils and greases was 40.5 %. The figure 10 below shows this.

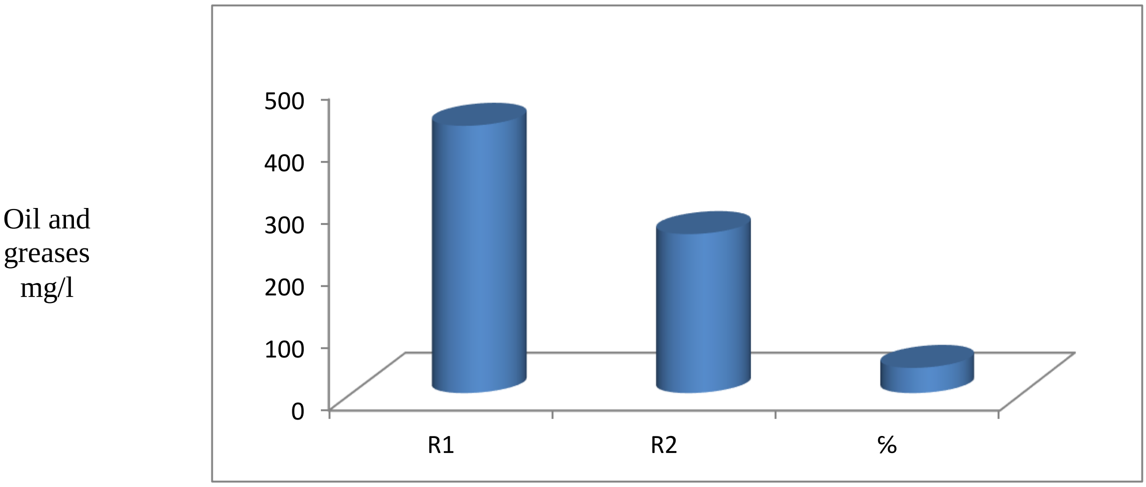


Figure 10. shows the rate of oils and greases for the incoming water and the treated water and the reduction efficiency in the treatment plant.

Date: October 2023

The results showed a significant increase in the values of oils and greases in the incoming water, as they exceeded the allowed limit, and the reason for this increase is due to the effect of industrial waste and the effect of household waste that flows into Sewage station and then returns to the station. As for its rate in the treated water, it exceeded the permissible limit, because the station is inefficient in reducing the percentage of oils and greases

3.3.3. Dissolved Oxygen

The dissolved oxygen record in the incoming water to the station during the winter and summer seasons was a rate of (3.5 mg ⁄ L), and the dissolved oxygen record in the station treated water during the two study seasons was a rate of (5.75 mg ⁄ L) and the allowable limit was (2.8 mg ⁄ L), The efficiency of the station was for dissolved oxygen% 0.64. The figure 11 below shows this.

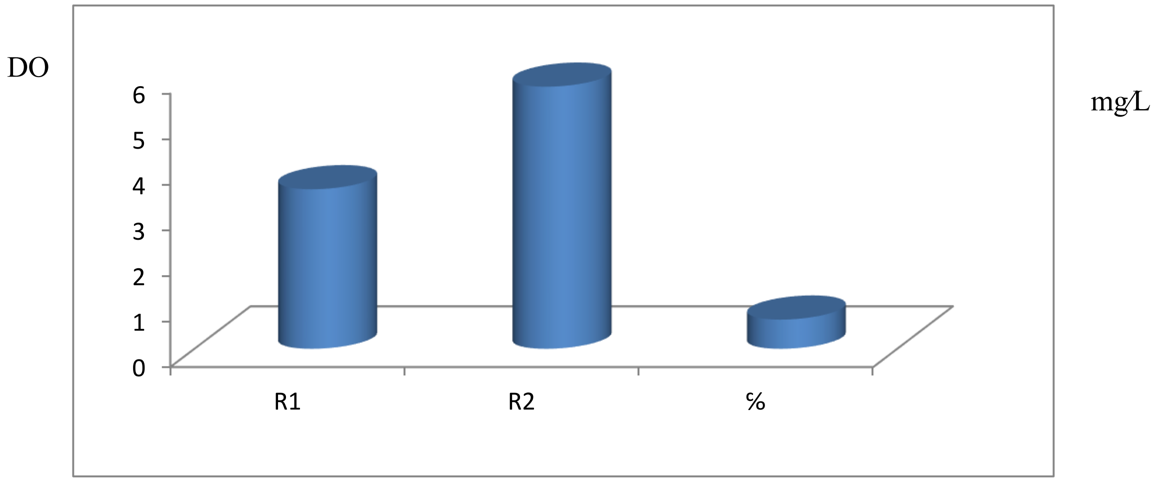


Figure 11. Shows the dissolved oxygen rate of the incoming water and the treated water and the reduction efficiency in the treatment plant.

Date: October 2023

The results showed a clear increase in the dissolved oxygen values, as the reason for the decrease in dissolved oxygen in the treatment plants is due to the poor automatic operating system used in this station in operating the ventilation devices, which depends on the dissolved oxygen sensor, which is located in the ventilation basin, in addition to the power outage [12]. Table 1 shows concentration of some pollution determinants in the city of Ramadi (the wastewater treatment plant in the Women's and Children's Hospital).

Table 1. Concentration of some pollution determinants in the city of Ramadi (the wastewater treatment plant in the Women's and Children's Hospital).

Analysis type		Winter	Summer	Average	Removal efficiency	Standard specifications (17)
T ° C	Entrance	19	38	28.5	10.5 %	35
	Director	17	34	25.5		
E.C us⁄cm	Entrance	14455	15280	14867.5	3.75%	1000
	Director	11797	12470	12133.5		
pH	Entrance	7.9	8.1	8	3.75%	9 - 6
	Director	8.2	8.4	8.3		
DO mg/L	Entrance	3.6	3.4	3.5		
	Director	5.9	5.6	5.75	0.64%	2.8
T.H mg/L	Entrance	1170	1203	1186.5		....
	Director	520	534	527	55.58%	
Cl^- mg/L	Entrance	350	343	342	6.79%	600
	Director	326	319	322.5		
NO_3^- mg/L	Entrance	1.9	0.76	1.33	26.3%	1
	Director	1.4	0.56	0.98		
COD mg/L	Entrance	303	255	279	30.6%	30
	Director	210	177	193.5		
Oil and greases mg/L	Entrance	298	561	429.5	40.5%	
	Director	177	334	255.5		
BOD mg/L	Entrance	345	115	230	49.23%	20
	Director	164	69.5	116.75		

4. Conclusions

High rate of electrical conductivity of incoming and treated water from the treatment plant and exceeded the permissible limit,High total hardness rate and exceeded standard specification, High rate of biochemical need for oxygen above the permissible limit.

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Date: October 2023

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Date: October 2023

Effect of Super Absorbent Polymer and Ceratophyllum Powder Application on Some Soil Physical Properties

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Abstract: A two factorial laboratory experiment was conducted according to randomized complete block design with three replications, to investigate the effect of super absorbent polymer (SAP) and ceratophyllum powder application on some physical characteristics of loamy sand soil. The first factor included three levels of super absorbent polymer, namely 0,0.2, and 0.4 %. While the second factor consists of three levels of ceratophyllum powder i.e., 0,2, and 4 %. The treated soil (treated with super absorbent polymer and ceratophyllum powder) was exposed to 14 cycles of wetting and drying. Effect of experiments factors on coefficient of linear extensibility, soil bulk density and total porosity were measured. The obtained results show that the super absorbent polymer and ceratophyllum powder application led to increase the dry soil bulk density, total porosity, and the coefficient of linear extensibility values for all application levels. Regarding the soil aggregate stability, a significant increase was observed under effect of super absorbent polymer and ceratophyllum powder application. Where the highest value of soil aggregate stability was recorded at 0.4% level of SAP reached 54.2%. Likewise, the highest value of soil aggregate stability under effect of ceratophyllum powder application reached 30.7% at 4% level of application, compare to the control treatment that gave 11.1 % with increasing rate reached 76.5%. In same direction, all moisture content had increased under effect of study factors. However, the super absorbent polymer was superior to ceratophyllum powder application .

1.Introduction

Dry land Farming involves improving water-use efficiency, especially in light texture soils (sandy soil textures). Dry lands occupy over 40% of the terrestrial surface [1]. Due to its large area, dry land farming plays a fundamental role in irrigated agriculture [2]. In dry areas, light soil textures are less productive than other because it is often highly susceptible to erodible. Moreover, it is characterized by low organic matter content, nutrient leaching, low water holding capacity and consequently result in weak soil structure. Precipitation variability and low quality soils in many arid-zone leads to low yields and large fluctuations in farmers' income. Therefore, soil amendments are important to enhance physiochemical soil properties creating better conditions for root development, water storage, in soil ecosystems. One of the main challenges face the modern agriculture is to develop sustainable production systems that would meet food production without endangering environmental resources [3]. To achieve such objective improving soil quality along with water saving is required. Soil

Date: October 2023

amendments involve all organic and inorganic substances mixed with the soil for getting a better soil condition regarding plant productivity. Superabsorbent polymer (SAP) is a soil conditioner technique that can amend the soil system conditions. Superabsorbent polymer has the ability to absorb and retain considerable amounts of water from the surrounding medium[4] . Due to its large water absorption capacity, SAP can be applied to effectively improve water utilization in irrigated agriculture, such as retaining moisture in the soil and reducing the irrigation water consumption [5]. Fast growth of macrophytes caused various socio-economic problems. Recently, aquatic plants have become constraint for ecologists and people dependent on water body since they deteriorate the water quality and also the biodiversity [6]. *Ceratophyllum demersum* L. is a submerged perennial macrophyte, normally found free floating in stagnant or slow moving water stream. Due to its wide distribution, it is easy to identify and easy to collect. Therefore, it can be a sustainable source for many utilizations. For this reason, there are many studies that shed light on macrophytes in different research field. Due to its large surface area in contact with the water, *ceratophyllum demersum* absorbs nutrients by their modified leaves from the surrounding water [7]. Therefore, ceratophyllum powder addition to the soil could provide plants with nutrients as alternative to minerals fertilizer. Also, it has reported that ceratophyllum has been used for biomethane production [8]. In spite of many studies focused on ceratophyllum utilizations. However, there is little information available about using ceratophyllum as soil amendments. Therefore, the objective of the current study was conducted to evaluate the superabsorbent polymer and *ceratophyllum demersum* L. efficiency as soil conditioners.

2.Materials and Methods

The soil under study was classified according to USDA soil taxonomy under the subgroup as Typic Torrifluvents[9],According to the random sampling method, eight soil samples were randomly chosen from depth of 0-30cm (effective root-zone) using soil auger. The studied soil was loamy sand soil texture. To form one representative soil sample, the collected samples were thoroughly mixed, air-dried and preserved in plastic bag. At the laboratory, the representative sample crushed and passed through 2mm sieve to determine the selected soil chemical and physical properties. The pH and EC for the studied soil were measured using a pH and EC meter respectively. Acid extraction method was used to determine organic matter according to [10]. Cation exchange capacity was measured by atomic absorption spectrophotometry. Dry soil bulk density was measured by using core samplers (5x5 cm height and diameter). The percentages of sand, silt clay were measured by using hydrometer method. The measured soil physical and chemical properties were listed in (Table 1). Two factorial; experiment was conducted according to randomized complete block design with three replications. The first factor includes two levels of Superabsorbent polymer, namely 0.2 and 0.4 % taking the symbols of P1 and P2 respectively, while the second factor consists of two levels of ceratophyllum Powder i.e., 2 and 4 % taking the symbols of O1 and O2 respectively. The A0 (without superabsorbent polymer and ceratophyllum Powder application) treatment was set as a control treatment. Sample from

Date: October 2023

each treatment was collected to draw the soil water retention curve under effect of eight tensions, namely 0,33,50,100,200,500,1000 and 1500 kpa. To study the coefficient of linear extensibility, 200 g of soil was transferred into four beakers of 250ml capacity each, and treated with superabsorbent polymer and ceratophyllum powder with three replications. The allowable depletion was 50% from available water before each water application events. The containers were placed under conditions just like field conditions for 14 weeks include 14 drying-wetting cycles. Soil water holding capacity was determined at eight different tensions i.e., 0,33,50,100,200,500,1000 and 1500 kpa. Using pressure plate [11]. RTC software was used to draw the soil water retention curve. The gravimetric moisture content for the aforementioned tensions is 0.41,0.063,0.05,0.048,0.04,0.038,0.034 and 0.029 cm-3.cm-3 respectively. The relationship between the volumetric soil moisture content and matric suction of the experimental treatments after the sieved (passed through 2 mm in diameter sieve) soil samples were saturated. The saturated samples were subjected to different tensions ranging between 0.1 and 1500 kPa. Haines-Apparatus was used for tensions between 0.1 to 8 kPa, while pressure plate Apparatus was used for tensions from 10 to 1500 kPa. Soil gravimetric moisture content was determined under different tensions. Thereafter, volumetric soil moisture was calculated. For obtaining the best fitting for soil moisture retention curves, Van Genuchten equation was followed to describe the relationship between relative soil moisture content as a function of soil matric (ψ) as the following;

$$\theta_E = \frac{1}{1+[\alpha\varphi]^m}$$

θ_E : is the effective soil moisture.

$\alpha, n, and\ m$ is experimental coefficient.

$m=1-\frac{1}{n}$

To draw the moisture distribution curves, the mathematical program RETC was used in order to solve equation 1 and to find the coefficients $\boldsymbol{\alpha}$, **n**, and **m** by the iterative method in order to obtain the best fitting for the data of the moisture characteristics curve. The soil dry bulk density for all treatments under study (with and without superabsorbent polymer and ceratophyllum powder application) was calculated at the beginning of the experiment (0 cycles) and after 14 wetting and drying cycles, using core method [12]. The soil porosity was calculated based on the measured soil bulk density, knowing that the soil particles density was 2.48 Mg. M^{-3}. The coefficient of linear extensibility (COLE) was determined by measuring the vertical free swelling of the treated soil[13] , as the following:

$$COLE = \left(\frac{V_m}{V_d}\right)^{1/3} - 1 \quad (2)$$

Vm : Volume of saturated soil sample in cm-3.

Vd : Volume of ari-dried soil sample in cm-3

Soil aggregate stability was determined by collecting soil samples, passed through two sieves 1 and 2 mm in diameter. Subsequently, 4 g of soil was taken from the residual soil on sieve 1, transferred to a sieve of 0.25 mm in diameter. Thereafter, the passed soil kept in container containing 100 ml of distilled water, then the device was operated for 3 minutes according to[14] . Thereafter, the device contents were transferred into oven and dried at 105 °C. Soil weight was recorded before and after drying to calculate the soil mass (WS), the previous process was repeated by adding 100 ml of calgon with concentration of 2 % to the container before operating the device for 6 minutes. After that, the soil sample was transferred into oven to calculate the soil mass (WC) after sieving with calgon before and after drying. The percentage of soil aggregate stability was calculated according to the following equation:

$$\%SA = \frac{WS}{WS+WC} * 100 \quad (3)$$

Where:

SA: is the percentage of soil aggregate stability (%); WS: is mass of soil after sieving(g); WC: is mass of soil after sieving with calgon(g).

Table 1. Some physical and chemical properties of considered soil

Measurement	Unit	Value
Soil reaction(pH)		7.5
Electrical conductivity (EC)	dS.m-1	3.6
Soil organic matter (OM)	g.kg-1	7.2
Cation-exchange capacity (CEC)	cmolc/kg	8.56
Soil particles density	Mg/m3	2.48
Dry bulk density	Mg/m3	1.45
Porosity	%	41.5
Soil aggregate stability	%	11.8
Available water	cm3.cm3	0.034
Field capacity (FC)	33 kpa	0.063
Permanent wilting point(PWP)	1500 kpa	0.029
Sand	g.kg-1	792
Silt	g.kg-1	112
Clay	g.kg-1	96
Soil Texture	Loamy Sand	

3.Results and Discussion

3.1. Effect of SAP and ceratophyllum Powder application on bulk density, porosity and COLE

The obtained results show a decrease in dry soil bulk density with increasing of superabsorbent polymer and ceratophyllum Powder application. Consequently, a significant increase in soil porosity. The evidence show that the super absorbent polymer superior to ceratophyllum Powder in increasing soil porosity thereby decreasing soil bulk density. The highest porosity value was observed at 0.4% level of SAP reached 48.11%. Similarly, the highest porosity value was observed under effect of ceratophyllum powder application reached 45.02% at 4% level of application, compare to control treatment that gave 40.18% with increasing rate reached 19.7 and 12% respectively, probably due to the role of the study factors (superabsorbent polymer and ceratophyllum powder) in improving soil physical properties such as soil structure. Consequently, reduces the soil bulk density and increasing the porosity. Soil porosity notably increased with increasing ceratophyllum powder application where the lowest porosity was observed at O1 (2% ceratophyllum powder) treatment reached 43.9% increased to 45% at O2 (4% ceratophyllum powder) treatment with increasing rate up to 2.5%, this finding consistent with[15] who reported that ceratophyllum decomposition release cellulosic

Date: October 2023

materials that have a role in improving soil properties. Consequently, reducing soil bulk density. Similarly, superabsorbent polymer application reduced the soil bulk density by reducing the supplied water irrigation requirements. Consequently, achieving proper media for plant root development.

Table2. Effect of SAP and ceratophyllum powder application on bulk density and porosity

O.M \ Irrigation	I1		I2		I3		Average	
	ρb	***f***	**ρb**	***f***	**ρb**	***f***	**ρb**	***f***
A0	1.47	40.72	1.48	40.32	1.50	39.51	1.48	40.18
P1	1.29	47.98	1.32	46.77	1.35	45.56	1.32	46.77
P2	1.26	49.2	1.28	48.38	1.32	46.77	1.28	48.11
O1	1.36	45.16	1.38	44.35	1.43	42.33	1.39	43.9
O2	1.34	45.96	1.35	45.56	1.40	43.54	1.36	45.02
Average	1.34	46	1.36	45.07	1.40	43.54	1.36	44.8
LSD (0.05)	ρb		C=0.01764		I=0.01366		I*C=0.03055	
LSD (0.05)	f		C=0.711		I=0.550		I*C=1.231	

The results listed in Table (3) also show the effect of the superabsorbent polymer addition on the coefficient of linear extensibility (COLE) values after one cycle of wetting and after 14 cycles of wetting, the evidence show that the superabsorbent polymer was superior to ceratophyllum powder in terms of soil swelling. Also, a significant change in soil properties was observed with increasing the concentration of SAP and ceratophyllum powder at one cycle and after 14 cycles of wetting and drying, with increasing the soil ability to effect on the coefficient of linear extensibility (COLE) with increasing the superabsorbent polymer content in the soil.

Table 3. Coefficient of linear extensibility (COLE) values after 1 and14 wetting-drying cycles

Levels	P1	P2	O1	O2
1 cycle	0.82	0.98	0.33	0.56
14 cycles	1.3	1.46	0.49	0.66
LSD (0.05)	0.0999		0.0745	

3.2 Soil water retention curves

Volumetric moisture content values at different matric tensions of soil samples collected after 14 weeks (at the end of the experiment) are listed in Table 2. It is clear from Figure 1 that the increasing water potential led to a reduction in volumetric moisture content for all treatments. However, the volumetric moisture content increased with increasing superabsorbent polymer and ceratophyllum powder in the soil under study at different matric tensions. In this context, the highest volumetric moisture content was observed at 0 cm tension reached 0.52 at P2(0.4% superabsorbent polymer) treatment, followed by O2 andA0 that gave 0.47 and 0.41 respectively under the same tension. Increasing the tension to 330 cm led to decrease the volumetric moisture content. However, the P2 and

Date: October 2023

O2 treatments still achieving the highest values of volumetric moisture content by giving 0.111 and 0.086 for P2 and O2 respectively. Same pattern was observed at 500,1000.2000,5000, 10000, and 15000 cm tensions. Where all volumetric moisture content values were increased with increasing the superabsorbent polymer content in the soil. The increasing in volumetric moisture content attributed to the water holding capacity of superabsorbent polymer at particular tensions. Conversely, the volumetric moisture content decreased with decreasing the superabsorbent polymer and ceratophyllum powder content in the considered soil. The lowest volumetric moisture content was 0.029 for A0 treatment recorded at tension of 1500 cm, while the highest recorded value was 0.051 for P2 treatment under the same tension. By comparing the volumetric moisture content for the superabsorbent polymer and ceratophyllum powder treatments, the obtained results show superior the superabsorbent polymer to ceratophyllum powder treatments, where the highest value of volumetric moisture content was observed at water tension of 330cm reached 0.111 for P2 treatment compare to 0.086 at O2 treatment under the same tension. Regarding the 15000 cm tension, the highest value of volumetric moisture content for the superabsorbent polymer and ceratophyllum powder treatments was recorded at P2 and O2 treatments reached 0.051and 0.038 respectively under the same tension. The superiority of superabsorbent polymer attributed its high ability in improving and prolong soil water holding capacity. Increasing the soil water holding capacity as a result of superabsorbent polymer and ceratophyllum powder addition probably due to the potential of these factors to improve the soil physical properties, which led to an increase in the total porosity. Consequently, the stored water in this porosity increased [15].

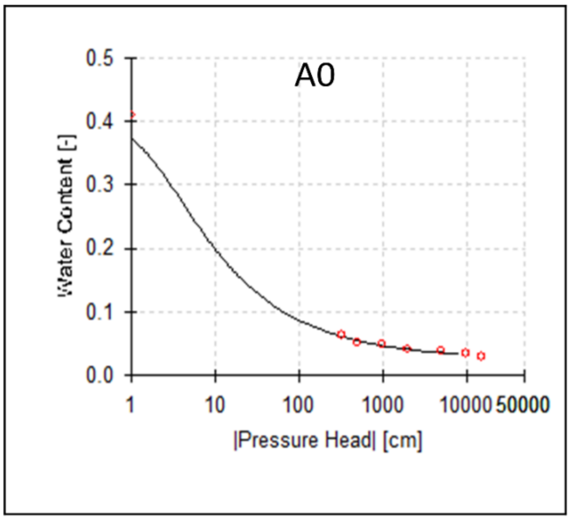

Figure1. Gravimetric soil moisture retention curve

Date: October 2023

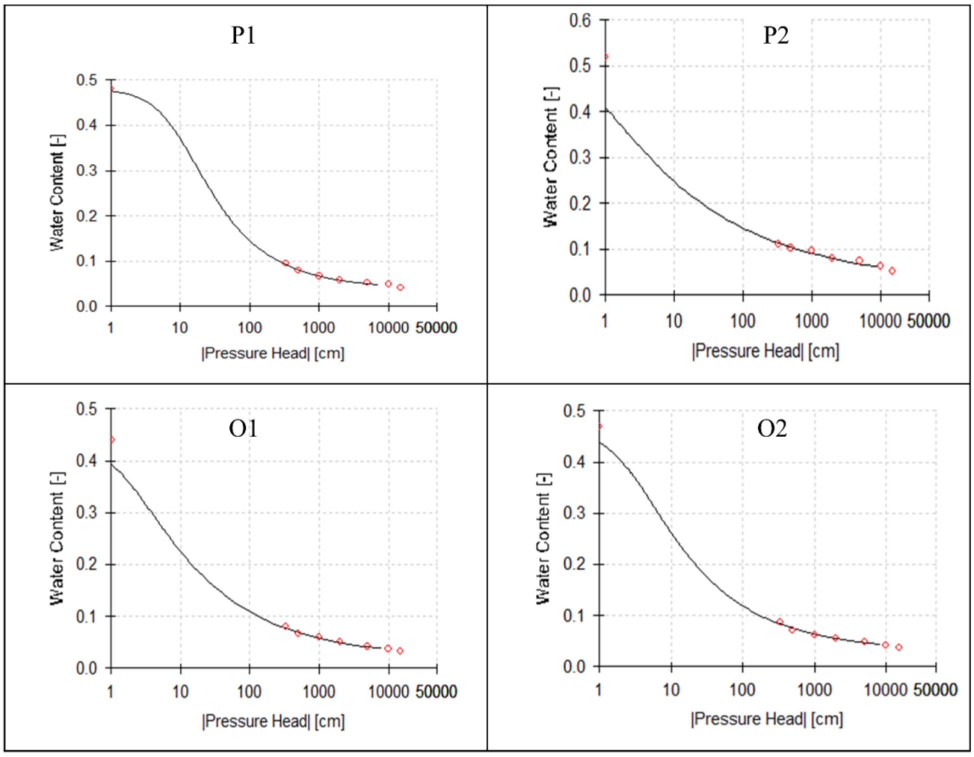

Figure2: Gravimetric soil moisture retention curves for treatments under study

3.2 Effect of SAP and ceratophyllum powder on soil aggregate stability

Soil aggregate stability significantly increased with increasing the superabsorbent polymer and ceratophyllum powder content in considered soil Table 4. The obtained results show that the superabsorbent polymer was superior to ceratophyllum powder in improving soil aggregate stability. In this vein, the highest value of soil aggregate stability was recorded at P2 (0.4%) treatment reached 54.2%. While the soil aggregate stability under effect of ceratophyllum powder was increased from 28.7% at O_1 to 30.7% at O_2 (4%) treatment compare to the control treatment A0 that gave 11.1% with increasing rate of 76.5%. The increasing could attribute to the fact that the ceratophyllum powder after its decomposition, leaves cellulosic materials play crucial role in improving soil properties, particularly soil aggregate stability[15] . Also, superabsorbent polymer increases soil aggregate resistance against fragment sufficiently to achieve stability of outer surfaces of soil aggregates. In this regard, the highest soil aggregate stability value was 44.2 and 54.2% for treatments P1 and P2, respectively. This finding consistent with [17] and [18], who reported that the superabsorbent polymer application increased the macro soil aggregate stability in addition to increasing mean weight diameter (MWD), geometric mean diameter (GMD) [17]. The reason can be attributed to superabsorbent polymer addition which adsorbed on the outer surfaces of soil aggregates, and a small portion of the SAP had permeated into the pore space of the aggregates, [18].

Date: October 2023

Table4. Soil aggregate stability for studied treatments

Levels of amendments addition	**Levels of water addition**			**Average**
	I1	**I2**	**I3**	
A0	11.8	11.3	10.4	11.1
P1	49	47.6	45.1	47.2
P2	55.5	54	53.2	54.2
O1	30.4	29	26.7	28.7
O2	32.3	30.8	29	30.7
Average	37.8	36.5	34.8	36.38
LSD (0.05)	C=1.391	I=1.077	I×C= 2.409	

4.Conclusions

The current study results showed that overall treatments the superabsorbent polymer and ceratophyllum powder had positive effect on selected soil physical properties. However, the super absorbent polymer superior to ceratophyllum powder in improving soil porosity due to its high ability in increasing soil water holding capacity for long time compare to control treatment. Consequently, reducing the effect of wetting drying cycles. In general, superabsorbent polymer and ceratophyllum powder application reduced the soil bulk density by reducing the irrigation requirements. Accordingly, achieving proper media for plant root development. The obtained results show that the superabsorbent polymer and ceratophyllum powder effect on soil swelling. Consequently, effect on the coefficient of linear extensibility (COLE). However, this effect linked with the superabsorbent polymer content in the soil. Regarding the soil aggregate stability, the superabsorbent polymer was superior to ceratophyllum powder in enhancing soil aggregate stability. The superiority of superabsorbent polymer can be attributed to its high ability to hold water. Thus mitigate the effect of wetting drying cycles.

Acknowledgments

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Date: October 2023

Evaluation of the Suitability of Sulfur Springs Water for Vital Uses by Studying the Physical, Chemical Properties of Some Sulfur Springs Water in the City of Hit

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Abstract: By studying some of the physical and chemical properties of the water of sulfur springs and identifying the nature of that water and the concentration of elements and ions in it and the percentage of salts, and by looking at the Iraqi environmental legislation and the World Health Organization (WHO), we find that the water of the studied springs is unfit for human and animal consumption, because of the concentration of dissolved salts in it, which Exceeding the general allowable rate, in addition to the high concentration of dissolved ions that lead to a change in the properties of that water. It can also be confirmed on the field that the water of those springs is rich in hydrogen sulfide gas (H2S), which is formed as a result of the oxidation of organic substances and the reduction of sulfate ions. In addition, most of the springs of the study area are characterized by the mixing of their water with oil derivatives, adding a state of pollution to that water, which increased the unfitness of that water for drinking purposes. Liquid petroleum (consisting of a complex mixture of different compounds, some of which are volatile or light, and some are heavy such as asphalt materials and bitumen), and natural gas such as methane, ethane, propane, and butane (Al-Jumaili and Ahmed; 2018) . These factors and pollutants combined made that water unfit for drinking or human consumption. According to the classification of the American salinity laboratory for the year 1954, and the classification of the FAO for the year 1992, it is considered suitable water for irrigation purposes and watering field. In addition to the validity of spring water for industrial purposes, and its use for therapeutic purposes and hospitalization due to its richness in salts, elements and ions.

1. Introduction

Our globe is distinguished by its abundance and its richness in blessings and precious natural treasures, what is apparent from it and what is hidden, and some of it is still hidden from us. However, the greatest of those blessings of all, which all forms of life have known since creation, and which they could not dispense with or replace, is the blessing of water. As the sustainability of the life of all organisms is linked to the presence of water. Despite the abundance and sustainability of this blessing in its various sources, the increasing demand for water resources will place a burden on population growth, as one of the biggest obstacles to environmental

Date: October 2023

sustainability is the mismatch between people's material desires and natural resources in the world.

And as an effect of the increase in the demand for water resources, corresponding to the increase in the need for food resources, and agriculture has a share of water for irrigation, which will decrease in the face of the increasing needs for food, so the main challenge for agriculture is how to produce more food, by consuming less water. As a result of the population increase and the accompanying increase in agricultural areas in the country, the need for irrigation water doubled, which prompted the need to use groundwater in many parts of the world, especially in arid and semi-arid regions, including Iraq. Despite the presence of surface water sources in Iraq, represented by rivers and lakes, and the dependence of many cities on the waters of the Tigris and Euphrates rivers, in addition to the spread of cities on the banks of the two rivers, there are areas relatively high above the level of the river water, which makes it difficult to rely on it in daily uses. And the cost of obtaining that water, so it became necessary to replace the nearby and available groundwater (wells and springs), after making sure of the validity of its water, and its efficiency for irrigating crops, and for daily use [1] . Among the most prominent types of perpetual groundwater flow is the water of springs (springs) flowing from under the surface of the earth, naturally and from rock formations of different types. As the springs are local points, where groundwater returns to the surface roads, and is discharged through compact channels and fracture networks, and often has very high discharges. In our study, we shed light on some natural sulfur springs, touching on some of the chemical, physical and biological properties of their water. We chose the sulfur springs in the city of Hit as a subject for the study. Its water was used for irrigation and irrigation purposes, in addition to therapeutic and hospital uses. The city of Hit, which is located in the western part of Iraq, is distinguished by the abundance of sulfur springs and tar springs, and the smell of gases emanating from those springs can be inhaled from a short distance. Mineral water, although it was excluded from the influence of volcanic activity [2]. It is noted that these springs are distributed within geological regions affected by the presence of cracks in the earth's crust[3]. Spring water flows from under the surface of the earth naturally, and it does not have fixed physical and chemical properties, as it flows from different types of rock formations. Because of this expansion in the spread of springs and sulfur springs within the city of Hit, four of the most important and largest of these springs were selected in different regions and the discrepancy in the properties and qualities of their water and its suitability for daily agricultural and industrial uses was identified.

2. Materials and Methods

2. 1. Description of the study area Description of study area

The study area included some sulfur springs in the west of Al-Anbar Governorate, in the city of Hit located between longitudes (15-42\◦-15-43\◦) to the east and latitudes (15-33\◦ - 38-34\◦) to the north and at a distance of (190) km west of the capital, Baghdad, within the Anbar Governorate. The number of springs within the study area exceeds (20) springs. In this study, (4) were selected from those springs and springs, and they are in sequence as follows (Al-khuder Fountain, Jarba Fountain, Qoesem Fountain, and Jarura fountain)

Date: October 2023

Figure1. the location of the sulfur springs under study in the city of Hit

2.2. Physical characteristic

2.2.1. Water Temperature

The water temperature was measured on site using a graduated mercury thermometer (0-100) C°.

2.2.2. Electrical Conductivity

Using a device (electrical conductivity meter EC - and Temperature meter) model WTW Cond 720 manufactured in the German company HANNA (Germany), the electrical conductivity of the studied water samples was measured.

2.2.3. Suspended Materials for Solid: It includes two tests

Total Solid Suspended (T.S.S.)

The concentration of suspended matter in water was calculated as per [4]. The concentration of suspended matter is calculated in terms of (mg / liter) through the following mathematical relationship:

T.S.S. = (W2 - W1) x 1000 / Volume (L). where:

W2 = weight of filter paper after filtration (weight of paper + precipitates from filtered water)

W1 = weight of the filter paper before filtering the water (weight of the dry paper)

Total Dissolved Suspended (T.D.S.)

The concentration of dissolved salts is calculated using the mathematical equation:

T.D.S. = (W2 – W1) x 1000 / Volume (L)

W2 = Weight of the lid after evaporation   W1 = Weight of the lid before evaporation

Date: October 2023

2.3. Chemical analyses

2.3.1. pH

According to[5,6] , the PH concentration in water was measured using a PH-meter and Temperature meter, model AD 1000, country of origin, Romania.

2.3.2. Biochemical Oxygen Demand (BOD)

It is a method for indirectly measuring organic matter in water by measuring the extent of change in the percentage of dissolved oxygen (D.O.). The method of modifying the azoad [6] is used to measure the concentration of dissolved oxygen in the water. As we determine the value of DO1, then we determine the value of DO5 and then apply the following mathematical equation to calculate the BOD value in mg/l units.

2.3.3. Hardness

It is the concentration of calcium and magnesium ions (and sometimes other ions) in water. The amount of calcium and magnesium ions in the water depends on the conditions experienced by the water source. The hardness is measured in the laboratory by titration with EDTA in the presence of an Erichrome Blak-T indicator to detect the end point of the reaction.

2.3.4. The nitrite ion (NO_2)

The examination was carried out using a sulfanilamide solution, and then using a spectrophotometer at a wavelength of (543 n.m.) to examine the nitrite concentration in terms of (µg nitrite / liter),[5].

2.3.5. Nitrate ion (NO_3)

The chromotropic acid method was used to measure the nitrate ion concentration [7] and then using a spectrophotometer at a wavelength of (430 n.m.) in units of (micrograms / liter).

2.3.6. Determination of Sulphate

The turbidity method was used to estimate the sulfate concentration by the optical method using a spectrophotometer, as stated in[4], then a spectrophotometer was used at a wavelength of (470 n.m.) and in terms of mg / liter.

2.3.7. Phosphate Ion:

Phosphate ion concentration was estimated using the tinrose chloride method[5] and then using a spectrophotometer at a wavelength of (690 n.m.) and in units of mg/ liter.

2.3.8. Chloride Ion

The silver nitrate titration method was used to estimate the concentration of chloride ion in water. The concentration of chloride ion is estimated in mg/l units.

3. Results and Discussion

3.1. Determination of the physical and chemical properties of water

3.1.1. Temperature

It is noted that the water temperatures in the different stations and during the study period ranged between 25°C and 34°C, and the variation was significant at the level ($p \leq 0.05$). It is noted through the water temperatures recorded for the different sites and during the study period that the water temperatures in three of those sites occurred between (30-34) °C, and this is evidence that the water is of constant temperature, and that the water is of the same origin and origin [3] . As for the difference in temperature, it appeared clearly with a decrease in the water temperature in Station No. (2) Ain Al-Jarba, and the reason for the obvious decrease in the temperature of Al-

Ain water is explained by the pollution of Al-Ain water by the sewage sources of a number of nearby sites, in addition to the Al-Ain site near the Euphrates River. Al-Ain water level with river water rises and falls. Geologists believe that the feeding of these springs comes from sources, the most prominent of which is the leakage of rainwater into the ground, or through the penetration of the waters of the Euphrates into the layer of limestone rocks (Al-Faris Al-Kalasi) [8,9]. While the statistical calculations of the average temperatures taken for the springs water during the study period show that there is a variation in the temperatures during the months of the study. And as shown in Table No. (1).

Table1. Shows average temperatures taken during the months of the study

	August	September	October
Temperature	31	30.5	30.5

The table shows that there is some variation in the average temperatures recorded for the water of the studied sites during the study period. Similar to water temperatures, with a significant difference from the month (August) due to lower average temperatures. It is likely that the reason for this discrepancy is due to the change in the air temperature during the months of the study and the rate of exposure to sunlight in relation to the earth's crust, which in turn affects the average temperature of the earth's interior and groundwater.

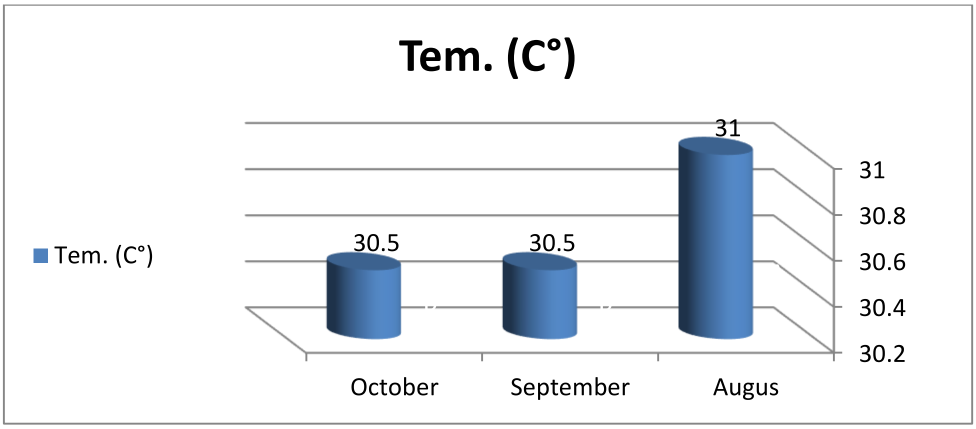

Figure 1. shows the significant difference in the average temperatures recorded for the water of the studied sites during the months of the study

3.1.2. Electrical Conductivity (EC)

The numerical value represents the number of ions (negative and positive) dissolved in water and responsible for the transmission of electric current [10]. The electrical conductivity of water depends on the temperature, the type of ions, and their concentration in the water, and it is considered one of the quick ways to express the salinity of the water [1]. And by taking the general averages of the electrical conductivity value of the water of different sites and during the months of the study, it is noted that there is no real significant difference between the values of the electrical conductivity rates during the study period, as it is noted that the water of different springs recorded an electrical conductivity value that ranged between (36.25-37.7) ms/cm. The reason for the high value of the electrical conductivity of the water of the studied springs is due to the nature of the geological formations in the areas where these springs are spread, and this is evidence of an increase in the salt concentrations of the water.

Date: October 2023

Table2. Shows the general rates of electrical conductivity value of the studied springs water during the study period

	August	September	October
Electrical conductivity (EC)	36.25	36.25	37.25

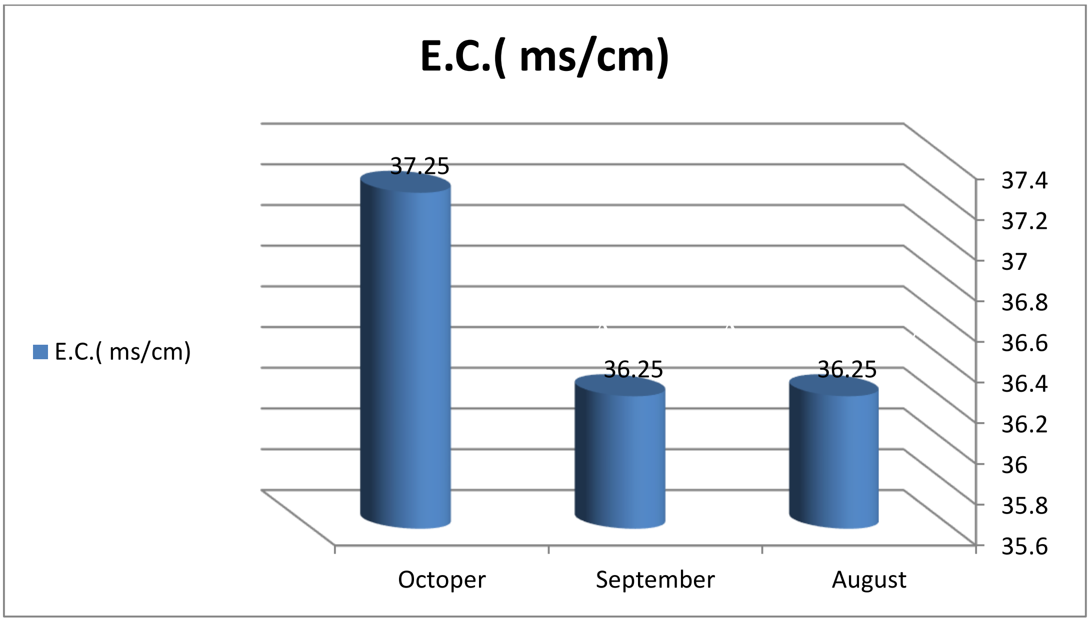

Figure 2. Chart of variation between delivery rates during the study period

3.1.3. Total Suspended Solid and Total Dissolved Solid (T.S.S.) (T.D.S.)

Suspended Solids (TSS) are suspended solids (organic and inorganic), which have a fundamental role in reducing water purity and increasing its turbidity, and thus affect other physical and chemical properties of water. While the total dissolved solids (TDS) represent all the dissolved substances in the water in both its ionized and non-ionized states (except colloidal, suspended and dissolved gases) and is an indicator of the rate of electrical conductivity of water, the general rates of the concentration of suspended solids for the different sites studied showed a clear convergence in their rates during the study period As shown in Table No. (3) and Figure No. (3), which shows that there is no significant difference between the rates of different concentrations of the springs water examined during the study period.

Table3. shows the general averages of the concentration of suspended solids for the water of different springs during the study period

	August	September	October
Total Suspended Solids (TSS)	500	375	300

Date: October 2023

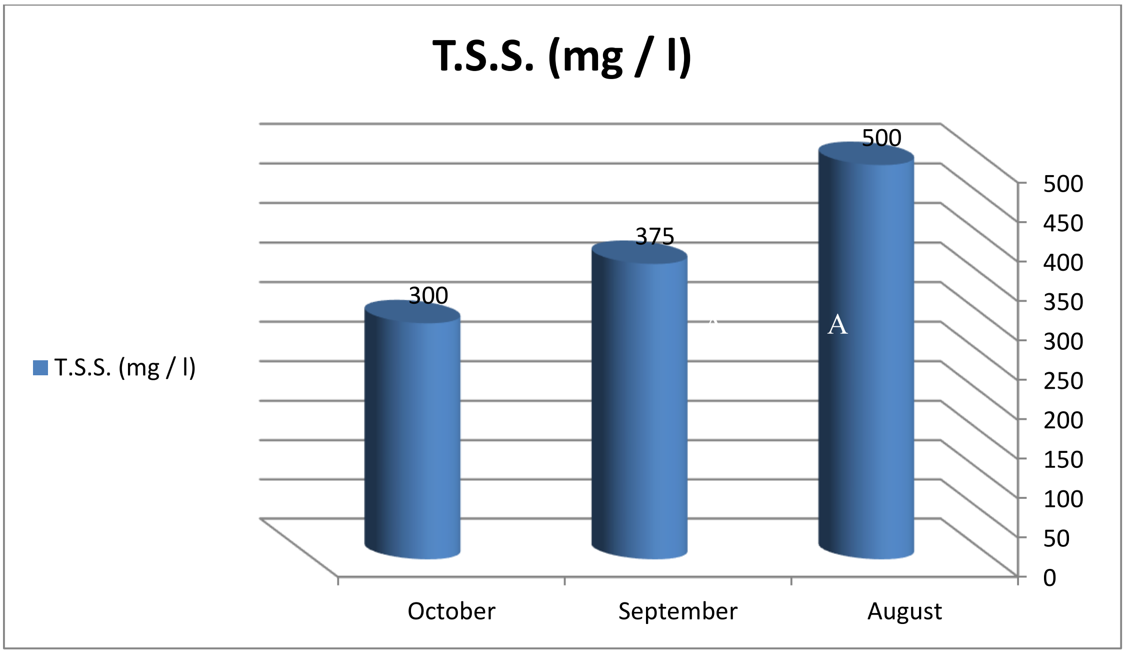

Figure 3. Showing the levels of solid suspended matter concentrations in the studied springs water during the study period

It was noted that the general rates taken for the water of the studied stations and during the study period (the temporal distribution of the calculated concentration rates) did not notice a significant difference between the general rates, which ranged between (8275 - 11125) mg/L, as shown in Table No. (4) and Figure No. (4)

Table 4. Shows the general rates of total dissolved solids concentrations of the studied spring water during the study period

	August	September	October
Total dissolved solids (TDS)	8275	11125	10550

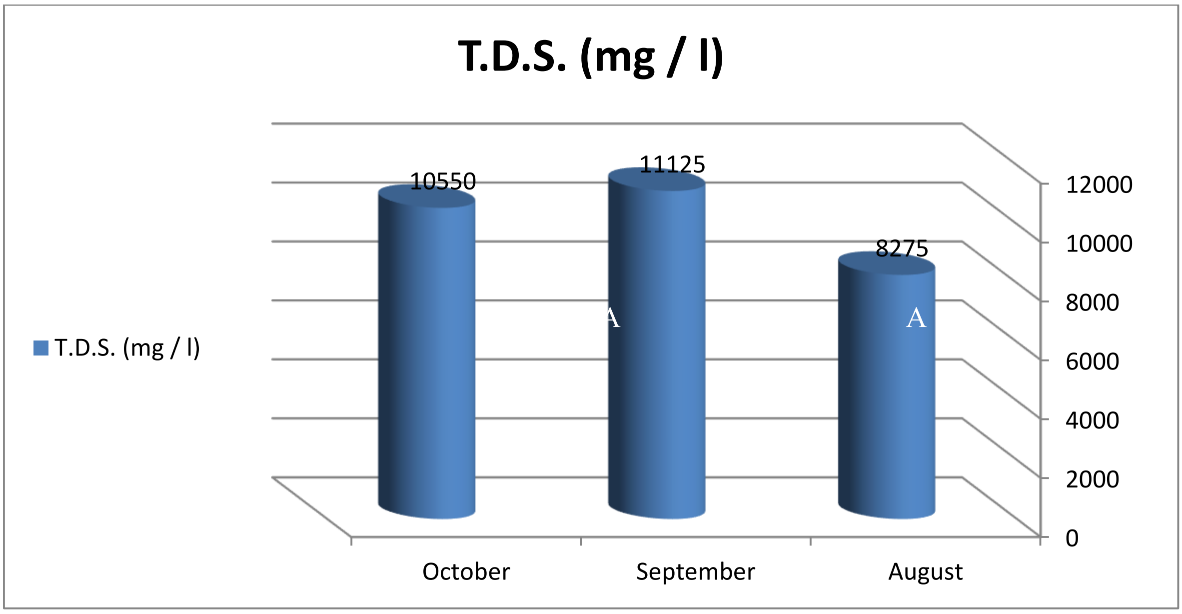

Figure 4. Shows the general concentration level of total dissolved solids in the water of different springs during the study period

Date: October 2023

The high level of dissolved ions gives an idea of the type of aquifer for the water of those springs, the nature of the rocks, and the source of that water[11]. The recorded concentrations of total dissolved substances in the water of the studied springs show that the water of those springs is not fit for drinking purposes due to the high concentration of dissolved salts to the upper limit of the permissible limit in drinking water according to the standards of the World Health Organization[12]. In the light of the geological and health studies of the mineral springs, the water of the studied springs can be considered heavy mineral water because it contains a TDS value of more than (1000) mg/L, suitable for medical and therapeutic uses.

3.1.4. pH

It represents the concentration of hydrogen ions in the water, through which the acidity or alkalinity of the water is determined, and its effect appears on the biological and chemical activities of the water and thus affects aquatic organisms. Where the general averages of the water of different springs taken during the study period recorded a gradient and variation in the pH values during the months of the study. As it is noted that there is a significant difference at the level ($p \leq 0.05$) between the pH value recorded during the months (August and October) for the different study stations, while there was no significant difference in the PH value of the studied springs water according to the spatial distribution, as it gave water from different locations Approximate pH value.

Table 5. Shows the general averages of the pH value of the studied springs water during the study period

	August	September	October
pH	7.2	7	7.07

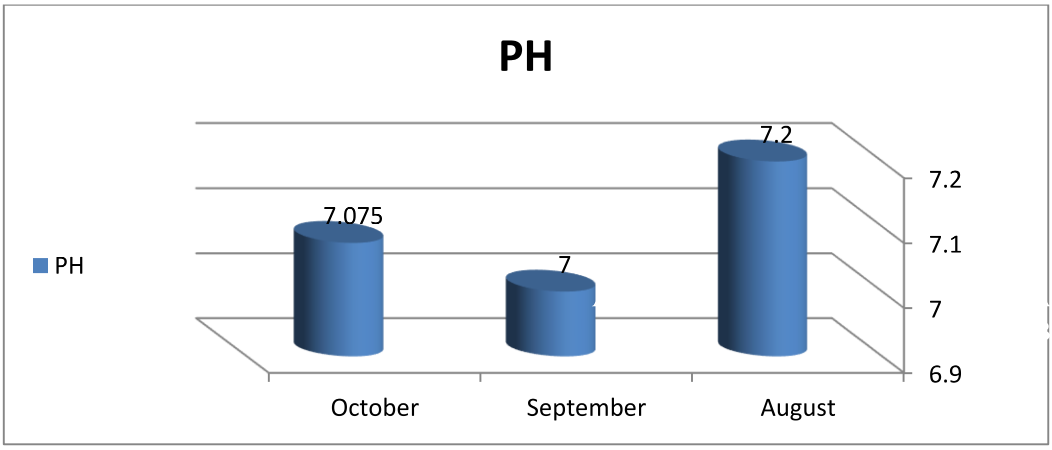

Figure 5. Shows the general concentration level of the pH value in the water of different springs during the study period and the significant difference between the studied values during the study months

3.1.5. Dissolved Oxygen (DO)

It represents the measure of water quality and validity, by determining the concentration of dissolved oxygen in a sample of water. The general rates of dissolved oxygen concentration of the studied spring water during the study period showed that there was no significant difference between the values of the concentration rates of spring water during the months of the study.

Table 6. Shows the general rates of dissolved oxygen concentration in the studied springs water during the study period

	August	September	October
Dissolved Oxygen (DO)	1.145	1.15	1.1975

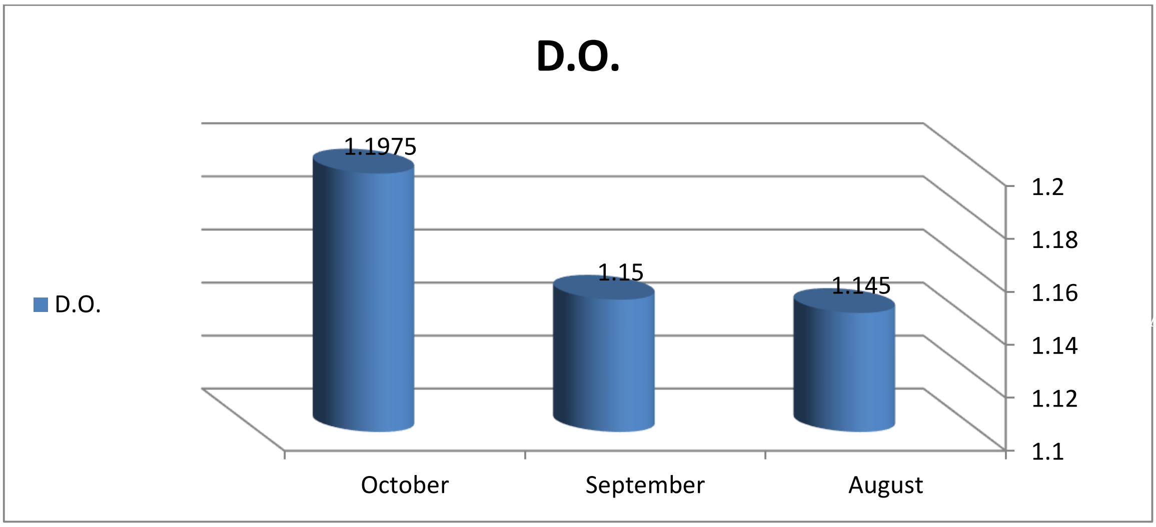

Figure 6. Shows the general concentration level of dissolved oxygen concentration in the water of different springs during the study period and the significant difference between the studied values during the study months

3.1.6. Biological requirement of oxygen (BOD)

It represents the amount of oxygen consumed when organic substances are broken down in the water, added through the activity of microorganisms, which negatively affects the quality of that water[13]. And by taking the general averages of the value of the biological oxygen requirement (BOD), there was no significant difference in it according to the spatial and temporal distributions, and at a significant level ($P \leq 0.05$).

Table 7. Shows the general averages of the value of the biological requirement in the studied springs water during the study period

	August	September	October
Biological requirement of oxygen (BOD)	5975	4750	7337.5

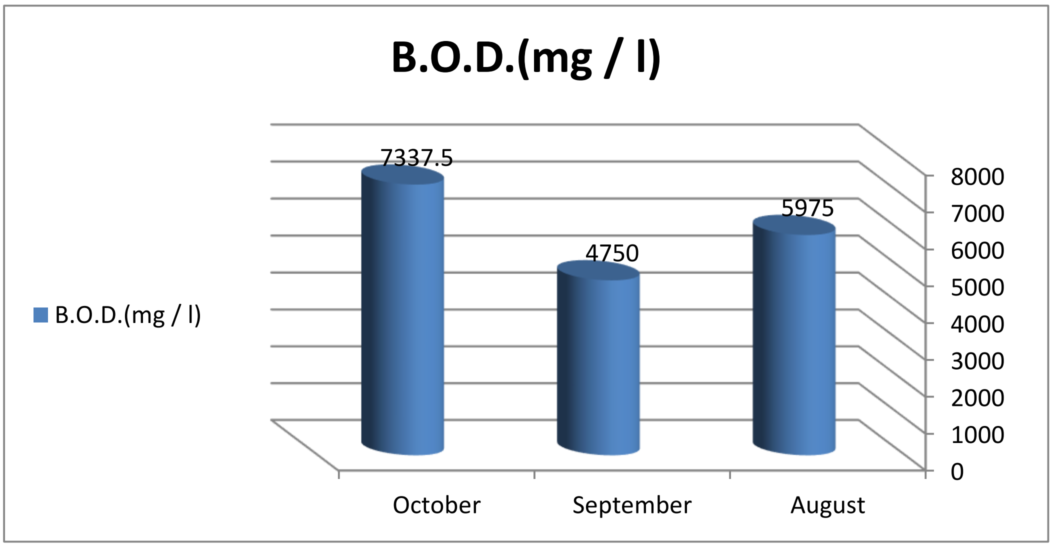

Figure 7. Shows the level of the general rates of the value of the vital requirement in the water of different springs during the study period and the significant difference between the studied values during the months of the study

According to the recorded results of the value of the biological oxygen requirement (BOD) in the water of the studied springs, it confirms that the studied water is not suitable for human use. According to the World Health Organization, the water suitable for human use as a good water source after purification, the BOD value is between (1.7 - 3) mg/L, i.e. Less than (5) mg/L.[14].

3.1.7. Nitrite ion and Nitrate NO_3, NO_2

Nitrite and nitrate are salts of nitric acid, and they are inorganic chemical compounds rich in nitrogen, but they differ from each other in their composition.

Table 8. General rates of nitrite ion concentration (NO_2) in the studied spring water during the study months

	August	September	October
NO2	14.75	2.75	14.75

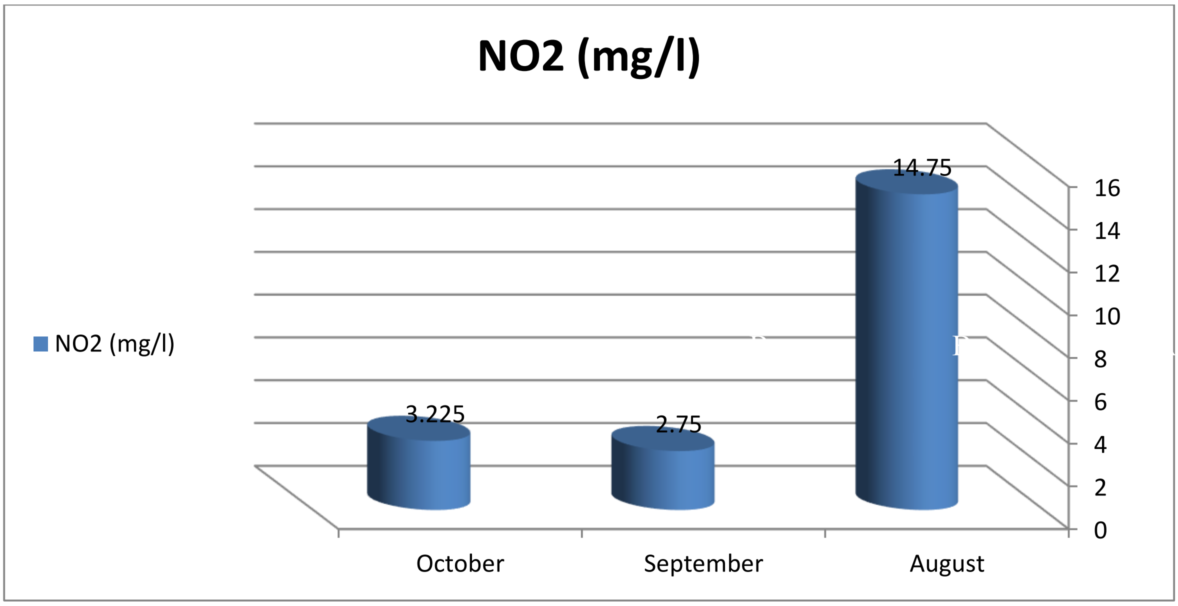

Figure8. Shows the level of the general rates of nitrite ion concentration (NO_2) in the water of different springs during the study period and the significant difference between the studied values during the study months

While the results of the statistical analysis of the general rates of nitrate ion concentration showed a clear significant difference at a significant level ($P \leq 0.05$).

Table 9. General rates of nitrate ion concentration (NO_3) in the water of the studied springs during the months of the study

	August	September	October
NO3	6.125	1.7	4.375

Date: October 2023

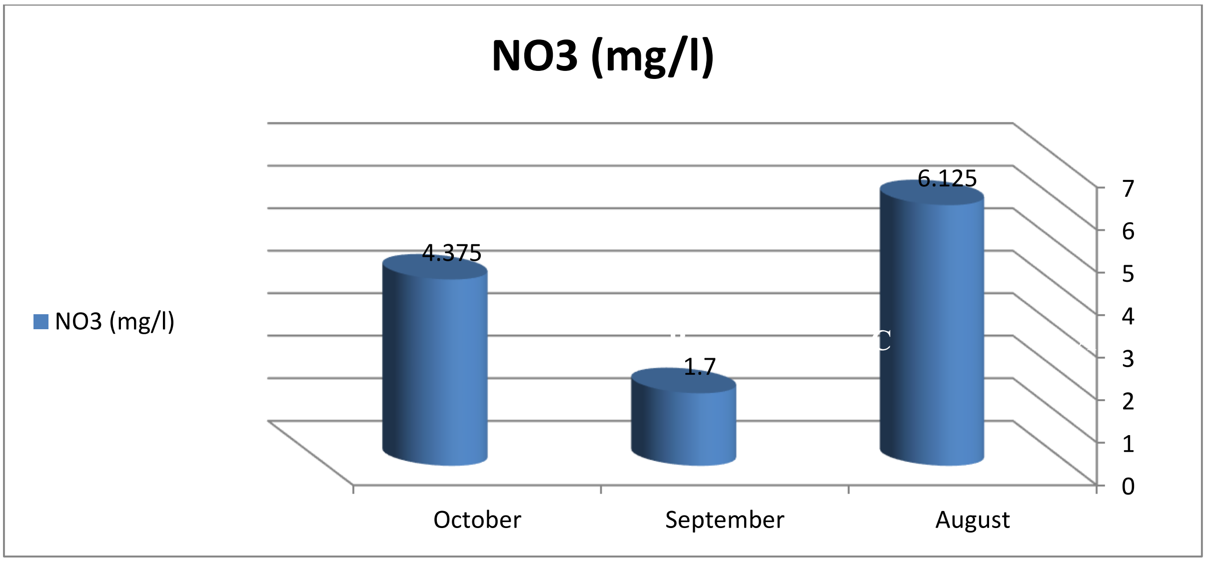

Figure 9. Shows the level of general rates of nitrate ion concentration (NO_3) in the water of different springs during the study period and the significant difference between the studied values during the study months

And since nitrates and nitrites are highly soluble ions, the European Union's instructions regarding potable water stipulate that the level of nitrates in one liter of water should not exceed (50) mg/L, which is a level that the European Union considers safe for consumer health**.**

3.1.8. Sulfate ion SO_4

It is produced from several processes and sources, the most important of which is the dissolution of gypsum in water, and from sulfur dioxide gas SO_2, in addition to the processes of biodegradation of organic materials rich in sulfur, and sulfate ions are among the most negative ions present in water [15]. The high concentration was noted as a result of the melting of gypsum rocks and sediments, which spread and cover most of the springs formation area [1]. According to the proven results of the sulfate ion concentration ($SO_4^{=}$), the water of the studied stations can be considered unfit for drinking due to the high concentration of the sulfate ion in it, it can be used for industrial purposes or for watering crops, and the high concentration of sulfate ion added to the water of the studied springs a bitter taste and to varying degrees according to the level of sulfate dissolved in it, as the high concentration of sulfate ions exceeded (500) mg /L in groundwater gives a bitter taste to that water. By calculating the general rates of sulfate ion concentrations for the water of the springs studied through statistical processes, a significant difference was observed in the value of the general rates of sulfate ion concentration for the water of different stations, at a significant level ($P \leq 0.05$).

Table 10. General rates of sulfate ion concentration ($SO_4^{=}$) in the studied spring water during the study months

	August	September	October
SO4	495	112.5	170

Date: October 2023

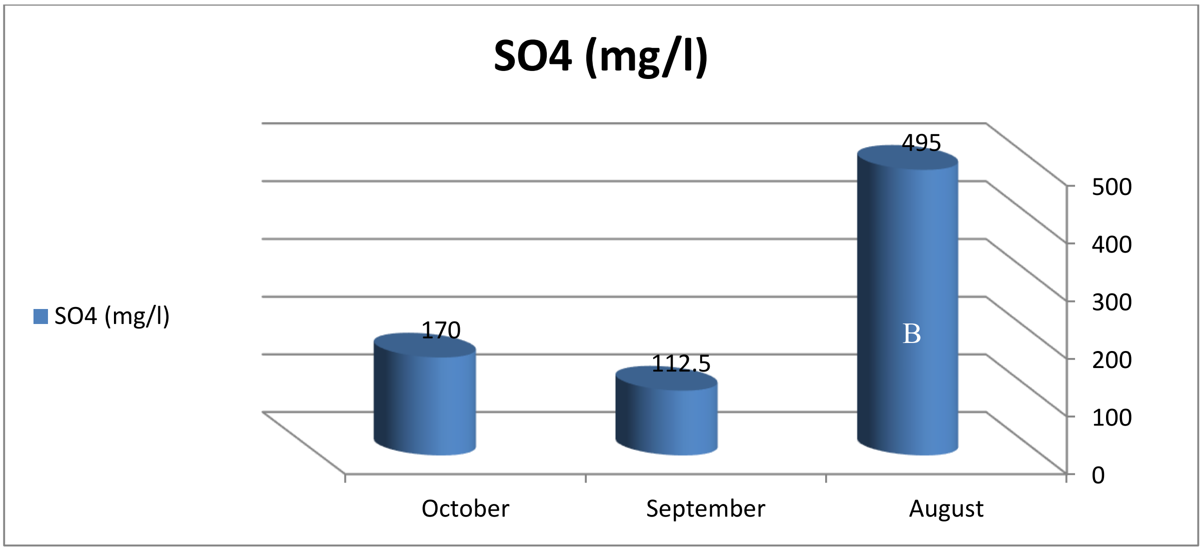

Figure 10. Shows the level of general averages of sulfate ion concentration ($SO_4^{=}$) in the water of different springs during the study period and the significant difference between the studied values during the study months

1.1.9. Phosphate ion PO_4

Phosphate is one of the determining factors for the growth of aquatic organisms such as plants and phytoplankton, with its low abundance in aquatic environments, where organisms use dissolved inorganic phosphate [13]. Through the results of the statistical operations of the general averages of the results of measuring the phosphate ion concentration, PO_4, of the water of the different stations during the study period, we notice a significant difference in the phosphate ion concentration of the water of the studied stations according to the spatial distribution at a significant level ($P \leq 0.05$) .

Table 11. General rates of phosphate ion concentration (PO_4) in the studied spring water during the study months

	August	September	October
PO_4	76.25	55.75	32.75

Date: October 2023

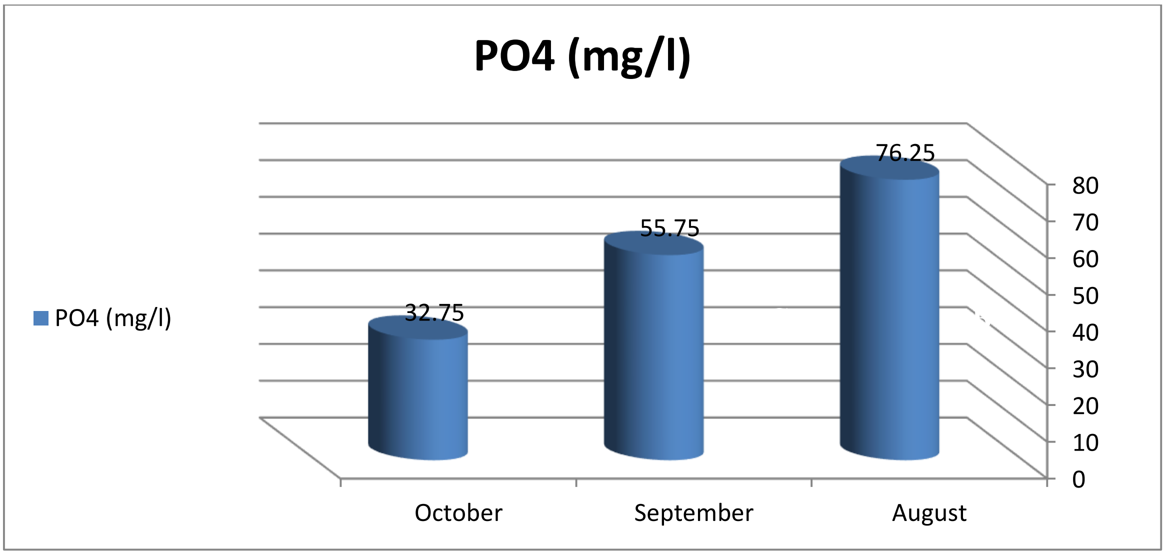

Figure 11. Shows the level of general averages of phosphate ion concentration (PO4) in the water of different springs during the study period and the significant difference between the studied values during the study months

4.Conclusion

The water of the studied stations, and according to its temperature, it falls within the type of warm water, as it recorded temperatures ranging between (30.5 - 31) degrees Celsius, and the electrical conductivity values of the water were between (36.25 - 37.25) ms/cm, which was characterized by a wide range of variation. The concentration of salts and the ratio of dissolved solids between (8275 - 11125) mg/L makes it range from water of a salty nature to salty water according to the classification of water. The water of sulfur springs also recorded a very low level of oxygen concentration, where after dilution by (18: 1) With distilled water, the value of dissolved oxygen was between (1.1975 – 1.145) mg/L, in addition to the richness of the studied spring water in H_2S hydrogen sulfide gas, tar and other wastes of petroleum derivatives and various gases. The water of the studied stations (springs) was highly hard in terms of its richness in calcium and magnesium ions.

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Date: October 2023

Study of the Euphrates River's Water Quality in Front of and Behind the Haditha Dam in Anbar Province, Iraq

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Abstract: Contaminants in natural water continue to be one of the largest environmental issues on the planet. This is due to the fact that due to population expansion, urbanization, agricultural practices, and industrialization, there is a significant increase in the demand for freshwater and a water crisis in arid and semi-arid areas. The present study aimed to assess the suitability of water quality at Haditha Dam. In this study, 9 parameters, including Nitrate NO_3, Carbonate CO_3, bicarbonate HCO_3, Sulphate SO4, Chloride Cl, Calcium Ca, Magnesium Mg, Sodium Na, and Potassium K were measured and investigated to assess water quality for Haditha Dam Project in both sides (Behind and in front of the dam). The current study focuses on the examination of water quality data collected over a one-year period from both sides of the Euphrates River through the collection of 48 samples. The parameters that were examined used the accepted techniques. Findings showed that average concentrations were lowest during the dry season and highest during the rainy season for K, Ca, Na, Mg, Cl, and SO4. However, HCO_3 and CO_3 concentrations were the highest averages in the dry season, while the lowest average was in the wet season. The results were compared with Iraqi standards for water quality and the World Health Organization (WHO). The planning and logical management of water resources, including the possibility of using them for irrigation and drinking water, can benefit from this study. According to the findings, river water is deemed unsafe for drinking and human consumption, however it can be utilized for irrigation.

1. Introduction

A sustainable environment depends on both the quantity and quality of water [1], which is why it is so important. The quality of surface water is influenced by a variety of environmental factors, such as precipitation, soil erosion, and weather conditions. The demand for the use of water resources, together with other unnatural activities including urbanization, industrialization, municipal wastewater generation, and runoff water from agricultural areas, have an impact on surface water quality [2–6]. More than 80% of illnesses in people are caused by water contamination [7]. As a result, it's important to strengthen the community's access to appropriate water supply. Water quality, however, is what has to be assessed the most.

The Tigris and Euphrates rivers, which are regarded as Iraq's two primary sources of water, have recently begun to decrease in quality at a quick and accelerating rate. The UNESCWA-BGR [8] observed a decline in the Euphrates River discharge at Hussaybah (the Euphrates River's site entry in Iraq), where they measured 15.5 billion cubic meters between 1999 and 2010[9]. In Iraq, there are now two distinct types of water quality issues. The first is salinity, and the second is the quantity of pollutants in the water that are introduced into freshwater sources by governmental, commercial, and industrial activity.

The spread of agriculture throughout the Euphrates and Tigris watersheds, both inside and outside of Iraq, is the cause of the salinization of the Euphrates, Tigris, and other rivers in Iraq. Economic growth and population growth are other factors that are being used to explain rising loads of different

Date: October 2023

pollutants. Droughts worsen the deterioration of water quality and are the main factor in the desertification of agricultural areas, [13,14]. The yearly water discharges into the Euphrates River have been steadily decreasing as a result of the construction of substantial dams in Turkey (GAP project) and Syria. TDS, TH, pH, DO, nitrate, and phosphate are the primary variables affecting water quality, according to Al-Shujairi [9]. The Euphrates River is the main supply of water for Anbar Province and the southern parts of Iraq. The water quality of the Tigris and Euphrates rivers was evaluated through a number of researches. Hassan et al [10] study of the Tigris River's water quality and contamination for various pollutants, including temperature, electrical conductivity, salinity, water flow, total dissolved solids, total suspended solids, dissolved oxygen, biological oxygen demand, total nitrogen, and total phosphorus, examined the water quality and contamination for these pollutants as well as others. The investigation demonstrated that the river's water quality is variable, ranging from poor to marginal. Because of numerous pollution-related consequences on the river, Salman et al. [11] asserted that the water quality of the Hilla River (a branch of the Euphrates River) was merely fair. One of the most common problems is the existence of an excess of bicarbonates in irrigation water.

Water that contains calcium carbonate or magnesium carbonate, such as limestone or dolomite, is able to release bicarbonates into the water when it passes through the rock formation. The bicarbonate, calcium, and/or magnesium ions that are released from the stone. Bicarbonates raise the pH of the water [16] which has a detrimental effect on soil and plant health despite appearing to be safe. There may be an excessive amount of sodium (Na) and chloride in irrigation water from personal wells, ponds, and rivers (Cl). When snowmelt runoff was at its highest in the spring or in the summer, when drought-induced water levels were brought to low levels, the Na and Cl levels in wells and ponds surged. To determine the extent of the Na and Cl pollution and its duration during these times, a number of water tests should be carried out in order to determine the quality of the water. This knowledge will be useful for choosing the proper corrective measures, [17]. While Na and Cl can directly endanger plants, they might contribute to a rise in the concentration of soluble salts (EC) in the growing medium or hinder plants' ability to take in water.

Too many soluble salts can harm plants, which can also cause them to grow less quickly and become more susceptible to disease. Foliar chlorosis brought on by high Na and Cl resembles that brought on by a deficit in magnesium, iron, and nitrogen [17]. Potassium and phosphate, among other plant nutrients, are frequently found in quite minute quantities in water. When contaminants are found in irrigation water at levels more than a few parts per million, it may be a result of fertilizer contamination or another source of contamination. The growth of plants depends on sulfur, despite the fact that it is not usually found in fertilizers. It is assessed in irrigation water in order to give an indication of probable deficiency problems. If the concentration is less than around 50 ppm, [18] additional sulfate may need to be administered for healthy plant growth. A few nutrients are analyzed to see if the water supply can be contaminated. If they are found in high amounts (for example, >5 ppm nitrate), they should be taken into account in the fertility program. The ways in which fertilizer is used need to be examined and modified in order to prevent further contamination [18]. The goal of this study is to evaluate the water quality of the Euphrates River by examining the contamination brought on by various contaminants that lower the quality of the water at Haditha Dam in Anbar Province, Iraq, both in front of and behind the dam.

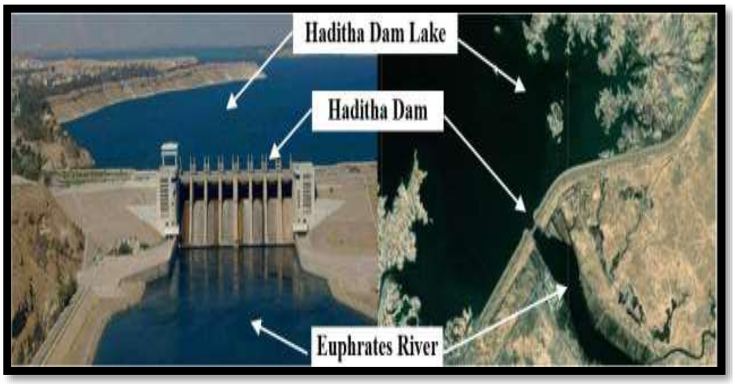


Figure 1. Study Area

Date: October 2023

2. Materials and Methods

2.1. Study Area

Haditha reservoir is one of the largest and major water bodies on the Euphrates River. It is located in the western part of Iraq to the north of Haditha city at a distance of eight km (Figures 1,2). It is formed as a result of Haditha dam construction, which was established in 1986. It has become a multi-purpose water uses. The study area lies between latitudes (34° 40′ and 34° 13′) North and between longitudes (42° 26′ and 41° 55′) East. River and the reservoir covers about 500 km2 at maximum flood water level of 147 m.as.l with 10 km of shoreline. The climate of the study area lies within the arid or semi-arid region, which is characterized by low rainfall rates ranging from 45 mm to 200 mm and the annual average is 127 mm

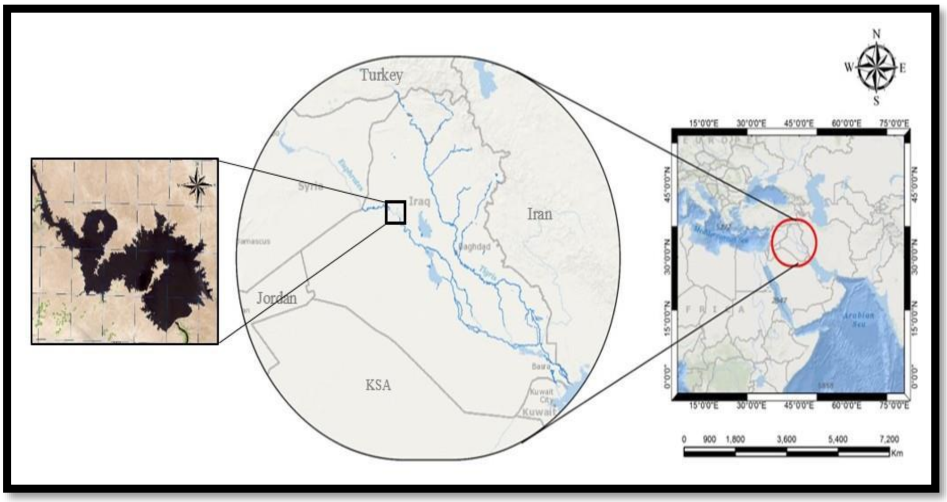


Figure 2. Location of Haditha Reservoir

2.2.Sampling, Measures, and Analysis

Monthly samples were taken from the selected sites over the period of January 2021 to January 2022. Nine parameters were determined and investigated. These parameters were Nitrate NO_3, Carbonate CO_3, bicarbonate HCO_3, Sulphate SO_4, Chloride Cl, Calcium Ca, Magnesium Mg, Sodium Na, and Potassium K which investigated in both locations in front of and behind the dam. Analytical techniques were used to examine each parameter, referring to the procedures and techniques recommended by conventional methodologies [12]. The water sampling of Haditha Dam was done during the wet and dry seasons (January 2022 to December 2022) as per the standard procedures of the Iraqi Standards Guidelines. For the collection and analysis of various water variables, standard methods were followed. All chemical tests were conducted in Haditha Dam Project laboratories. All the plastic bottles were thoroughly washed and dried before sample collection and the bottles were rinsed with water samples to be collected at the time of collection. After sample collection proper labeling was done.

2.3.Water Quality Standards

The following physical and chemical parameters were determined according to Iraqi standard, as shown in Table (1). In addition, the present study was dependent on the drinking-purposes recommendations made by the Iraqi Guiding line (number 417) (updated 2009), as shown in Table (2), which has been taken into consideration for comparing with measured data, in order to determine whether the studied river water is suitable for human consumption.

Date: October 2023

Table 1. Irrigation water Iraqi standards, [19]

Water quality parameters	Unit	Standard
pH	-	4-8.6
Total dissolve solid (TDS)	mg/l	2500
Alkalinity	mg/l	200
Electrical conductivity (EC)	$\mu s/cm$	2250
Calcium (Ca)	mg/l	450
Chloride (Cl)	mg/l	250
Sulfate (So_4)	mg/l	200
Potassium (K)	mg/l	100
Total suspended solid (TSS)	mg/l	60
Total hardness	mg/l	300
Sodium (Na)	mg/l	250

Table 2. Standards of Water Quality (Iraqi guideline (IQS, 2009) and WHO Guideline (WHO, 2007), [20]

Parameters	Unit	Iraqi guideline 2009	WHO 2007
pH		6.5-8.5	6.5-8.5
Total dissolve solid (TDS)	mg/l	1000	1000
Magnesium (Mg)	mg/l	100	125
Nitrate (N03)	mg/l	50	50
Calcium (Ca)	mg/l	150	75
Chloride (Cl)	mg/l	350	250
Sulfate (So_4)	mg/l	400	250
Potassium (K)	mg/l	12	12
lead (Pb)	mg/l	0.01	0.01
Cadmium (Cd)	mg/l	0.003	0.003
Sodium (Na)	mg/l	200	200
Copper (Cu)	mg/l	1	1
Zinc (Zn)	mg/l	3	3
Irion (Fe)	mg/l	0.3	0.3
Manganese (Mn)	mg/l	0.1	0.1

3. Results and Discussion

The kinds and concentrations of natural pollutants are determined by the characteristics of the geological components of the surface water's flow and the quality of recharge water. The chemicals calcium, magnesium, chloride, sodium, fluoride, nitrate, iron, and many others may be absorbed by the water as it passes through sedimentary rocks and soils. This means that the adverse impact of these natural pollutants relies on both their kind and concentration, [15]. Data have been collected from different samples taken at different times and places at the Haditha Dam. The descriptive statistics for the analyzed parameters are summarized in Table 3 that shows all these results. The relationship between concentrations of these chemical compounds and the sampling position with varying times over one year were represented, as shown, in Figures (1-8). It is important to mention that values of pH measured over the year were between 7.5 during the dry season and 7.94 during the rainy season. A change in the source's quality is reflected in the pH measurement. Additionally, higher pH levels lessen chlorine's ability to kill germs. The basicity of the interaction is measured in this study by the average pH values. They are within the range of 4 to 6.6 that is acceptable for irrigation water.

Date: October 2023

It can be seen that the highest values of K at the front and behind the dam are 10.45 mg/l and 10.05, respectively. However, the lowest level at the front and behind the dam is 6.5 mg/l and 6 mg/l, respectively, as shown in Figure 1. The difference between these values could be mainly attributed to the seasons when samples were taken in, it can be indicated that the rainy season in November was the main reason behind the highest values of K. Where, some nutrients, such as Phosphorous P, Nitrogen N, and Potassium, K, can be drifted into the surface water, during the rainy season entering body water and increasing the nutrient elements, including K. As it known that the months from October to March can be highly considered as the rainy seasons in Iraq and that explain why pH values have increased in the rainy season. In addition, the samples taken from behind the dam have high levels compared with those taken from in front of the dam because behind the dam represents the Euphrates river. On the other hand, the reservoir (Haditha Dam Lake) is found in front of the dam where many nutrients can be reduced. The same trend can be also noticed for the concentrations of sodium Na, calcium Ca, magnesium Mg, and Chloride Cl where the highest levels most of them are found in the rainy season (December) both behind and in front of the dam. However, the lowest levels existed in the dry season (Jun) in both places, as shown in Figures 2,3,4, and 5. According to the Iraqi Standards Guidelines, K, Na, Ca, Mg, and Cl levels were existed and distributed normally behind and in front of the dam for both dry and wet seasons.

Date: October 2023

Table 3. Average Values of Water Quality for Euphrates River in front and Behind the Haditha Dam, Anbar Province, Iraq.

Date	**Sampling Place**	**NO_3**	**CO_3**	**HCO_3**	**SO_4**	**CL**	**Ca**	**MG**	**Na**	**K**
Jan.	In Front of Dam	0	2.4	100.4	180.5	59	38.6	22.4	32.75	7.8
Jan.	Behind of Dam	0	0	103.4	184.5	59	39	22.75	34.45	8.35
Feb.	In Front of Dam	0	0	105.45	177.5	52.5	38.65	26.4	31.5	6.4
Feb.	Behind of Dam	0	0	108.55	182	53.5	39.9	27.4	34	7.7
March	In Front of Dam	0	4.8	109.65	168.5	55.5	39.5	25.25	30.5	7.2
March	Behind of Dam	0	4.8	114.6	169	58.5	41.5	25.95	30.65	7.6
April	In Front of Dam	0	4.8	106.63	159.5	52	37.1	20.75	24.95	6
April	Behind of Dam	0	4.8	108.9	163.5	55.75	38.85	21.65	26.45	6.5
May	In Front of Dam	0	9.6	125.85	166.5	57.1	39.2	21	25.9	6.65
May	Behind of Dam	0	9.6	128.05	169.5	58.65	40.3	22.25	27.25	7.05
Jun	In Front of Dam	0	12	114.25	180.65	64.25	38.6	21.5	28	7.2
Jun	Behind of Dam	0	12	117.15	182.2	65.3	40.8	22.1	28.55	7.55
July	In Front of Dam	0	10.8	102.45	189	68.45	41.7	23.15	29.45	8
July	Behind of Dam	0	13.2	106.15	191	70.6	43.65	24.55	29.9	8.05
Aug.	In Front of Dam	0	12	99.05	189.5	71.5	42.65	23.9	30.05	8.65
Aug.	Behind of Dam	0	14.4	107.3	190	72.75	43.9	24.9	30.4	8.75
Sep.	In Front of Dam	0	8.4	92.7	191.25	72.45	43.4	26.2	30.35	9.25
Sep.	Behind of Dam	0	8.4	109.75	192.75	75.25	44.25	27.35	30.9	9.45
Oct.	In Front of Dam	0	9.6	90.3	192.8	76.75	44.1	26.6	31.15	9.65
Oct.	Behind of Dam	0	9.6	92.75	193.65	77.35	44.7	26.8	31.25	9.8
Nov.	In Front of Dam	0	7.2	85.4	195.15	85.3	45.65	25.85	36.5	10.05
Nov.	Behind of Dam	0	6	87.85	197.3	87.8	46.3	26.35	38.2	10.45
Dec.	In Front of Dam	0	4.8	91.45	203	90.5	51.45	28.3	47	9.75
Dec.	Behind of Dam	0	4.8	95.15	206.5	94.85	53.85	29.7	51	9.85

Date: October 2023

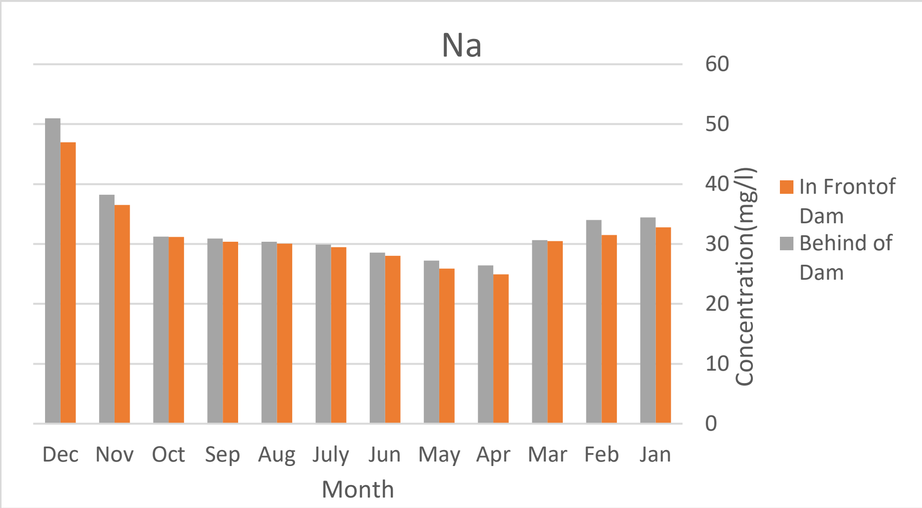


Figure 2. Sampling Date Vs Concentrations of Na(mg/l)

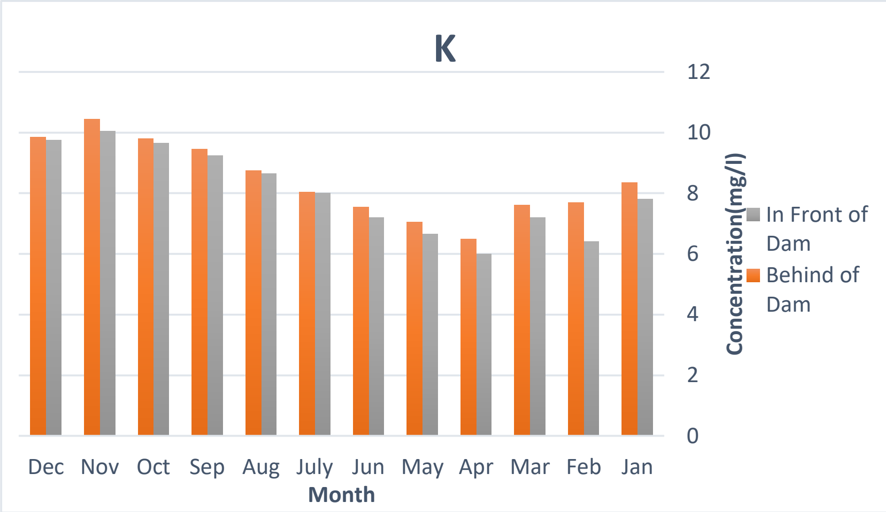
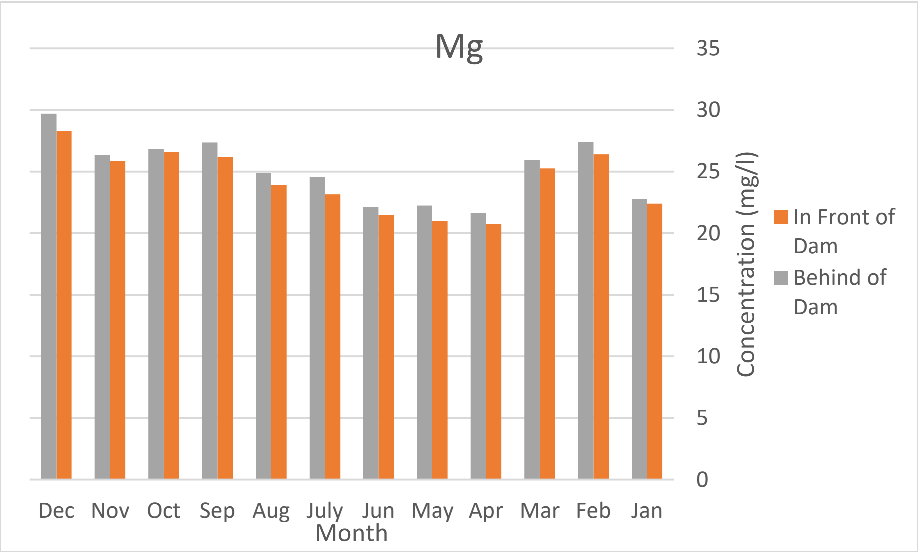
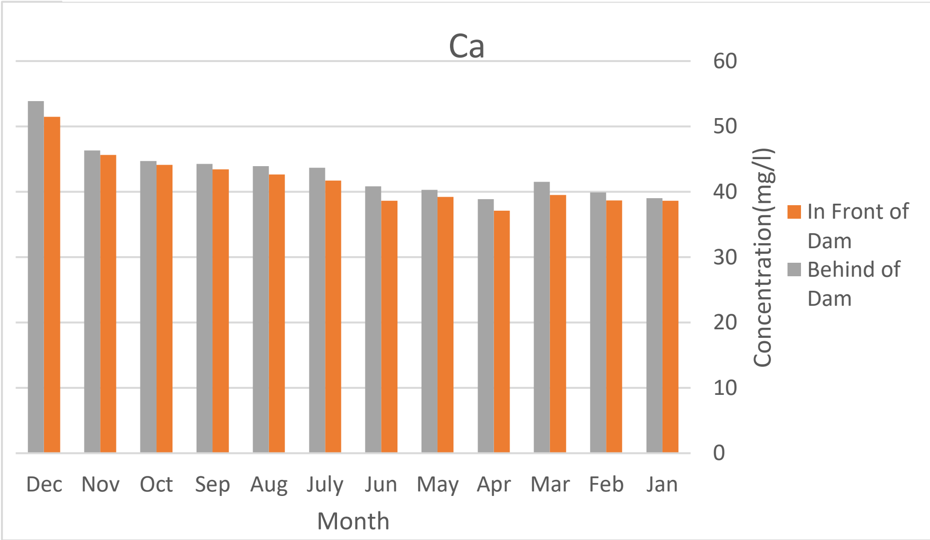


Figure 1. Sampling Date Vs Concentrations of K(mg/l)





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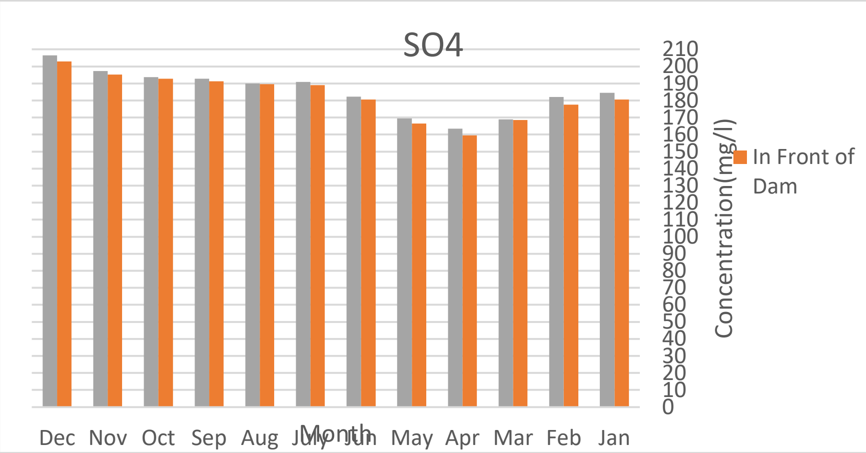

Figure 6. Sampling Date Vs Concentrations of SO_4(mg/l)

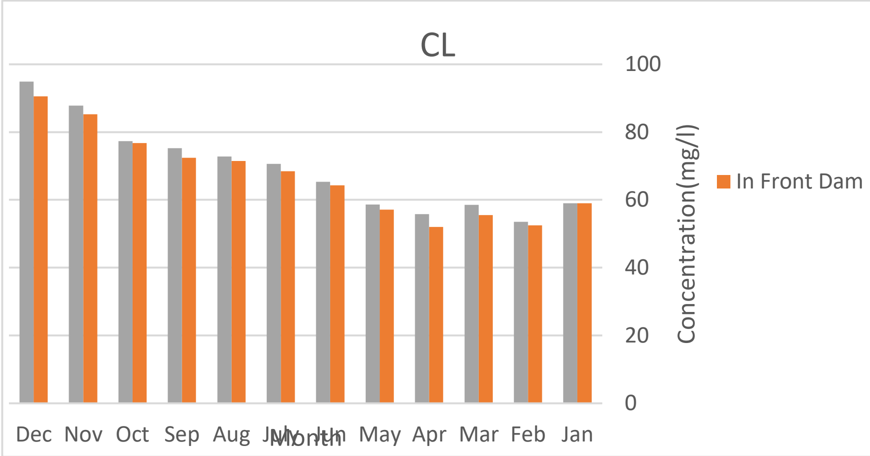

Figure 5. Sampling Date Vs Concentrations of Cl(mg/l)

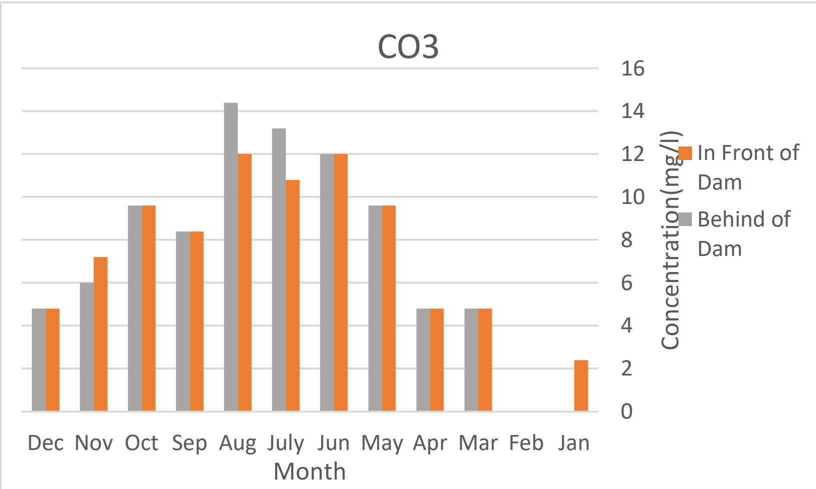

Figure 8. Sampling Date Vs Concentrations of CO_3(mg/l)

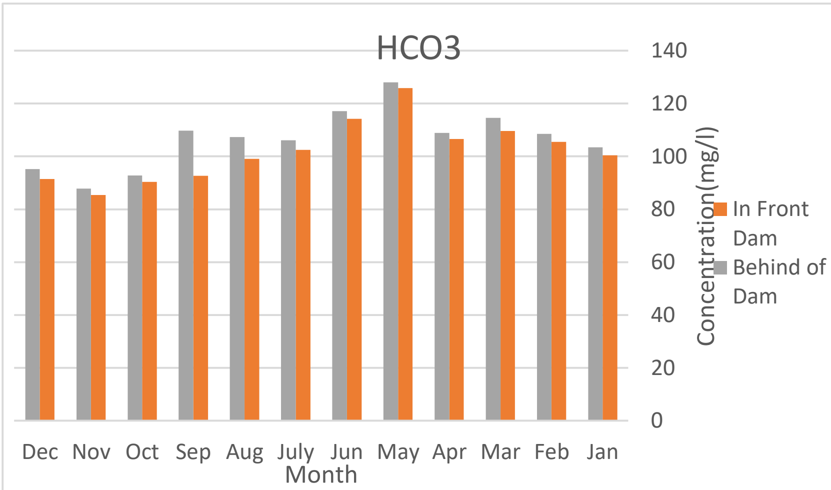

Figure 7. Sampling Date Vs Concentrations of HCO_3(mg/l)

Generally, K and Na existed with low levels in both locations compared to other chemical compounds, including Mg, Ca, and Cl, which existed at high concentrations. The amount of calcium and magnesium in the water can be determined by its hardness. Magnesium and calcium, which are measured in parts of element per million parts of water (ppm) on a weight basis, are crucial for plant growth. Magnesium and calcium concentrations between 30 and 50 ppm and 40 to 100 ppm are ideal for irrigation water, respectively, [17]. According to the result, Ca and Mg are 40 to 55 ppm and 25 to 30 ppm, respectively, so they can be considered desirable for irrigation water. High sodium levels prevent plants from absorbing calcium, which may lead to excessive calcium and magnesium leaching from growing media. Additionally, salt may be absorbed by the leaves, causing leaf burn. Chloride poses a risk of excessive foliar absorption under overhead watering or leaf edge burn in susceptible plants as a result of excessive root uptake. There is no danger from high foliar absorption if Cl concentrations are less than 100 ppm. There is no risk of poisoning from root uptake if Cl concentrations are less than roughly 150 ppm. As a remedy for these problems, increasing the amount or frequency of water-soluble fertilizer is not advised because doing so will merely raise total EC and make the issue worse, [17].

Na and Cl levels should normally be kept below 50 ppm and 140 ppm for plants, respectively. However, depending on the sensitivity of the crop, higher levels may be tolerated. For overhead irrigation, sodium concentrations of 50 ppm or less are deemed acceptable. Based on the obtained data in this study, the highest concentrations of Na and Cl were around 50 and 90 mg/l, respectively, which means Na and Cl were at Acceptable levels.

Compared to the rest of the chemical elements (described above), SO_4 compounds were present in very high concentrations in both dam sites during the rainy season, whereas small amounts were present in April, as shown in Figure 6. The Sulfate was discovered to be between 164 and 206 mg/l. The values were likely exceeded because some metals, such calcium sulfate or carbon dioxide, dissolve in the air and combine with rainwater as it falls. On the other hand, HCO_3 and NO_3 compounds were present in high concentrations in the dry season at both sites of the dam, compared to low concentrations in the rainy season, in contrast to the rest of the chemical compounds, which were present in abundance in the rainy season, as shown in Figures 7 and 8. Where high levels of HCO_3 and CO_3 were noticed in May and August, respectively while low levels of them were in December. in addition, CO_3 levels were below the detection limit in February. with regard to NO_3 compounds, data were below the detection limit in all months over the year, as shown in Table 1. Bicarbonate only exists dissolved in water. The bicarbonates in water react with soil's soluble calcium and magnesium to form insoluble calcium carbonate (limestone, $CaCO_3$) and magnesium carbonate (found in dolomitic limestone, MgCO3), which is what forms the white crust visible around irrigation emitters after water evaporates. This implies that the plants will have reduced access to soluble calcium and magnesium as a result, [17]. Calcium and bicarbonate can interact in the water to generate lime deposits, which can clog drip irrigation emitters. When the water's pH is higher than 7.5 and the bicarbonate concentration is above 120 ppm, blockage is most likely to occur. At higher temperatures, bicarbonate interacts with calcium to generate insoluble calcium carbonate more quickly. That explains why your hot water faucet develops a white crust more quickly than your cold-water faucet, [16].

4.Conclusion

In the present study, the water quality of 48 samples taken from different locations of Haditha dam during the winter and summer seasons was evaluated from the viewpoint of its suitability for drinking and irrigation. All obtained data were compared with the guidelines of the Iraqi standards of water quality to figure out whether they met these standards or not. For the calculation of water quality, 9 parameters were selected represented by K, Na, Mg, Ca, CL, SO4, HCO3, CO3, and NO3 for chemical analysis. Data analysis shows that all chemical elements met Iraqi standards for water quality and most concentrations were highly concentrated in the wet seasons at behind the dam. There was a relationship between different parameters of water as mentioned above and the quality of water. The rainy season reported the greatest average levels of K, Ca, Na, Mg, Cl, and SO4, while the dry season had the lowest average concentrations. However, the average levels of HCO3 and CO3 were highest during the dry season while they were lowest during the wet season. The planning and wise management of water resources, including their potential for use as irrigation and drinking water, can benefit from the findings of this study. The findings show that although river water cannot be used for agriculture, it is deemed unfit for drinking and human consumption.

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Use of Epiphytic Diatoms in Cyperus Papyrus L . As Bioindicators in the Assessment of the Health of the Upper Euphrates River Between the Haditha Dam and Al-Baghdadi, Iraq

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Abstract: The aim of this study is to use epiphytic diatoms in Cyperus papyrus L. plant as biological indicators for estimating the water quality of the upper Euphrates River between Haditha Dam and Al-Baghdadi . Biodiversity and biological indicators for water quality estimation , along with the Canadian Water Quality Index. The study showed that the water of the upper Euphrates River is warm, light alkaline , the electrical conductivity and the total dissolved soled of water affected by agricultural land water and human activities, turbidity, total hardness and the biological oxygen demand , chloride and sodium did not exceed the permissible limits, while the values of calcium, nitrate and phosphate exceeded the permissible limits. And that the calcium values have exceeded the magnesium values, and that the water in the river is well ventilated . We have identified 130 species of epiphytic diatoms in Cyperus papyrus L. plant , including 6 species (5%) belonging to the centrales diatoms and 124 species (95%) belonging to the pennales diatoms, and the highest total number of cells of the epiphytic diatoms was recorded as 1322.3 cells x 103 / gm in site I . The values of physical and chemical factors, ecological indices , and water quality index agreed that the water of the upper Euphrates River is of moderate pollution, medium biodiversity, mesotrophic , and homogeneous in the presence of species.

1. Introduction
Some species of epiphytic algae are a good guide for estimating the water quality of water bodies compared to phytoplankton, where epiphytic algae lead to the stability of the medium and the processing of food to the rest of the aquatic organisms being relatively stable in the aquatic ecosystems [1] , where benthic algae are an essential component of the food web [2] non-diatomaceous algae were employed by many researchers as bio-indicators for water quality estimation, but they were considered less efficient than diatomaceous algae as bio-indicators due to the great variation in their external forms , and it my need to be grown In the laboratory [2]. As for diatoms , they are good indicators for determining the health of aquatic systems, because they constitute the vast majority of the rest of the other parts of algae and are the main food source for most invertebrates and fish [3 , 4] . Diatoms are also a biological monitor of changes in water systems due to their presence in different environments, the ease of collecting their samples, their reproduction period is intermediate between bacteria and invertebrates, and they are sensitive to changes in water bodies and the degree of their pollution .
The purpose of the present study is to employ epiphytic diatoms at Cyperus papyrus L. Plant as biological indicators for estimating the water quality of the upper Euphrates River between Haditha Dam and Al-Baghdadi .

2. Material and Methods
2.1. Study area
Six sites were selected to sample the Euphrates River from the Haditha Dam to the Al-Baghdadi district in Anbar Governorate - western Iraq (Fig. 1) , during the period of November 2019 to July 2020.

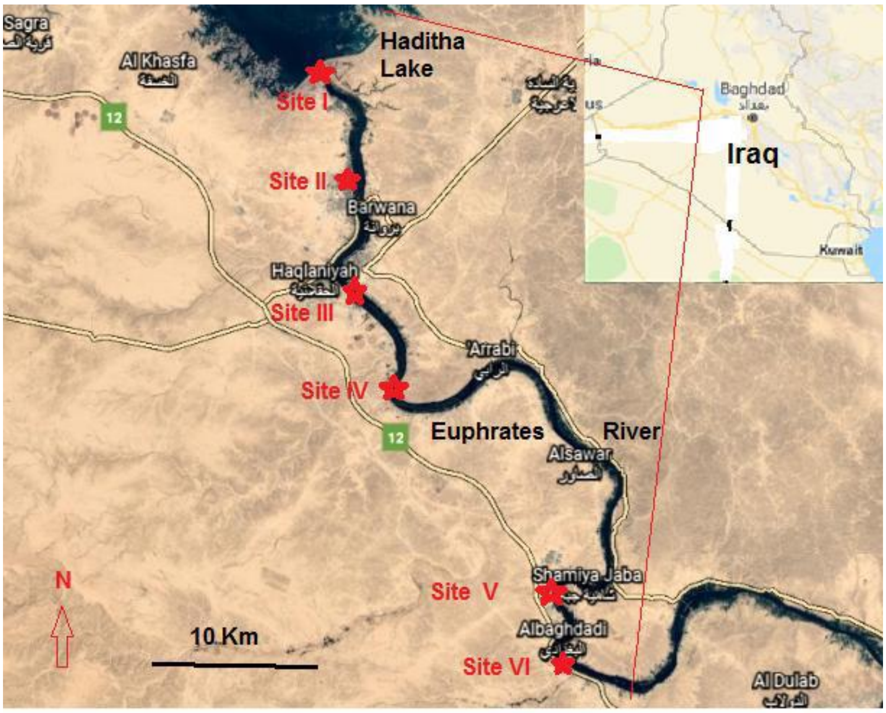

Figure 1. Map of Sampling Sites in the Upper Euphrates River Between the Haditha Dam and Al-Baghdadi

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The geographical coordinates for the sampling sites were determined in accordance with table (1) .

Table 1 . Geographic coordinates of sampling sites along the upper Euphrates River between the Haditha Dam and Al-Baghdadi.

Sites	Location	Longitudes (eastward)	Latitudes (northwards)
I	Haditha Dam	42° 21' 43"	34° 12' 10"
II	Haditha	42° 23' 20"	34° 07' 39'
III	Haklaniah	42° 22' 43'	34° 05' 13"
IV	Aaloos	42° 24' 03"	34° 01' 14"
V	JOOBA	42° 32' 03"	33° 54' 33"
VI	Al-Baghdadi	42° 31' 47"	33° 52' 16"

2.2. Physical & chemical parameters

Mercury thermometers were used to measure the temperature of water and air, an conductivity meter device to estimate the electrical conductivity (EC) of water, a digital portable pH meter device to measure the pH of water, and a turbidity meter device to estimate water turbidity. Dissolved oxygen (DO) , biological oxygen demand (BOD) and total dissolved solids (TDS) were measured according to [5] .The total hardness (TH) and ions of calcium (Ca) , magnesium (Mg) chloride (Cl) and Sodium (Na) were determined according to [6] , while phosphate (PO4) and nitrate (NO3) were estimated according to [7 , 8].

2.3 Epiphytic diatoms diversity

Epiphytic diatom samples for Cyperus papyrus L. were collected in accordance with the [6] . The species of diatoms were identified, clarification of their structures, and sediment removal from them, based on a group of references [10 , 11] , and the total count of algae cells was calculated according to Micro -transect method .

2.4 Ecological indicators

The Reference referred to in the table (2) was used for the implementation of the ecological indicators .

Table 2 . Ecological indicators performed in this study in the waters of the upper Euphrates River between the Haditha Dam and Al-Baghdadi.

Biodivesity Indices	Reference
Shannon Diversity Index	Shannon & Weaver [12]
Richness Index	Stiling [13]
Evenness Index	Neves et al., [14]
Bio-Indicators Indices	
Percente sensitive epecies (% ss)	Metzmeier [15]
Pollution Tolerance Index	Lang&Bertalot [16]
Trophic Diatomic Index	Kelly & Whitton [17]
Water Quality Index	
CCME-WQI	CCME [18]

3. Results and Discussion

3.1 Physical & Chemical Parameters

A selection of physical and chemical parameters were conducted at the sites of the current study, shown in Table (3), where the water temperature revealed the highest rate of 25 C° in sites I and II, and the lowest rate recorded in site VI of about 18.7 C°, as the water the Euphrates River is affected by the factors surrounding it, such as the rise and fall in temperatures and thermal pollutants, so the waters of the Euphrates River are considered warm [19] . The pH values showed no significant local variation , because the lowest mean was 7.5 at site I and the highest mean was 7.8 at site II . The reason for the slight variations in the sites of the current study may be attributed to the Euphrates River having a high buffer capacity and a light alkalinity [20] . The values of the EC showed clear site variations, where the lowest rate of 639 µ.S / cm was recorded in site VI and the highest rate of 1127 µ.S / cm recorded in site III . The high conductivity values for site III (Al-Haqlaniya) may have been affected by the water from that site with agricultural land residues and sewage and human activities.

Turbidity values exceeded the permissible limits in all sites [18] , as their values showed a significant local variation, as the lowest levels were recorded at 7.8 NTU at site III, while the highest levels were 10.7 NTU at site II. The high turbidity values in Site II (Haditha) may be attributed to the influence of this site by the flowing water and its turbulence from the gates of Haditha Lake Dam [19] . TDS values were greater than allowable values for aquatic organisms [18] , where the lowest rate was recorded at 494 mg / l in site I, while the highest rate was recorded at 737 mg / l in site III, as this site was affected by agricultural lands, sewage water and human activities [21] . The TH values did not exceed the limits allowed locally and globally, as the lowest rate was recorded at 248 mg $CaCO_3$ / l in site I, while the highest rate was recorded at 361 mg $CaCO_3$ / l , in site III , as this site is affected by the residues of agricultural lands, sewage water and human activities [22] . The mean values of Ca showed that they exceeded the permissible limits [23] and were higher than the mean values of Mg in all sites, where the highest mean of Ca and Mg 76.3 & 35.5 mg / l in site III was recorded, respectively. Ca concentrations prevail over Mg , due to the wastewater laden with organic matter that releases CO_2 gas, as it interacts with Ca more than , which leads to the formation of $CaCO_3$ in the water, which shows high concentrations of Ca [21] .

DO rates did not show any local variation in their rates, as the highest rate was recorded at 10.3 mg/ l in site IV and VI , and no critical values for DO concentrations were recorded, so the upper Euphrates waters are considered to be well aerated [24] . While the permissible values for the BOD concentrations exceeded limits 6.33 & 7.35 mg / l in sites I and VI, respectively, so the water of the upper Euphrates River is considered to be of questionable purity [23] . The averages of Cl and Na concentrations varied between the sites, where the highest rate of chloride was recorded at 99.5 mg / L in Site III, while the highest rate of Na was recorded at 69.5 mg / L in Site II, and its values did not exceed the permissible limits [18] . The decline in Cl and Na ion values can be attributed to the reduction of water discharge from Haditha Lake [25] .

The values of plant nutrients exceeded the permissible limits [18] , and varied locally in their values, as the highest average NO3 values were recorded at 80.0 mg / L in site VI, and this may be attributed to the availability of DO , which leads to the oxidation of NO2 into NO3 due to the increase in the density of phytoplankton, which photosynthesis [26] and the highest record rate of phosphate 0.22 mg / l in site III, and this may be attributed to the excretion of residues containing a large amount of PO4 by the waste of agricultural lands and sewage water containing drains [22].

Table 3 . The physical and chemical parameters measured in the this study of the upper waters of the Euphrates River from the Haditha Dam to Al-Baghdadi .

Parameters	Site I	Site II	Site III	Site IV	Site V	Site VI
Water Temperature (	15-38	14-37	16-35	17-35	17-33	13-22
C°)	25± 9.9	25.3± 9.4	23.5±8.1	23.7±7.8	23.5±6.8	18.7±4.9
pH	7.3-7.6	7.5-7.7	7.6-8.1	7.4-7.7	7.3-7.9	7.6-7.9
	7.5 ± 1.5	7.6± 0.08	7.8±0.22	7.6±0.12	7.6±0.25	7.7±0.15
Electrical Conductivity	1110-543	600-1436	762-1519	675-1519	577-1720	582-670
(µ.s./cm)	731±256	871±383	1127±331	843±259	914±539	639±40
Turbidity (NTU)	0.5-24.0	0.5-37.4	1.0-23.6	2.0-28.4	0.5-29.5	1.2-28.2
	8.9±10.4	10.7±17.9	7.8±10.6	8.7±13.2	9.1±13.7	8.4±13.2
Total Dissolved Soled	398-630	432-774	554-1070	446-555	410-1411	418-581
(mg/l)	464±111	599±177	737±231	493±49.3	701±475	483±69.7
Total Hardness	200-340	252-369	300-460	247-355	240-381	240-381
(mgCaCO3/l)	248±62.8	288±54.7	361±75.4	278±51.6	283±66.8	283±66.3
Ca (mg/l)	42-84	52-66	64-100	52-62	48-76	48-66
	56.3±16.4	59.8±5.8	76.3±16.3	56.5±5.3	62.3±11.5	58±7.5
Mg (mg/l)	23-31	24-33	29-50	22-33	21-30	24-29
	27±3.37	29.3±3.86	35.5±9.75	28.8±4.79	26.5±4.0	27.8±2.5
O2 (mg/l)	5.4-11.9	8.5-10.3	7.8-10	8.2-14.0	8.1-10.1	8.8-12.4
	8.7±2.69	9.5±0.74	9.2±0.99	10.3±2.60	9.6±1.0	10.3±1.8
BOD (mg/l)	5-10	2.6-6.0	1.2-9.1	1.0-8.2	2.0±10.0	3.0-11.2
	7.35±2.52	4.88±1.58	4.33±3.39	3.40±3.31	4.10±4.0	6.33±3.7
Cl (mg/l)	49-97	56-86	20-220	23-82	21-79	20-78
	65.3±22.4	70±13.2	99.5±85.3	59.8±25.7	54.8±24.3	54.3±24.6
Na (mg/l)	25-77	20-132	25-74	27-71	21-141	11-141
	52.8±21.5	69.5±46.3	56.0±21.7	53.3±18.6	61.8±55.5	60.3±57.7
NO3 (mg/l)	10-89	17-92	11-96	13-134	16-144	15-150
	55.3±37.9	50.5±34.8	46.8±40.6	57.8±54.7	63.5±60.5	80.0±73.5
PO4 (mg/l)	0.14-0.17	0.15-0.19	0.14-0.37	0.15-0.20	0.10-0.17	0.13-0.34
	0.16±0.16	0.17±0.02	0.22±0.10	0.17±0.02	0.14±0.03	0.19±0.09

3.2 Qualitative & quantitative study of epiphytic algae

In the current study, 130 species of epiphytic diatoms on Cyperus papyrus L plants were identified (table 4), 6 species (5%) belong to the central s diatoms order, and 124 species (95%) were identified from the pennales diatoms order (fig 2.).

Table 4 . Density and presence of epiphytic algae species on Cyperus papyrus L . at sampling sites in the upper Euphrates River between the Haditha Dam and Al-Baghdadi .

Taxa	Site I	Site II	Site III	Site IV	Site V	Site VI
BACLLARIOPHYCEAE						
CENTRALES						
Aulacoseira granulate Ehr Ralf	+++	+++	+++	++	++	+++
A.italica Her.	+	+++	+	+	+	++
A.varians Agardh	+++	++	++	+++	+++	+
Cyclotell abodanica Aulenst	+	-	+	-	+	+
C.comtaEhr Kuetzing	+	-	-	-	+	-
C.meneghiniana Keutzing	+++	++	++	+	+	+
PENNALES						

Achnanthes affinis Grunow	+	-	-	-	+	-
A.brevipes Agardh	+	+	+++	+	+	+
A.flexella Kutz	+	+	+	+	+	+
Amphora normannii Rab.	-	-	-	+	-	+
A.ovalis Ktz. Kuetz.	+++	+++	++	+++	+	+
A.pediculus Kuetz.	+++	+	+	+	++	++
A.veneta Kuetz.	++	+	+	+	+	+
Baciiaria paxillifer Muell Hendey	+++	+++	+	++	+	++
Caloneis amphisbaena Bory Cleve	++	++	+	+++	+	+
C.bacillum Grun. Cleve	-	+	-	+	+	+
C.permagna Bail. Cleve	++	+	+	+	+	+
C.silicula Her. cleve	++	-	+	-	+	-
Cocconies disculus Schumann Cleve	+++	+++	+	++	++	++
C.pediculus Ehernberg	+++	+++	+++	++	++	+++
C.plancentula Ehrenberg	++	+	+	+	+	++
C.plancentula var. euglypta Her. Cleve	++	+	++	+++	++	+
C.plancentula var. lineata Her Cleve	++	+++	+++	+++	+	+++
Cymatopleura elliptica Breb W.Smith	+	+	+	+	+	+
C.solea Breb. W. Smith	++	++	+	+	+	+
C. solea var. varlaire Breb. W. Smith	+	-	+	+	-	+
Cymbella affine Kuezing	+	+	+	+	+	-
C.aspera Her. H.Paragaillo	+++	++	++	-	++	++
C.angustata W.Smith	+	-	-	-	-	+
C.amphaicephala Naegeii	-	-	-	-	-	+
C.abtusiuscul W.Smith	-	-	-	+	+	+
C.cesatii Rabenhorst Grun	+	+	+	+	-	+
C. cistula HER Kirchn	+	++	+	+	+	-
C.cymbiformis Ktz. van Heruck	+++	+++	+	+	+	+
C.gracillis Rabenhorst Cleve	++	+	+	+	+	+
C.helvetica Kuetizing	++	++	+	+	+	++
C.lanceolata Her.	+++	+	+	+++	-	-
C.leptoceros Her. Grunow	++	++	+	+	+	+
C.prostrate Hrek Cleve	+	+	++	+	-	+
C.parva W. Smith	+	+	-	-	-	+
C.tumida Breb van	+++	+++	+++	+++	++	++
C.ventricosa Kuetzing	+++	++	++	+++	+++	++
Diatoma elongatum Lungb Agardh	+	+	++	-	+	+
D.tenuse Agardh	+	-	++	+++	+	+
D.tenuse var. elongatum Lyngbya	+++	+	-	+++	-	-
D.vulgare Bory	++	++	++	+++	-	-
Diploneis ovalis Hills Cleve	+	+	+	-	-	-
Epithemia smithii Carruthers	+	-	-	-	+	-
Eunotia monodon Ehrenber	+	+	-	-	-	-
Fragillaria capuncina Desmazier	+	+	++	+	+	+
F.critonesis Kitton	+++	+++	+++	+++	++	++
F. intermedia Grunow	+	-	+	+	-	+
F.pulchella Ralfs Kutzing	++	+	-	+	+	-
F.vaucheriae Ktz. Bory	+	+	+	+	+	-
Gomphoneis olivaceum Horne P.Dawson	++	+	++	+	+	-
Gomphonema acuminatum Ehrenbe	+	-	-	-	+	+
G.angustatum Ktz. Rabenho	+	-	+	-	-	-
G.constrictum Ehrenberg	+++	+++	++	+++	+++	++
G.constrictum var. capitatata Her. Grunow	+	+	++	+++	+	+
G..fanesis Mailard	+	-	-	+	+	+

G.gracilis var. lanceolate Kutz	+	+	+	+	+	+
G.intricatum Kuetzing	+	++	++	++	+	+
G.olivaceum Langby	+	+	++	+++	+	++
G.parvulum Ktz. Kuetzing	+	+	+	-	+	-
G.turris Ehrenberg	-	+	-	+	+	+
Gomphonitzschia ungeri Grnow	+	+	-	-	-	+
Gyrosigma acuminatum Ktz. Rabenhorst	+	+	+	+	+	-
G.attenuatum Ktz. Rabenhorst	+	+	+	+	+	-
G.distortum W.Smith	-	-	+	-	+	+
G.nodiferum Grun Reim	+	+	+	+	+	+
G.scalproides Rabenhorst Cleve	+	++	-	-	-	+
G.tenuirostrum Grun Cleve	-	-	+	+	+	-
Hantzschia amphoixys var. major Grun	+	+	+	-	+	-
'Meridion cicular Agardh	+++	++	+	+	+	+++
Navicula atmus Ktz. Grun	+	++	+	+	+	-
N.capitata Her.	+	+	+	-	+	-
N.cryptocephala Kuetzing	+	+	+	+	-	+
N.crucicula W.Smith	-	+	+	+	-	+
N.gracillis Her.	+	+	+	+	+	-
N.faoensis Grun	-	+	+	-	-	-
N.imbricata Block	+	+	-	-	+	+
N.lanceolata Ag. Kuetzing	+	+	+	+	-	+
N.radiosa Kuetzing	++	++	+	+	+	+
N.rhycocephala Kuezing	+	+	+	+	-	-
N.sallnarum Grunow	+	+	+	-	+	+
N.symmetrica Pat.	+	+	+	+	+	+
N.tripuncatata O.F.Muell Bory	+	+	+	-	+	+
Neidium binode Her.	+	-	-	-	-	-
N.dubim Her.	-	+	+	+	-	-
Nitizschia dissipata Kutzing	+	+	-	+	+	+
N.fonticola Grunow	+	+	+	+	+	-
N.frustulum Ktz. Grun	+	+	+	+	-	+
N.hungaricca Grunow	+	+	+	+	+	+
N.hybrida Grunow	+	-	-	-	-	-
N.linearis W.smith	++	++	+	++	+	+
N.lanceolata Ag. Kuezing	+	+	-	+	-	+
N.obotusa W.smith	+++	+++	+	+	+	++
N.palea Ktz. W.Smith	+++	++	-	+	++	+
N.romana Groun	+	++	+	+	+	+
N.sigma Ktz.	++	+	-	+	-	+
N. sigmoidea Her. W.smith	+	+	+	+	+	+
Peronia intermedium Comber	++	++	++	++	+	+
Pinnularia borealis Ehrenber	+	+	+	-	+	+
P.cuneata Gruon	-	-	+	-	-	-
P.lata Breb. W.Smith	-	-	-	+	-	+
P.subcapitata var. hilseana Jan O. Mull	+	+	-	+	+	-
P.major Ktz. W.Smith	+	-	+	-	+	-
Plerosigma angulatum Quek W.Smith	+	+	+	+	+	+
P.salinarum Grun	+	+	-	-	-	-
Rhicosphenia curvata Ktz. Grunow	+	+	++	++	+++	+++
Rhophalodia gibbia Her. O.Mueller	+	+	+	+	+	+
R.gibberula Her. O. Mueller	+	-	+	+	-	+
Surirella ovalis de. Brebisson	+	+	+	+	+	+
S.robusta Her.	+	-	+	+	+	-
Stauroneis fluminea Patr .Freese	+	+	+	+	+	+

S. wislouchii Angsowa	+	+	+	+	-	+
Synedra acus Kuetzing	+	+	+	-	-	-
S.amphacephala Kuetzing	+	+	+	+	-	-
S.capitata Ehrenberg	++	+	-	-	+	+
S.dicatissima Her.	++	+	+	+	-	+
S.formosa Hantzsch ex Raben	+	-	-	+	-	-
S.fillformis var. exills Cleve	++	+	+	-	-	+
S.fasciculata Ag. Ktz.	++	+	-	++	+	+
S.pulchella Ralfs	+++	++	+	++	++	+
S.rumpens Kg.	+	+	+	+	+	-
S.ulna Nitzs. Ehrenberg	++	++	++	+++	++	++
S.ulna var. subaequalis Grun	+++	++	+	+	+	+
S.ulna var spthulifera Grunow	++	+	+	-	+	+
Tabellaria fenenstrata Lyng Kutzing	+	+	+	-	-	-

Notes : (+ < 10 Cell x 103/gm) (++ 10- 20 Cell x 103/gm) (+++ > 20 Cell x 103/gm)(- Unregistered)

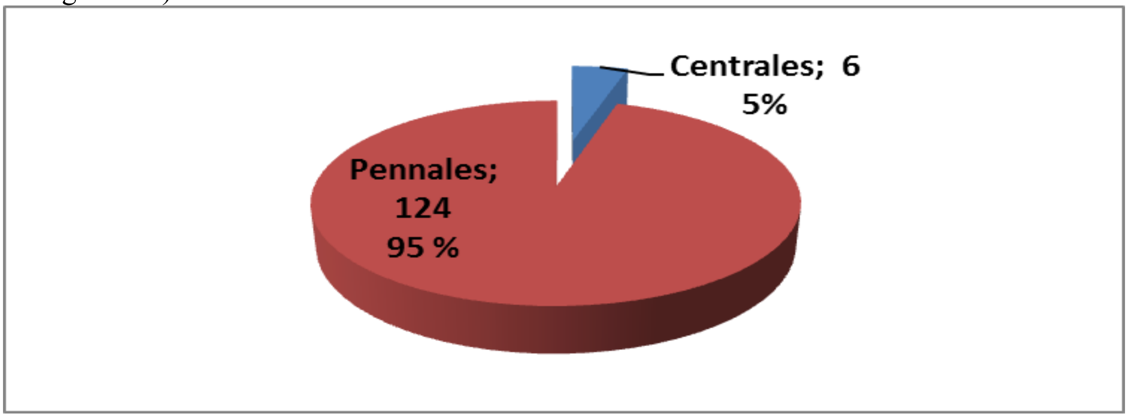

Figure 2 . The number of spices of epiphytic diatoms on Cyperus papyrus L. and percentage values at all study sites.

Table 5 . Number of genera (G.) and species (sp.) identified at the current study site.

Sites	Centrales		Pennales	
	G.	Sp.	G.	Sp.
I Haditha Dam	2	6	30	112
II Haditha	2	4	30	103
III Haklaniah	2	5	27	93
IV Aaloos	2	4	23	89
V JOOBA	2	6	25	88
VI Al-Baghdadi	2	5	23	86

Several studies have found that epiphytic algae on aquatic plants provide a clear indication of external influences in the water and assess its quality more than floating algae [27] . The registration, quality, and quantity of pennales diatoms are higher than centrals diatoms is a case recorded in many local and international studies because the environment and presence of most pennales diatoms are in fresh water, while most of the centrals diatoms are found in seas and oceans [28] .
The greatest total number of of pennales diatoms cells on Cyperus papyrus L. for both orders was recorded in site I , where the number of cells of pennales diatoms was recorded with borders 1322.3 cell x 103 / gm while the number of cells of centrals diatoms was recorded 148.3 cell x 103 / gm (fig. 3) . Possibly the strong density of epiphytic diatoms on Cyperus papyrus L. at Site I (Haditha Dam) may be attributed to the abundance and movement of water coming from the gates of the dam to Haditha Lake as well as the levels of dissolved oxygen, which in turn encourages the growth of algae [19] .

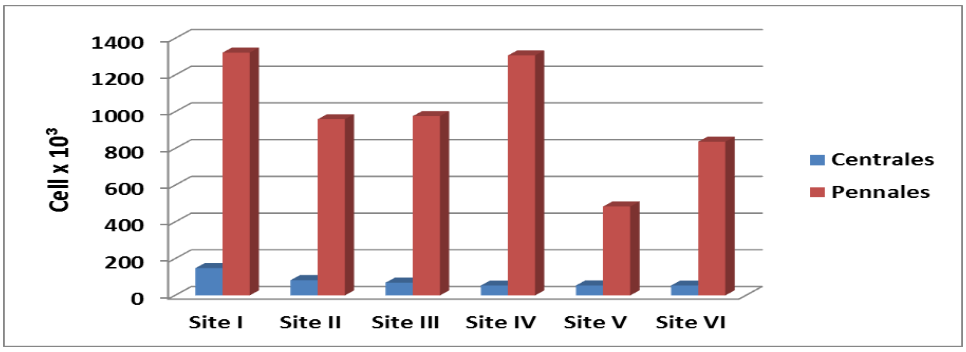

Figure 3 .Total number of epiphytic diatom cells on Cyperus papyrus L. to sampling sites in the upper Euphrates River between the Haditha Dam and Al-Baghdadi .

3.3 Ecological indicators
3.3.1. Biodiversity indices
3.3.1.1. Shannon's index (H). The Shannon's index values showed a variation in their values between sites, as their values did not exceed 2.0 Therefore, the waters of the upper Euphrates River are considered to be of lees diversity and moderate pollution [29] (Table 6) , as the highest values were recorded at 1.52 in site I and the lowest values 0.84 in site III (Fig. 4) . Low biodiversity values for epiphytic diatoms of Cyperus papyrus L plant. plants It may be attributed to the nature of the external shape of the smooth stems of the plant, which reduces the adhesion process of diatoms, as well as the basic properties of water, the amount of light and nutrients, which leads to an effect on the amount of emergence of species [30] .

Table 6. Shannon Index values for epiphytic diatoms on Cyperus papyrus L plant and their relationship to water pollution status [29]

Shannon Diversity Index	Diversit Level	Pollution Level
0.0 – 1.0	Very Less	Heavy
1.0 – 2.0	Lees	Moderate
2.0 – 3.0	Moderate	Light
3.0 – 4.0	High	Slight

3.3.1.2. Richness Index (RI). The values of the Richness index varied among the sites, as the highest value was 16.04 in site I and the lowest value was 9.70 in site IV (Fig, 4) . Recording the highest values of the RI in this site I is consistent with the highest number of species identified in this site (Table 5), the plant shape, metabolic activity and host aquatic plant density affect the diversity of algae species attached to plants [31] . The mean values from current study sites refer to the RI (13.0), hence the epiphytic diatoms at Cyperus papyrus L. plant are described as moderate biodiversity (Table 7) [13] .

3.3.1.3. Evenness Index (EI). The values of the Evenness index showed that there was no net change in their localization differences (Fig . 4) . The decrease in the results of the EI indicated the dominance of a certain species over the rest of the other species, or the dominance of a few species with high density, and this indicates the nature of conditions that are not suitable for the presence of all spices of algae. Higher than 5. 0 indicates that there is no stress or environmental pressure on the species, which means that they are seemingly equal [32] . The mean values for the current study sites refer to the EI (0.6), hence the epiphytic diatoms to the Cyperus papyrus L. are described as homogeneous in appearance (Table 7) [33] .

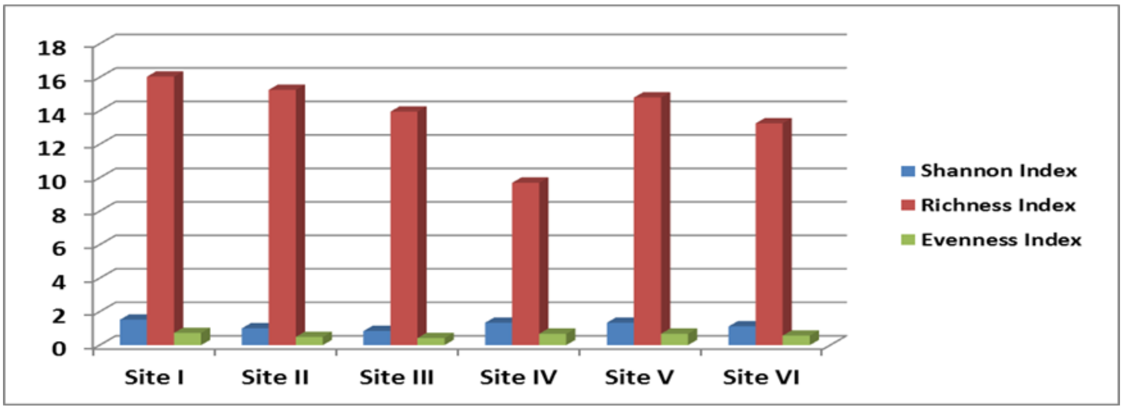

Figure 4 . Local variations of biodiversity indices values during the current study period.

3.3.2 BioIndicators Indices.

3.3.2.1 Percentage sensitive species (% ss) . The mean values of the percentage sensitive spices did not show a significant variation in their site variations, as the highest rate was recorded at 6.95 in site II, while the lowest rate was recorded at 0.36 in site III (Fig. 5) . Site II is (Haditha) affected by the waters of Haditha Lake, which is reflected in recording the highest values for ss % , in contrast to Site III affected by the water of agricultural lands, sewage water and other human activities, which recorded the lowest values of ss % . Based on ss % results , Upper Euphrates water is considered moderately contaminated (Table 7). The increase and decrease in the percentage values ss % values for sensitive and pollution-resistant diatom species coincides with the change in water quality [25] .

3.3.2.2 Pollution Tolerance Index (PTI). PTI values were compared across sites for the present study (Fig. 5), where the values were recorded as an average 2.88 of PTI , and according to the results of PTI in the current study, so the water of the upper Euphrates River is considered to be moderately polluted [16] (Table 7). A number of medium- tolerant species have been diagnosed in this study, namely: Cyclotella abodanica , cocconies plancentula , meridian cicular , Navicula cryptocephala , Nitizschia dissipata , N. frutulum and N. linearis .[34]

3.3.2.3.Trophic Diatomic Index (TDI). The values of the TDI converged at all the sites of this study, with a mean of 51.41 (Fig. 5). Therefore, the waters of the upper Euphrates River are considered to be of Mesotrophic and moderate pollution (Table 7) , as Kelly & Whitton [17] indicated that the water bodies Eutrophic are considered to be highly polluted, while The water bodies are Oligotrophic with low pollution. A number of indicative mesotrophic water spices have been identified in this study, namely: Achnanthes affinis , A. brevipes , A. flexella , Caloneis bacillum , C. permagana , C. silicula , C. placentula , Fragillaria vaucheriae and Synedra ulna .[17]

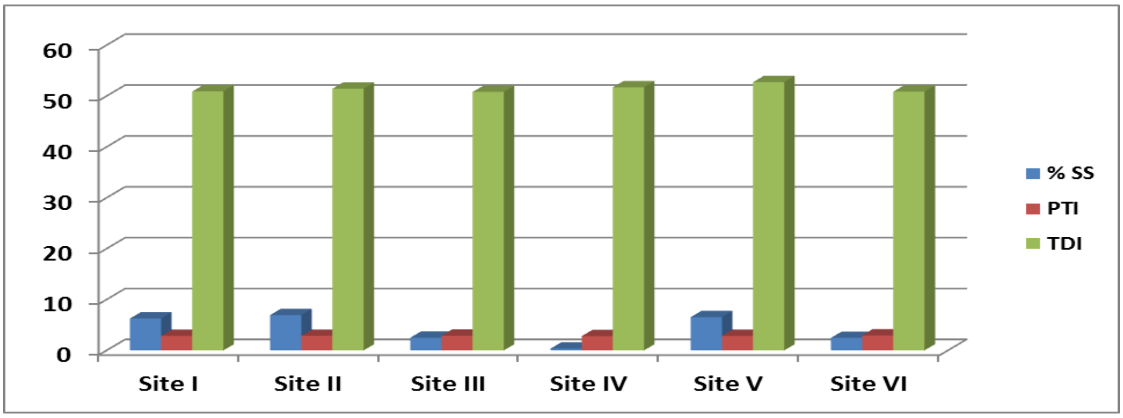

Figure 5 . Local changes in the values of the bio – indicators indices over the current study period.

3.3.3 Canadian Water Quality Index j (CCWE).The values of the CCWE did not show a significant locational variation, as the highest values were recorded at 84.76 in site IV , while the lowest values were recorded at 77.09 in site III affected by agricultural land residues and human activities (fig. 6). The results of this study, show that water quality in the upper Euphrates River is ranked as of fair [18] (table 7).

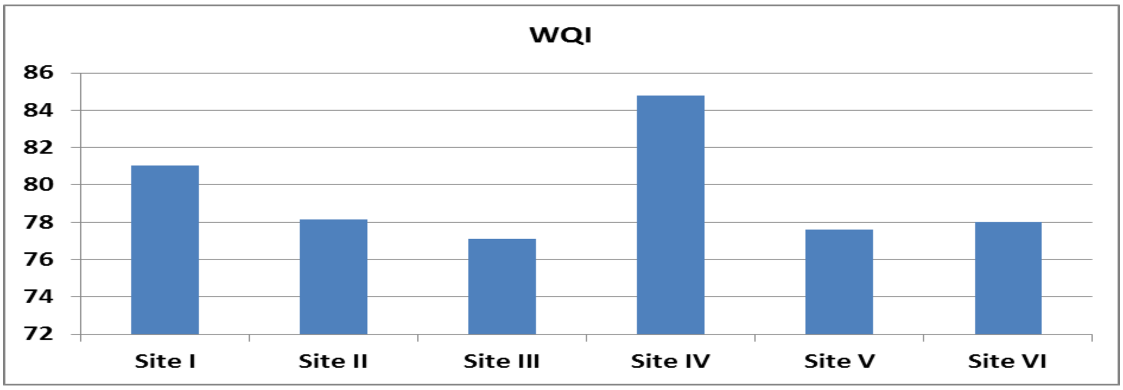

Figure 6. The Canadian Water Quality Index was assessed in the waters of the upper Euphrates River between the Haditha Dam and Al-Baghdadi for the current study period.

Table 7 . Ecological Indices values measured during the current study period .

Biodivesity Indices	Site I	Site II	Site III	Site IV	Site V	Site VI	Mean	Diversity type
Shannon Diversity Index	1.52	1.00	0.84	1.34	1.34	1.12	1.20	lees Biodiversity
Richness Index	16.04	15.25	13.95	9.70	14.79	13.25	13.83	Medium to lees Biodiversity
Evenness Index	0.73	0.49	0.42	0.68	0.68	0.57	0.60	Homogene-ous species
Bio-Indicators Indices								Pollution Degree
Percente sensitive epecies (% ss)	6.27	6.95	2.51	0.36	6.55	2.48	4.18	Moderat polluted Water
Pollution Tolerance Index	2.84	2.88	2.90	2.81	2.86	2.96	2.88	Moderat polluted Water
Trophic Diatomic Index	50.90	51.44	50.81	51.72	52.73	50.86	51.41	Moderat polluted Water
Water Quality Index								Water Qualit
CCME-WQI	81.05	78.16	77.09	84.76	77.61	78.03	78.58	Fair

4. Conclusion

Based on the results of the present study, the epiphytic algae on Cyperus papyrus L. plant is a good biological indicators in describing the state of the water quality of the upper Euphrates River, where the results of the physical and chemical factors agree with the results of the ecological indicators , as well as their compatibility with the Canadian water quality index. River water has been characterized as moderately polluted, medium to low in biodiversity, and fair water quality.

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Effect of Application Different Combinations of Phosphogypsum and Humic Acids Mixed With Saline Irrigation Water on Broccoli Yield and NPK Concentration

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Abstract. Long-term irrigation with saline water causes detrimental effects on the soil-crop system. The study aimed to determine the best combination of Phosphogypsum and humic acid can mitigate the negative effects of saline water irrigation on broccoli growth. Therefore, two-factorial field experiment was conducted according to a randomized complete block design with three replications during autumn season of 2021 in Fallujah district /Anbar governorate in sandy loam soil. The first factor included three levels of saline water irrigation, namely 2.5, 5.0 and 7.0 dS.m-1. while the second factor involved three levels of humic acids i.e., 0.0, 0.25 and 0.50 g/l mixed with three levels of phosphogypsum that is 0.0, 0.25 and 0.50 g/l. Fruits weight, height, yield, plant nitrogen content, plant phosphorus, and plant potassium content were measured. The results showed that the combinations under study (humic acids and phosphogypsum) had a crucial role in reducing the negative effects of irrigation salinity. Moreover, the macronutrients availability increased with increasing humic acids concentration in irrigation water. The observed results show a significant increase in the weight of broccoli fruit and yield at T8 by giving 325 g. plant-1and 8.66 t.h-1 respectively under effect of the combination under study. Also, the studied combinations led to increase the N,P,and K concentration in plant tissues. Where the highest observed averages of nitrogen and potassium were 3.96% and 2.56% at T8 treatment. While The highest concentration of phosphorus was observed at treatment T9 reached 0.47%.

1. Introduction

Sufficient water supply is crucial for sustainable human development. However, unpredictability surrounding future climate changes are activating disquiet regarding already exhausted freshwater resources [1]. The global demand for freshwater is rising at a rate of 1 % yearly, driven by population growth along with increasing consumption patterns[2]. However, the continued expansion of irrigated agriculture and other water-intensive industries has caused the reduction of freshwater resources in parallel with water pollution [3]. In 2030, the Agenda for sustainable development emphasizes water as an indispensable element in achieving the sustainable development goals[4]. Globally, agricultural irrigation consumes70% of the freshwater [5]. However, the rapid increase of population, fast industrial growth has coincided with decline in available freshwater available for agriculture [6], making the water scarcity as a prominent problem, limiting the sustainability of agriculture sector. To mitigate such problem, many countries attempted to exploit saline water in irrigated agriculture [9].Being that irrigation water is indispensable for crop production, it is important to find alternatives to freshwater that are available for irrigation [7]. Saline water is a source of water with poor quality[8] . Using saline water irrigation can mitigate the scarcity of agricultural freshwater resources, particularly in arid areas [9]. Nevertheless, long term irrigation with saline water often causes adverse effects on the soil-crop system. Accordingly, the choose of acceptable saline water management is the intrinsic challenge to improve crop production. Waste materials recycling is the most effective solutions to conserve natural resources as low cost-effective disposal option. Phosphogypsum is the main by-product in the production of phosphate fertilizers industry. Every year, from 200 to 300 metric ton of Phosphogypsum is produced worldwide [10]. Both Phosphogypsum and gypsum are calcium sulfate dehydrate [10]. The name of Phosphogypsum is a solid by-product generated of wet-process phosphoric acid production. The calcium sulfate dehydrates ($CaSO_4.2H_2O$), form more than 90% of Phosphogypsum [11]. Recent studies, pointed that Phosphogypsum application promoting the exchange of calcium and sodium due to its high content of calcium [12]. Consequently, improving the soil physical and chemical properties. Humic acid (HA) is a primary component of humic substances, making up over 60% of the soil organic matter [13]. HA can enhance the soil physical and chemical properties and ameliorate plant metabolic processes [14]. Furthermore, promoting the plant tolerance to diverse environmental stresses [15]. Broccoli (Brassica oleracea), is considered as one of the important vegetables provides health benefits comprising of high concentrations of various nutritive, broccoli has a good advantage as fighting cancer food because it contains great amounts of antioxidants and fiber. Little information is available about the interaction between Phosphogypsum and humic acid. Therefore, the aim of this study was to determine the best combination of Phosphogypsum and humic acid to reduce the adverse effect of water irrigation salinity on broccoli growth.

2. Materials and Methods

2.1. Study Site Description and selected measurements

A field experiment was carried out during autumn season of 2021-2022 in Fallujah district/Anbar governorate in sandy loam soil from 15/10/2021 to 5/2/2022. The soil under study was classified under the subgroup as Typic Torrifluvents according to USDA Soil Taxonomy (Burt et.el., 2014), soil samples were randomly collected up to 0-30 cm depth using soil auger and thoroughly mixed to form representative soil sample. The representative sample was air-dried and preserved in plastic bag and thereafter, transferred to the laboratory, crushed to pass through 2mm sieve to determine the selected soil chemical and physical properties according to the methods described by [17]. In the present study, pH and EC were determined from the 1:5 soil-water suspensions by using a pH and EC meter respectively. The soil organic matter (SOM) was determined according to the acid extraction method according to [18]. While the total nitrogen was determined using the Kjeldahl method. Olsen method was used to determine the available Phosphor. The exchangeable bases were measured by atomic absorption spectrophotometry for Ca and Mg while flame photometer was used to measure Na and K. The sulfates were estimated by precipitation with barium chloride and arabic gum and measured by a color spectrophotometer, and the chlorides were estimated in the extract using the colorimetric method. The dissolved carbonates were estimated in the soil extract using the colorimetric method using the Autoanalyser method. Core samplers (5x5 cm height and diameter) were used to collect undisturbed soil samples for bulk density determination. Hydrometer method was used to determine percentages of sand, silt clay (soil texture). The measured physical and chemical properties for soil, irrigation water and phosphogypsum under study were documented in (Table 1).

Table 1. Some properties of soil, irrigation water and phosphogypsum

Parameter	Soil	irrigation water			phosphogypsum	Unit
		S1	S2	S3		
pH	8.1	7.9	7.72	7.68	5.8	
SAR	1.5	1.93	2.57	4.12		
EC	1.8	2.5	5	7	3.8	dS.m-1
Organic matter	2.72					gm.kg -1
Lime (CaCO3)	217					gm. kg-1
Ca+2	10.55	11.15	14.2	19.11	63.16	
Mg+2	5.8	6	8.32	10.7	12.10	
Na+1	6.15	8	12.22	22.5	0.50	
K+	0.62	0.15	0.28	0.39	2.20	mmol.l-1
SO4-2	1.5	5.1	8.4	12.1		
HCO-3	1.1	1.18	1.5	1.9		
Cl-1	10.8	17.2	19	20.32		
Nitrogen (N)	70.5					
Phosphorous (P)	32					mg.kg -1
Potassium (K)	109.5					
Soil Bulk Density	1.32					Mg.m-3
Soil Particles	Sand					
	Silt					g.kg -1
	Clay					
Texture Soil	Sandy loam					

pH is soil reaction; EC is soil electrical conductivity; SAR is sodium adsorption ratio

2.2. Experimental Design and Study Treatments

Two-factorial experiment was conducted according to a randomized complete block design with three replications. The first factor consisting of three levels of saline water irrigation, namely 2.5, 5.0 and 7.0 dS.m^{-1} taking the symbols of S_1, S_2 and S_3 respectively. While the second factor included a combination of three levels of humic acids i.e., 0.0, 0.25 and 0.50 g/l taking the symbols of H_0, H_1 and H_2 and three levels of phosphogypsum that is 0.0, 0.25 and 0.50 g/l taking the symbols of PG0, PG_1 and PG_2 respectively. The humic acids under study were purchased from the local market in the form of a powder (country of origin: spain), it is completely soluble in water (100% soluble in water) and composed of 68% humic acid, 17% fulvic acid and 12% K_2O. The combinations of phosphogypsum and humic acids were applied mixing with saline irrigation water as the following H_0PG_0, H_0PG_1, H_0PG_2, H_1PG_0, H_1PG_1, H_1PG_2, H_2PG_0, H_2PG_1, H_2PG_2. taking the symbols of T_1 to T_9 respectively.

2.3. Field preparation and plant measurements

Before planting soil services operations such as ploughing, disc harrowing and levelling were performed as field preparation. Drip irrigation system was installed and evaluated in the field before planting according to the distribution uniformity of 95% and the percentage of variation of 5%. The broccoli was cultivated as rows on raised bed system, the row length was 3 meter, the distance between the adjacent plant within a row was 0.50 meter. While the distance between the adjacent row was 0.75 meter, with plant density of 26.666 plant per hectare. Irrigation was conducted at 35%

depletion of available water content according to evaporation pan class A. GR emitters with discharge of 8 l/h was used. The adopted fertilizer recommendation was 92 kg N h^{-1}, 200 kg P2O5 h^{-1}, 150 kg K2O h^{-1} according to[19] at the end of the study, the crops were harvested. Data concerning plant height (cm), yield per plant (g $plant^{-1}$) and productivity (t/h) were measured. The fruits were taken, air dried, then in the oven at a temperature of 65 °C, and chemically digested according to [20]. The total nitrogen was estimated according to the Kjeldahl method, phosphorus was estimated using a spectrophotometer, and potassium was determined using the Flame Photometer. The salinity levels of the irrigation water were prepared by mixing the river water with the agricultural drainage water. The bellow equation was used to calculate the mixing ratios required for each level of irrigation water salinity used in the experiment[21]. The obtained results were statistically analyzed using Gen Stat software, and the averages were compared using the least significant difference test L.S.D at the probability level of 0.05.

$$\boldsymbol{EC_i = [EC_a\ x\ a] + [EC_{b\ (1-a)}]}$$

EC_i is electrical conductivity of the required irrigation water ($dS.m^{-1}$); EC_a is electrical conductivity of river water ($dS.m^{-1}$); a is percentage of river water in the mixture; $EC_b$is electrical conductivity of drainage water ($dS.m^{-1}$).

3. Results and Discussion

3.1. Effect of combinations under study on fruits weight

The data regarding the effect of the salinity of the irrigation water and the combinations of phosphogypsum and humic acids on the broccoli fruits weight are presented in Table 2. The obtained results show a significant reduction (at $P<0.05$) in the average of broccoli fruit weight with increasing salinity levels of irrigation water. In this direction, the lowest fruit weight was recorded at S_3 (7dS.m-^{1}) treatment by giving 169.11 g. $plant^{-1}$. On contrary, reducing the salinity level led to increase the broccoli fruit weight, where the treatment S_2 (5.0 $dS.m^{-1}$) gave 262.44 g. $plant^{-1}$ with decreasing rate of 25.31% compare to S_1(2.5 $dS.m^{-1}$) treatment which had a broccoli fruit weight of 351.39 g plant-^{1}. The decrease in the fruits weight can be attributed to the increases in the level of irrigation water salinity, which leads to an increase in soil electrical conductivity. Moreover, the toxic effect of saline elements, as well as a disturbance in the nutritional balance, which in turn negatively affects the weight of broccoli fruit [22]. With regard to, the combinations of phosphogypsum and humic acids.The observed data shows There was a significant increase in the weight of broccoli fruit at treatments T_2, T_4, T_5, T_7, T_8, and T_9. However, the weight of broccoli fruit decreased at the treatments T_3 and T_6 compared to the control treatment T_1. The highest value was recorded at treatment T_8 by giving 325 g. $plant^{-1}$ compared to control treatment T^1 that gave 222.43 g. $plant^{-1}$, with increasing rate reached 46.11%, while the lowest observed fruit weight was recorded at treatment T_3 by giving 188.43 g. $plant^{-1}$, with decreasing rate of 15.28% compare to control treatment T_1. The increase in fruit weight was probably due to humic acids application which plays a crucial role in improving the soil physical, chemical and biological properties [23]. Furthermore, humic acids application led to reduce the soil electrical conductivity due to the presence of active groups such as carboxyl and hydroxyl, which form complexes with sodium easily leachable, at the same time it forms less mobile complexes with calcium. Consequently, this process positively reflects on plant growth [20,24]. Additionally, humic acids also enhance plant resistance to salt stress and reduce the impact of toxic elements [13]. In addition, phosphogypsum mitigates the impact of sodium and reduces the soil reaction (soil pH), which has a positive effect on the nutrients availability, accordingly increases the weight of broccoli fruit [25]. Regarding T_3 treatment, which gave the lowest fruit weight, the reduction was probably due to the absence of humic acid that mitigate the effect of water irrigation salinity, therefore, raising the salinity could reduce the fruits weight. Regarding the effect of the interaction between the applied combinations and the irrigation water salinity levels, the best fruit weight of broccoli plant was obtained from the combination T8 and the level of salinity of irrigation water S_1 by recording 435 g plant^{-1} while the lowest rate of fruit weight was recorded at T_3 and S_1 water irrigation level by giving 113 g. plant^{-1}.

Table 2. Effect of application different combinations of phosphogypsum and humic on fruits weight (g. plant^{-1})

Salinity levels (dS.m-1)	Combinations under study									
	T1	T2	T3	T4	T5	T6	T7	T8	T9	Average of Salinity
S1	286.6	310	245	372	394.7	347.67	388.66	435	383	351.39
S2	231.7	252.7	207.3	264	325	207	302	346.33	226	262.44
S3	149	170.3	113	181.7	192.7	168.3	183.67	193.67	169.7	169.11
Average of combinations	222.4	244.33	188.43	272.56	304.1	240.99	291.44	325	259.56	

L.S.D (0.05)		
Interaction (S*T)	Salinity levels(S)	Combinations(T)
36.79	**12.26**	**21.24**

S_1, S_2, S_3 is the salinity levels; T_1 to T_9 is the combinations of phosphogypsum, humic acids and saline irrigation water, LSD is least significant difference.

3.2. Effect of combinations under study on broccoli yield

The effect of water irrigation salinity and combinations of phosphogypsum and humic acids on broccoli yields results are presented in Table 3. The statistical analysis results at $P<0.05$ level showed a significant decrease in the productivity value rates for broccoli plants with an increase in the salinity level of irrigation water. In this context, the lowest yield value was observed at S_3 (7dS.m^{-1}) treatment by recording 4.5 t.h^{-1} with decreasing rate up to 51.92%. while reducing water irrigation salinity, clearly reflected on broccoli productivity. In this regard, the treatment S_2 recorded the highest yield by giving 6.99 t.h^{-1} with decreasing rate of 25.32% compare to S_1 that gave 9.36 t.h^{-1}. The decrease in the average productivity values of broccoli plant might attributed to the increase in the level of salinity of irrigation water. Where increasing the salinity concentration resulted from irrigation water leads to increase the soil electrical conductivity. Consequently, high osmotic pressures which affects plant growth by restricting the uptake water by the roots and interferes with balanced absorption of essential nutritional elements by plants which is reflected negatively on the productivity of the plant broccoli [22]. Conversely, the statistical analysis results showed a significant increase in productivity values of broccoli at T_2, T_4, T_5, T_7, T_8, and T_9 treatments, while the productivity was decreased at T_3 and T_6 treatments compare to control treatment (without application). The highest yield productivity was observed at T_8 treatment up to 8.66 t.h^{-1} compare to T_1 (without application) which gave 5.92 t.h^{-1} with increasing rate reached 46.28 %. While the lowest yield was obtained from T_3 treatment revealed 5.01 t.h^{-1} with a decreasing rate reached 15.37% compare to T_1 (without application). Increasing the productivity was probably due to humic acids application which play a crucial role in enhancing the soil conditions. In this regards, the presence of humic acids improve the mobility, and availability of soil minerals. Consequently, improve the ions acquisition by the plants [5]. Accordingly, increasing the plant productivity. Regarding the yield increasing under the phosphogypsum application, the increasing was probably due to the application of humic acids induced phosphogypsum adsorption during mineral transformation [26]. Concerning the effect of the interaction between the combinations and the irrigation water salinity levels, the best productivity of broccoli was recorded at T8 combination, and the S1 irrigation water salinity level amounted to 11.59 t. h^{-1}, while the lowest productivity of broccoli was recorded at T_3 combination and the S_3 water salinity level amounted to 3.00 t.h^{-1}.

Table 3. Effect of application different combinations of phosphogypsum and humic on yield (t h^{-1})

Salinity levels (dS m^{-1})	Combinations under study									Average of Salinity
	T1	T2	T3	T4	T5	T6	T7	T8	T9	
S1	7.63	8.26	6.53	9.91	10.51	9.26	10.35	11.59	10.20	9.36
S2	6.17	6.73	5.52	7.03	8.66	5.51	8.04	9.23	6.02	6.99
S3	3.96	4.53	3.00	4.83	5.13	4.48	4.89	5.16	4.52	4.5
Average of combinations	5.92	6.5	5.01	7.25	8.1	6.41	7.76	8.66	6.91	

L.S.D (0.05)		
Interaction(S*T)	Salinity levels (S)	Combinations (T)
0.9799	**0.5657**	**0.3266**

S_1, S_2, S_3 is the salinity levels; T_1 to T_9 is the combinations of phosphogypsum, humic acids and saline irrigation water, LSD is least significant difference.

3.3. Effect of combinations under study on plant height

The obtained results (at P<0.05) exhibited a significant decrease in the average of plant height with the increase in water irrigation salinity as shown in Table 4. The lowest value of average plant height was observed at S_3 (7dS.m^{-1}) treatment reached 25.94 cm, where a 22.75 decrease was observed compare to S_1 treatment. Simultaneously, S_2 (5 dS.m^{-1}) treatment gave average plant height reached 29.07 cm, with a decreasing rate up to 13.43 % compare to S_1 (2.5 dS.m^{-1}) that gave 33.58 cm. The decrease in the plant height value may be due to the increase in the salinity level of irrigation water, which can lead to an increase in the electrical conductivity of the soil and the harmful effects of saline elements. In addition, there can be disruptions in the nutritional balance that negatively affect the plant and result in a decrease in the plant height growth rate of broccoli [22].

Conversely, the phosphogypsum application significantly increased the plant height at the treatments T_2, T_4, T_5, T_6, T_7, T_8, T_9 compare to T_1. In this direction, the highest average plant height was resulted from T_8 treatment by giving 33.63 cm compare to T_1 (without phosphogypsum application) which recorded 28.1 cm with increasing rate reached 46.28 %. whilst a reduction in plant height was observed at T_3 treatment by recording the lowest average plant height reached 25.16 cm compare to T_1, where a 19.67 decrease was observed compare to T_1 treatment. The significant increase in the plant height was probably due to the role of humic acids in improving the soil physical, chemical, and biological properties, which also can stimulate plant growth, including changes in root thickness, length, branching, and density [27]. Moreover, humic substances improve nutrient use efficiency, enhance the uptake of both macro- and microelements and stimulating plant growth by supporting the plant with carbon, nitrogen, and secondary metabolism[28] . In addition, application of humic substances stimulate root growth, increasing mineral uptake and decreasing membrane damage, accordingly alleviate the adverse effects of salt stress [13]. Furthermore, phosphogypsum has a crucial role in reducing the sodium ion effect and soil reaction (pH), which reflected positively on increasing the availability of nutrients and increasing the plant height [25]. However, decreasing the plant height under phosphogypsum application at T_3, probably due to the effect low salt concentration at the T_3 treatment, where previous studies reported that phosphogypsum solubility decreases with decreasing the salt concentration in the solution [29]. Accordingly, the source of Ca would be less compare to other treatments. Thus, the plant height was adversely affected. Regarding the effect of interaction between the applied combinations and irrigation water salinity levels, the highest plant height value was recorded at T_8 treatment by giving 38.6 cm, while the lowest observed plant height was 20.6 cm at T_3 treatment.

Table 4. Effect of application different combinations of phosphogypsum and humic on plant height (cm)

Salinity levels (dS.m-1)	Combinations under study									
	T1	T2	T3	T4	T5	T6	T7	T8	T9	Average of Salinity
S1	30	34.6	29.3	33.3	38.3	31.6	33.6	38.6	33	33.58
S2	29.3	31.6	25.6	28	30.3	29	29	32.3	26.6	29.07
S3	25	28	20.6	26	27.3	24	27	30	25.6	25.94
Average of combinations	28.1	31.4	25.16	29.1	31.96	28.2	29.86	33.63	28.4	

L.S.D (0.05)		
Interaction (S*T)	Salinity levels (S)	Combinations (T)
2.158	**1.246**	**0.719**

S_1, S_2, S_3 is the salinity levels; T_1 to T_9 is the combinations of phosphogypsum, humic acids and saline irrigation water, LSD is least significant difference.

3.4. Effect of combinations under study on nitrogen concentration in broccoli

Effect of saline irrigation water, the combinations of phosphogypsum and humic acids on the concentration of nitrogen in broccoli are presented in Table 5. The observed results show a significant increase in broccoli nitrogen content linked with irrigation water salinity increases. From the obtained results, the highest average of nitrogen concentration was recorded at S_3 treatment up to 3.83% with increasing rate of 42.91% compare to S_1 treatment. While the average of nitrogen concentration at S_2 treatment was 3.25% with increasing rate of 25.32% compare to S_1 which had a nitrogen concentration value of 2.68%. Thus, the observed results suggested that the irrigation water salinity has a significant effect on the nitrogen concentration in broccoli. Regarding the phosphogypsum effects, a significant increase was observed in the rate of nitrogen concentration in broccoli at treatments T_2, T_3, T_4, T_5, T_6, T_7, T_8, and T_9, while the nitrogen concentration in the broccoli decreased at treatment T_1 (without application). In this regards, the highest average of nitrogen concentration value was observed at treatment T_8 by giving 3.96% compared to treatment T_1 (without application) which gave 2.26 % with an increase of 75.22%. The increase in concentration was probably due to the increase in levels of humic acid addition, which improve the chemical, physical, and biological properties of the soil and increase the availability of nutrients for the plant, especially nitrogen [30]. Regarding the effect of the interaction between the applied combinations and the levels of irrigation water salinity, the highest nitrogen concentration of broccoli plant was recorded at the combination T_8, and S_3 irrigation water salinity by recording 4.53%. While the lowest nitrogen concentration was attained from T_1 and irrigation water salinity S_1 reached 1.81%.

Table 5. Effect of application different combinations of phosphogypsum and humic on nitrogen concentration

Salinity levels (dS m^{-1})	Combinations under study									
	T1	T2	T3	T4	T5	T6	T7	T8	T9	Average of Salinity
S1	1.81	2.46	2.16	2.52	2.63	2.53	3.31	3.46	3.3	2.68
S2	2.36	2.58	2.37	3.49	3.79	3.46	3.76	3.91	3.59	3.25
S3	2.63	3.93	3.23	3.76	4.33	3.97	3.83	4.53	4.31	3.83
Average of combinations	2.26	2.99	2.58	3.25	3.58	3.32	3.63	3.96	3.73	

L.S.D (0.05)		
Interaction S*T	Salinity levels (S)	Combinations (T)
0.4194	**0.1398**	**0.2422**

S_1, S_2, S_3 is the salinity levels; T_1 to T_9 is the combinations of phosphogypsum, humic acids and saline irrigation water, LSD is least significant difference.

3.5. Effect of combinations under study on phosphorus concentration in broccoli

Effect of saline irrigation water, the combinations of phosphogypsum and humic acids on the concentration of phosphorus in broccoli are shown in Table 6. Results of Statistical analysis at a 0.05 level showed a significant reduction in the rates of phosphorus concentration in broccoli with a decreasing in the irrigation water salinity. The highest average of phosphorus concentration value was attained at S1 treatment by recording 0.42% while the average of phosphorus concentration value in broccoli at S2 treatment was 0.34% with decreasing of 23.5 % compared to S1. The obtained results show a significant increase in the phosphorus concentration at treatments T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9, while phosphorus concentration was deceased at T_1 treatment. The highest concentration of phosphorus was observed at treatment T9, with a concentration of 0.47%, compared to the control treatment T1, which had a concentration of 0.20%. Increasing the phosphorus concentration in the aforementioned treatments (T_2 to T_9) can be attributed to humic acids application which play a crucial role in converting insoluble phosphorus into dissolved phosphorus under effect of ion exchange with anions of humic acid. Consequently, re-mineralization of phosphogypsum into more soluble phosphorus [31]. Moreover, humic acids application could enhance phosphorus availability accordingly increasing P concentration in the plant tissues by increasing the relative abundance of Glomeromycota in the soil [32]. Regarding the interaction between the combinations, (humic acids, phosphogypsum and irrigation water salinity) the obtained results show that the highest phosphorus concentration was recorded at T8 and S_1 by giving 5.52 % while the lowest concentration was recorded at $T_1$and S_3 combination by giving 0.12%.

Table 6. Effect of application different combinations of phosphogypsum and humic on phosphorus concentration

Salinity levels (dS.m^{-1})	Combinations under study									
	T1	T2	T3	T4	T5	T6	T7	T8	T9	Average of Salinity
S1	0.26	0.35	0.45	0.28	0.44	0.48	0.36	5.52	0.64	0.42
S2	0.22	0.27	0.29	0.32	0.35	0.36	0.40	0.41	0.45	0.34
S3	0.12	0.13	0.18	0.19	0.22	0.23	0.28	0.29	0.33	0.21
Average of combinations	0.2	0.25	0.3	0.26	0.33	0.35	0.34	0.4	0.47	

L.S.D (0.05)		
Interaction (S*T)	Salinity levels (S)	Combinations(T)
0.08594	**0.02865**	**0.04962**

S_1, S_2, S_3 is the salinity levels; T_1 to T_9 is the combinations of phosphogypsum, humic acids and saline irrigation water, LSD is least significant difference.

3.6. Effect of combinations under study on potassium concentration in broccoli

Effect of saline irrigation water, the combinations of phosphogypsum and humic acids on potassium concentration in broccoli are shown in Table 7. The observed results show a significant increase in potassium concentration in broccoli plant tissues under effect of combinations under study. The presented data, show that the highest average of potassium concentration was recorded at T_8 and T_9 treatments by giving 2.56 and 2.41% respectively, followed by T_7 which gave 2.36 %. Increasing the potassium concentration in plant tissues under effect of the three aforementioned treatments (T_7, T_8, and T_9) can attribute to humic acids role in increasing uptake of minerals such as S, P, K and N (Arslan and Pehlivan, 2008), in addition the used humic acids contain 12% potassium oxides in its composition. Consequently, potassium concentration increased in plant tissues. Also, using moderate levels of phosphogypsum led to increase the potassium concentration in plant tissues [34].In other words, the phosphogypsum levels in the T_8 and T_9 were with acceptable rage to relase the potassium from phosphogypsum based on Sheikhi Shahrivarand Khademi, 2018 study. In general, the treatments T_1 to T_6 show a decrease in potassium concentration compare to treatments T_6 to T_9, probably due to the concentration of applied humic acids. Where the treatments T_6 to T_9 received, 0.5 g/l compare to

0.25 g/l in T_1 to T_6 treatments. This finding support the fact that the humic acids increase the nutrients availability for the plant. Accordingly, increasing its concertation in the plant tissues[35]. Regarding the salinity levels, the observed results show a decreasing patterns in potassium concentration with increasing the salinity level Table 8. The potassium reduction can attribute to salinity levels which might induced osmotic and ionic stresses cause unexpected variations in water potential ultimately inhibiting the efficiency of potassium uptake in stressed plants [36].

Table 7. Effect of application different combinations of phosphogypsum and humic on potassium concentration

Salinity levels (dS m^{-1})	Combinations under study									
	T1	T2	T3	T4	T5	T6	T7	T8	T9	Average of Salinity
S1	1.96	2.06	1.97	2.83	3.02	2.85	3.58	3.77	3.66	2.85
S2	1.54	1.82	1.67	1.79	1.94	1.83	1.99	2.22	2.03	1.87
S3	1.16	1.23	1.17	1.3	1.42	1.33	1.52	1.70	1.55	1.37
Average of combinations	1.55	1.70	1.60	1.97	2.12	2.00	2.36	2.56	2.41	

L.S.D (0.05)		
Interaction (S*T)	Salinity levels(S)	Combinations(T)
0.1669	**0.0556**	**0.0963**

S_1, S_2, S_3 is the salinity levels; T_1 to T_9 is the combinations of phosphogypsum, humic acids and saline irrigation water, LSD is least significant difference.

4. Conclusion

The current study results showed that overall treatments combinations, combined humic acids with phosphogypsum had positive effect on fruits weight, yield, plant height, N, P, K concentration in broccoli tissues. Moreover, it can be stated that the obtained results showed that humic acids application improved N, P, K uptake by plant. Accordingly, its concentration increased in plant tissues. Ultimately, nitrogen, phosphorus and potassium fertilizer requirements may be reduced when sufficient humic acids are present in the soil. Furthermore, the study findings suggested that the mixture of phosphogypsum and humic acids could reduce the negative effect of saline water. Therefore, this combination can use as a technique to alleviate the adverse effect of saline irrigation water. From current study findings, it can be concluded that the main effect was observed by the humic acids while phosphogypsum gave the additional effect.

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The Effect of Salicylic Acid on the Growth Features of Sunflower Crops in Iraqi Middle-area Conditions

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Abstract: In order to determine the role of adding salicylic acid in reducing the impact of drought on the sunflower crop and increasing its tolerance to water stress, a field experiment was conducted during the spring of 2020 AD in one of the private agricultural fields in Latifiya district, Baghdad. Two agents were used in the experiment; the first was salicylic acid, which contained four Concentrations are (0, 100, 200, and 300 mg. L^{-1}), and their corresponding symbols are S0, S1, S2, and S3, respectively. The second element is irrigation, which has three intervals (7, 14, and 21 days) between irrigations, and corresponding symbols I1, I2, and I3, respectively. The results indicated that, the highest plant height (PLH) was at 300 mg. L^{-1} treatment which was 189.98 cm. there are significant differences in the average number of leaves in the plant (NOL) when increasing the concentration of the spray solution of salicylic acid on the sun flower plant, as the highest average trait was 29.98 leaves. $Plant^{-1}$ at the treatment 300 mg. L^{-1}. The highest average LA was at the treatment 300 mg^{-1} which amounted to 1931.9 cm2.Plant-1.the treatment 300 mg. L^{-1} recorded the highest average for leaf area index (LAI) was 4.95. The irrigation intervals have shown a clear significant effect on all growth characters, the irrigation interval at 7 days gave highest rate of plant height (189.05 cm), number of leaves in the plant (NOL) (29.05leaf. $Plant^{-1}$), Leaf area of the plant (LA) (1711. $2cm^2.plant^{-1}$), Leaf area index (LAI) (4.83).

1. Introduction

The sunflower (*Helianthus annus* L.) is at the forefront of drought-tolerant crops due to the deepening of its roots, the large size of the plant and the presence of fluff on its leaves, which reduces the amount of water evaporated from the plant, as it uses 20-25% of its total water requirements during the first 30 days of its growth stage, while the largest percentage of its water needs is at the flowering and filling seeds stages [1], This stage of plant growth is the critical stage that falls within the time period in the months when temperatures rise in spring planting, which makes the plant go thorough drought problems when irrigation water is scarce at this stage, moreover, determining the water needs of most field crops is one of the most important factors in crop management, which leads to reducing the impact of water shortages and drought that Iraq and many regions of the world suffer from as a result of high temperatures [2].

The importance of this crop is due to the fact that it is one of the important oil crops in the world, as it occupies the third place after soybeans and palm oil, where the percentage of oil in its seeds reaches 55%, so it contributes about 14% of global oil production [3]. Salicylic acid is one of the most important phenolic derivatives widely spread in plant species, which has important physiological effects in plant growth, flowering and ion absorption, and helps accelerate the formation of chlorophyll and carotene pigments, accelerate photosynthesis and increase the activity of some important enzymes,therefore, it is necessary to work on finding a mechanism for irrigation by determining the quantities of added water, the dates of that addition and irrigation periods, and the management of irrigation water and its correct application and giving water in quantities that enable the cultivated crop to benefit from it efficiently is one of the important priorities in agricultural operations in arid and semi-arid areas [4]. In addition to its role in inhibiting the synthesis of ethylene and its opposite effect of abscisic acid (ABA) in the process of opening and closing stomata, it gives plants systemic immunity from pathogens and helps plants withstand stress resulting from extreme temperatures, freezing, drought and salinity [5].

The long-term water deficit leads to reducing plant growth, which occurs more than other stresses combined, which requires taking care of water sources and not wasting and rationing irrigation water for the purpose of obtaining the highest productivity with the least amount of water, in addition to that, the method of adapting crops to withstand drought has received great attention in recent years for its savings in water quantities [6]. Due to the importance of salicylic acid in reducing the effects of drought, this study was carried out with the aim of determining the role of salicylic acid that can be added sprayed on the vegetative system in increasing the tolerance of sunflower plants to moisture stress and determining the best concentration of it to obtain the best characteristics for vegetative growth under the conditions of the central region of Iraq.

2. Material and Methods

A field experiment was carried out during the spring season of 2020 in one of the private agricultural fields in the Latifiya district of Baghdad, with the aim of knowing the role of adding salicylic acid in reducing the effect of drought on the sunflower crop and increasing its tolerance to water stress. The experiment included two factors, the first is salicylic acid, which included four concentrations (0, 100, 200 and 300 mg. L^{-1}) and its symbol (S_0, S_1, S_2 and S_3) sequentially. The second factor is irrigation, which included three periods (7, 14 and 21) days between one irrigation and another and its symbol (I_1, I_2 and I_3) respectively. The split plots were used in Randomized Completely Blocks Design (RCBD) and with three replicates, where the irrigation interval factors occupied the main plots and the salicylic acid concentrations occupied the secondary plots.

The experiment land was plowed by the moldboard plow with two perpendicular ploughs, then smoothing, leveling and dividing operations were carried out into plots, and the dimensions of each plot were (3 m×3 m) with a distance of 2 m between each plot and another as well as between blocks for the purpose of controlling the lateral movement of water among the blocks during irrigation.

Each experimental unit includes 4 furrows, the space between each two furrows is 0.75 m. The space between each two pits is 0.25 m on the same furrow. Soil samples were taken randomly from the field before planting at depths 0–30 cm and 30–60 cm and then transferred to the laboratory and estimated some physical and chemical properties (Table 1). Sunflower seeds (Shumoos cultivar) were sown on 15/3/2020 at a depth of 5-4 cm, with 3-4 seeds in each pit. Urea fertilizer was added at a rate of 80 kg N ha^{-1} using urea (46% N) as a fertilizer source in two equal batches, the first at planting and the second after 45 days of planting (the beginning of the of flower buds formation). As for phosphate fertilizer, it was added by 80 kg P2O5 ha^{-1} using tri superphosphate fertilizer (46% P_2O_5) as a source of phosphorus at one batch before planting and potassium sulfate fertilizer SO_4K_2 (52% K_2O) at a rate of 200 kg. ha^{-1}[7].

Germination irrigation was given on 15/3/2020 at a rate of 344.8 liters. $plot^{-1}$ for one irrigation, then another irrigation was given on 20/3/2020 by the same amount to encourage the growth process and complete germination, then a third irrigation was given on 25/3/2020 to maintain an appropriate moisture content in addition to encouraging the growth of new plants. The failed pits patched on 1/4/2020 after the appearance of 75% of the seedlings, which was considered the date of germination, then the plants reduced to one plant, where the plant density became 53333.33 plants. ha^{-1}. The treatments were isolated on 1/4/2020 by placing signs and symbols indicating each treatment. During the period of crop growth in the field.All necessary procedures and field works were carried out to protect plants from weeds, diseases, insects and bird attacks.Early in the morning, salicylic acid was added to the plants as a spray solution on the vegetative growth one month after the germination date [8]. After the plants were washed with tap water before sunset for the day before the spraying process to remove dust from them, where the plants were sprayed with salicylic acid in each experimental unit, each according to the concentration specified for it until the complete wetness [9].

The first irrigation interval was 7 days stared on Tuesday 7/4/2020, while the second interval was 14 days started on Tuesday 14/4/2020, finally, the last irrigation interval; was 21 days on Tuesday 21/4/2020. The amount of irrigation water was increased at the beginning of the flowering stage until the physiological maturity of the plant, and the amount of irrigation water given to the plant became 767.5 liters per Panel for the one irrigation, ten plants were randomly taken from the intermediate furrows for each experimental unit after excluding the peripheral plants for each furrow on Wednesday 15/7/2020, the plants were harvested, and the following properties were studied: plant height-PLH- (cm), number of leaves (NOL) (leaf.plant^{-1}), leaf area- LA- (cm^2. Plant^{-1}), index of leaf area (ILA). The data was analyzed statistically [10].

Table 1. Some physical and chemical properties of the soil of the experiment field before planting for the 2020 season

Sample depth	0 – 30cm	30 – 60 cm
Sand (g.kg^{-1})	270	130
Silt (g.kg^{-1})	390	560
Clay (g.kg^{-1})	340	310
Texture	Clay Loam	Silty Clay Loam
Organic matter (g.kg^{-1})	8.5	3.4
Electrical conductivity (dS.m^{-1})	2.94	1.98
pH	7.75	7.56
Available Nitrogen (mg.kg^{-1})	83	21
Available Phosphorus (mg.kg^{-1})	7.5	6.2
Available Potassium (mg.kg^{-1})	169	89
Permanent wilting point % (PWP)	20.40	13.50
Field capacity% (FC)	30.30	23.80
Available water%	9.90	10.30
Bulk density (Mg.m^{-3})	1.29	1.38

Field soil was analyzed in the laboratories of the Ministry of Science and Technology – Baghdad – Iraq

3. Results and Discussion

3.1. Plant height (PLH) cm

The results of Table (2) indicated that there were significant differences in the average PLH when increasing the spray concentration of salicylic acid on the sun flower plant, the highest PLH was at 300 mg. L^{-1}treatment which was 189.98 cm, while the lowest PLH was at 0 mg. L^{-1}treatment of 181.49 cm. The reason for this may be that the effect of salicylic acid in this characteristic is due to its hormonal effect on the cell area. Also, the external addition of salicylic acid to the vegetative system of the plant led to contribute to the expansion and elongation of plant cells, which was sufficient to make a significant difference in this trait and thus increase the height of the plant**[11]**.The same table also shows that irrigation periods have a significant impact on the PLH, as it was noticed that the average PLH decreased significantly as the irrigation periods increased, The treatment was recorded for 7 days on an average plant height of 189.05 cm and decreased significantly to 186.63 cm at the 14-day treatment and then decreased significantly to 182.43 cm at the 21day treatment, this may be due to the fact that the vegetative growth stage of the plant is an active stage for the growth and expansion of cells and their division, which is affected by water stress, and that the availability of appropriate moisture during the stages of plant growth especially in the vegetative phase, it has led to an increase in the speed of photosynthesis and an increase in the amount of elements absorbed by the plant, which was positively reflected in the increase in cell division and elongation and thus increase the overall plant growth, including plant height [12].In addition, water stress leads to inhibition of Auxin action, which leads to a reduction in plant height[13].As for the effect of interference between the two study factors, the results indicated that there are significant differences in this trait, where it was noticed that the highest height of the plant was 192.87 cm when the treatment of interference S_3I_1, while the lowest height of the plant when the treatment of interference S_0I_3 amounted to 175.60 cm.

Table 2. Effect of Salicylic Acid Concentration and Irrigation Intervals on PLH Rate (cm) of 2020 Spring Loop Sunflower Crop

Irrigation Intervals rate	Salicylic acid concentration (ppm)				Irrigation intervals
	S3 300	S2 200	S1 100	S0 0	
189.05	192.87	190.37	187.43	185.53	I_1 7 days
186.63	190.20	187.73	185.27	183.33	I_2 14 days
182.43	186.87	185.13	182.10	175.60	I_3 21 days
	189.98	187.74	184.93	181.49	Salicylic acid concentration rate
interaction 2.15		Salicylic acid 0.80		Irrigation. intervals 1.93	L.S.D 0.05

3.2. Leaves number per plant (leaf. Plant-1)

The results of Table (3) indicate that there are significant differences in the average number of leaves in the plant (NOL) when increasing the concentration of the spray solution of salicylic acid on the sun flower plant, as the highest average trait was 29.98 leaves. $Plant^{-1}$ at the treatment 300 mg. L^{-1}, while the lowest average of 21.53 leaf. $Plant^{-1}$ was recorded at the treatment of control. This is because the external addition of salicylic acid to the plant contributed to the expansion and elongation of plant cells [14]. The table also shows that irrigation periods have a significant effect on the trait of NOL, as it was noticed that the average number of leaves in the plant decreased significantly by increasing the period among irrigations, the 7 days treatment recorded highest average of NOL in the plant amounted to 29.05 leaf. $Plant^{-1}$. It decreased significantly to 22.46 leaf. $Plant^{-1}$for the treatment of 21 days. The reason for this may be that the lack of moisture in the soil resulting from the lack of irrigation water makes the plant tend towards fruitful growth at the expense of vegetative growth as it is one of drought mitigation means [15]. As for the effect of interaction between the two study factors, the results indicated that there are significant differences in this trait, as the lowest average number of leaves in the plant was 15.53 leaf. $Plant^{-1}$ at S_0I_3 treatment, while the highest average for this trait at S_3I_1 interference treatment was 32.87 leaf. $Plant^{-1}$.

Table 3. Effect of Salicylic Acid Concentration and Irrigation Intervals on NOL Rate (leaf. Plant-1) of 2020 Spring Loop Sunflower Crop

Irrigation Intervals rate	Salicylic acid concentration (ppm) S3 300	S2 200	S1 100	S0 0	Irrigation intervals
29.05	32.87	30.37	27.43	25.53	I_1 7 days
26.63	30.20	27.73	25.27	23.33	I_2 14 days
22.46	26.87	25.13	22.10	15.73	I_3 21 days
	29.98	27.74	24.93	21.53	Salicylic acid concentration rate
Interaction 1.90		Salicylic acid 1.25		Irrigation. intervals 0.47	L.S.D 0.05

3.3. Leaf area of the plant (LA) (cm^2.plant^{-1})

The results of Table (4) indicated that there were significant differences in the average leaf area (LA) when increasing the concentration of the spray solution of salicylic acid on the plant. The highest average LAwas at the treatment 300 mg^{-1}which amounted to 1931.9 cm^2.Plant^{-1}, while the lowest average for this trait at the control treatment was 1184.7 cm^2.Plant^{-1}. The reason may be that salicylic acid works to reduce the effect of a biotic stress inhibiting growth and increase the level of plant hormones such as Auxines and cytokines affecting the processes of cell division and elongation **[16]** which resulted in an increase in the leaf area of the plant. The same table also shows that irrigation levels have a significant impact on this trait, as it was noticed that the average LA decreased significantly from 1711.2 cm^2.Plant^{-1} at I_1 (7 days) to the lowest average at I_3 (21 days) at 1319.5 cm^2.Plant^{-1}, This may be explained by the fact that the availability of water affects the increase of vegetative growth through the division and elongation of plant cells and the activity of enzymes in them and thus increase the leaf area of the plant [17].

The results proved that there is a significant interaction between the salicylic acid concentration treatments and irrigation levels in this property, where it was noticed that the interaction between the concentration treatment 300 mg. l-1 with the treatment of the irrigation period 7 days achieved the highest average of LA of 2198.6 cm2. Plant-1, measured by the concentration treatment 0 mg. L-1(control) with the treatment of the 21-day irrigation period which gave the mean minimum of 1084.7 cm2. Plant-1.

Table 4. Effect of Salicylic Acid Concentration and Irrigation Intervals on Average Leaf Area (LA) (cm2. Plant-1) of 2020 Spring Loop Sunflower Crop

Irrigation Intervals rate	Salicylic acid concentration (p.p.m.)				Irrigation intervals
	S3 300	S2 200	S1 100	S0 0	
1711.2	2198.6	1782.3	1579.1	1284.7	I_1 7 days
1627.9	2098.6	1749.0	1479.1	1184.7	I_2 14 days
1319.5	1498.6	1382.3	1312.5	1084.7	I_3 21 days
	1931.9	1637.9	1456.9	1184.7	Salicylic acid concentratior rate
interaction 71.87		Salicylic acid 36.00		Irrigation. intervals 61.21	L.S.D 0.05

3.4. Leaf index area (LIA)

The results of Table (5) show significant differences in the average leaf index area (LIA) by increasing the concentration of salicylic acid spray solution on the plant, where the treatment 300 mg. L^{-1}- recorded the highest average for this trait was 4.95, while the lowest average at the treatment of control was 3.33. When the plant is treated with salicylic acid, it will increase the concentration of pigments essential for photosynthesis [18]. The same table shows that irrigation levels have a significant effect on this trait, as it was noticed that the average leaf index area (LAI) decreased significantly from 4.83 at the I_1 treatment (7 days) to the lowest average at the I_3 treatment (21 days) of 3.58, Due to the fact that the cells elongate as a result of the swelling pressure on the cells' membranes from the inside, and by losing this pressure as a result of water stress, the elongation of the cells stops even before the appearance of signs of wilting on the leaves, which affects the growth and breadth of the cells and the increase in their leaf area**[19]**. The rate of leaf expansion decreases as a result of a decrease in the number and size of cells **[20]**. The leaf index area is a function of the number of leaves and the rate of leaf expansion, and the water stress negatively affects these two traits, which reflects negatively on the leaf area index. The results also indicated a significant effect of the interaction between the two study factors for this trait, as the combination between the concentration of 300 mg. L^{-1} with the irrigation period of 7 days recorded the highest average for the LAI of 5.70, while the control treatment of salicylic acid (0 mg. L^{-1}) with the irrigation period of 21 days gave the lowest average of 2.76.

Table 5. Effect of Salicylic Acid Concentration and Irrigation Levels on the Average Leaf Area Index of Sunflower Crop for Spring loop 2020.

Irrigation Intervals rate	Salicylic acid concentration (p.p.m.)				Irrigation intervals
	S3 300	S2 200	S1 100	S0 0	
4.83	5.70	5.00	4.50	4.13	I_1 7 days
3.93	4.85	4.20	3.55	3.12	I_2 14 days
3.58	4.31	3.86	3.38	2.76	I_3 21 days
	4.95	4.35	3.81	3.33	Salicylic acid concentration rate
interaction 0.14		Salicylic acid 0.10	Irrigation. intervals 0.03		L.S.D 0.05

4. Conclusion

There were significant differences in the average PLH when increasing the spray concentration of salicylic acid on the sun flower plant. There were significant differences in the average leaf area (LA) when increasing the concentration of the spray solution of salicylic acid on the plant. The study shows significant differences in the average leaf index area (LIA) by increasing the concentration of salicylic acid spray solution on the plant. Finally, there are significant differences in the average number of leaves in the plant (NOL) when increasing the concentration of the spray solution of salicylic acid on the sun flower plant.

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Hydrological Modeling and its Role in River Basin Management - Maimaran Valley Basin - a Case Study

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Abstract: The surface drainage network is one of the topographical phenomena in which surface runoff water is concentrated, which transports the running surface water from its sources to its estuaries. Climate, topography, soil, rock composition, and vegetation factors. The measurement and analysis of the surface drainage network is one of the basic tasks in hydrological studies. Human activities and events are concentrated in the river basins and their drainage areas. The environment and the shape of the land may control these activities and activities, and the human factor can greatly affect them, and help to modify and develop them in a way that makes good use of them. Water drainage networks also reflect the conditions of the factors affecting their formation. The study of its characteristics is one of the basic tasks in the geomorphological and hydrological studies. The study area is one of the dry valleys, and it represents an asymmetrical basin. The rains that fall in the winter season are considered the main funded source for the surface water running in the basin. We will use modern modeling methods to learn about the behavior of the water basin. The research aims to study the surface water resources of the Mimran Valley basin, understand the behavior of the basin, and determine the best places that can be exploited sustainably and without risk by using modeling of the active river components, which are (material contribution areas, turning areas, floodplains and river terraces, wetlands on the banks of the river).

1.Introduction

Undoubtedly, water plays a crucial role in all human societies, past and present. The most obvious social concerns around water focus on ensuring that the right amount of this vital resource is "available" in the right places and at the right times to sustain human health and life.

The study is based on a number of questions based on the lack of detailed hydrological models that can be relied upon in the development of water basins, methods of management and decision-making. Hence, the questions for this study arise, namely: Is it possible to manage the main basin and the secondary basins through modeling and identifying which basins are in response to sustainable development ,How can a map be built that has a prominent role in determining the most responsive basins ,There are no previous hydrological studies for this basin.

The construction of the model is based on a solid information base consisting of layers through which a model can be built that defines the areas of sustainable development of river basins.

The modeling will contribute to providing a clear picture to the decision-maker through a series of illustrative models that facilitate the process of basin management, hydrology and morphology.

Date: October 2023

The study aims at the following disclosure of the factors forming the ground appearance of the water basin in terms of the geological structure and its climate capabilities, which were reflected in the formation and development of most of the basin's hydrological characteristics.

Knowing how the main river channels are formed and behaved, as a result of their response to the main variables (geological structure and drainage) and to what extent they can achieve the ecological balance of the basin and represent them cartographically.

Building hydrological hydrological models using satellite visuals and climatic data to design a detailed hydrological map of the basin to achieve sustainable development of the basin and management of similar basins.

2. Materials and Methods

2.1. Location of study area:

The study area is located astronomically within the geographical coordinates between latitudes (35°10'54") and 34°59'22") north, and longitudes (45°29'24") and 45°8'49") east. The basin is located administratively in the southern and southwestern parts of Sulaymaniyah Governorate, with an area of (307.18) km 2. It also contains convex folds and concave folds filled with sediment.

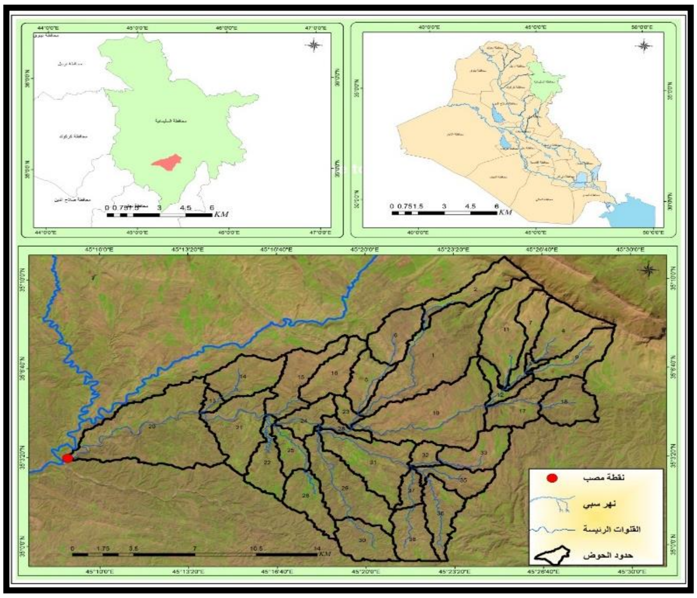

Figure 1. the location of the study area

Source: Based on the Digital Elevation Model (DEM) and the administrative map of Iraq at a scale of 1/1,000,000.

River basin management is characterized by a holistic approach, as the basin is the area that discharges water through its channel and its tributaries, and is of hydrological, environmental and economic importance. Integrated river basin management emphasizes the interdisciplinary coordination of water, land and related resources in a river basin or watershed to achieve long-term sustainable development.

There is a clear focus on river basins as the most appropriate spatial unit for water management. The decision to manage water on the basis of river basins is a political choice because it concerns national security, and seeks to achieve security, stability and well-being for its inhabitants. River basins thus become a measure of governance in which tensions arise between efficacy, participation, and legitimacy.

This topic came to address how this administration is modeled and then reach the areas that can be exploited to support decision-makers, and then activate the role of geographic information systems with all its data and programs to reach the most accurate results in this aspect. It should be noted that there is a group of ecosystems that the basin enjoys in the form of mutual relations, whether direct or inverse, such as the relationship of residential centers to the river.

3. Results and Discussion

3.1. The role of hydrology in river basin management

Ecosystem researchers have offered a pessimistic view of the extent and severity of the damage human activities have inflicted on 'natural' ecosystems across our planet particularly in river networks. Reflecting a combination of factors, many river systems are inherently sensitive to human disturbance, valley floors have been used heavily, resulting in countless modifications for agricultural, industrial and urban purposes. This use of land is usually accompanied by a direct modification of the flow of rivers by human activities based on it (dams, bridge columns, aqueducts, canals, etc.). These practices do not only affect natural systems and they affect the ecosystem services that these systems provide that are essential to human survival (such as provision of drinking water, irrigation supplies, etc.) on a daily basis. To address these concerns, a balanced approach to water resource management is required that strengthens the foundation of sustainability with an interdependent relationship between man and nature.

This topic reflects a special view of the science of hydrology to preserve the environment through the human relationship with the environment and its applications in the management of river basins. Studies have largely focused on demonstrating human impacts on river systems associated with changes in land use (particularly vegetation removal).

3.2. Modeling the components of the active river area:

Modeling Components of the Active River Area

An active river zone provides a systematic means for the evolution and protection of a river as a dynamic system under a wide range of conditions that is typical of natural river systems. They can be clearly identified spatially. This area includes a number of distinct components that provide specificity to guide the procedures for protection, restoration and management, as shown in Figure (1).

The framework of the active river region represents a clear overall spatial vision that includes both the channels and the riparian lands needed to accommodate the associated physical and environmental processes. This framework undertakes river conservation by providing an approach to assessing the regions and processes that shape, alter and maintain a wide range of habitat types and conditions for rivers and canals and along their entire length. In order to model the active components of the river, they must be detailed as follows:

Areas of material contribution.
Turning area.
Floodplains and river terraces.
Riverside wetlands.

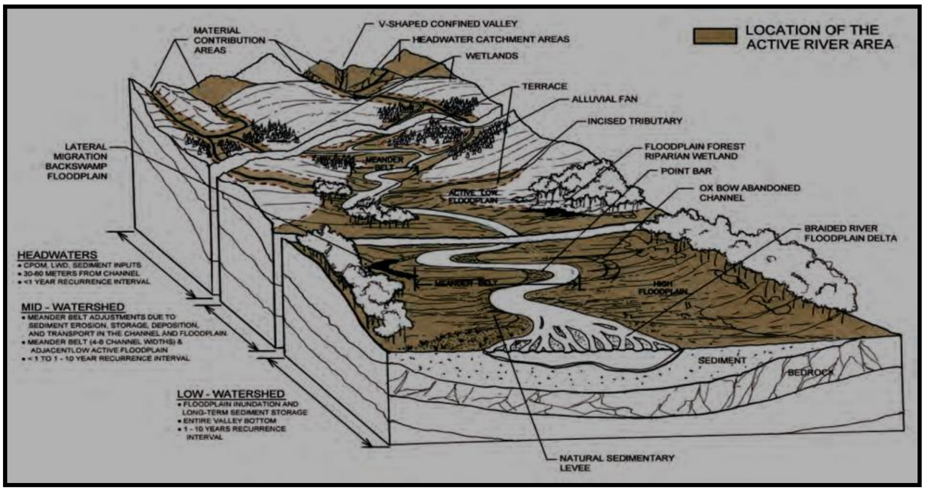

Figure 2. The dominant processes and disturbance regimes in the active river region.

The images of the relationship are reflected in the above figure in the form of Table (1), which shows the most active areas in the river basin to be managed

3.2.1. Material Contribution Areas

The upper reaches of the stream and some highlands areas directly adjacent to the stream channels contribute large quantities of organic and inorganic materials that the water carries to the streams. Two types of material contribution areas are identified. The first are small streams from the upper reaches of the watershed, where sewer channels are formed first, and these areas are important sources of organic and inorganic materials that serve as the basic building blocks for the food of the aquatic network. . For this reason, small watersheds are used to define these regions .

Table 1. Components of the active riverine area with the prevailing processes in it

natural operations	the description	Components of the active riverine zone
Hydrological flow method	Timing, magnitude, duration, and distribution of runoff events throughout the hydrological year influenced by climate, geology, land cover of water basins, connectivity, and valley/stream morphology.	Turning Range, Riverside Wetlands, Floodplains, Terraces, Material Contribution Areas
Sediment transport	The size, quantity, sorting, and distribution of sediments which are a function of geology, hydrology, connectivity, and valley/ stream morphology.	Bend range, riparian wetlands, floodplains, terraces, and physical zones
Handling and transportation of organic materials	Abundance, diversity, and physical retention of organic material available for biological uptake and natural refuge that is a function of bank, vegetation, vegetation, climate, hydrology, connectivity, and valley/stream morphology Maintain	Material Contribution Areas, Turning Range, Floodplains
Establishing contact	connectivity between the channel and the riparian range to support the movement of water, organic matter, organisms, sediments, and organisms Along the up and down watershed and horizontally/vertically between the runoff channel and its floodplain.	Bending range, riverside wetlands, floodplains.
Water quality maintenance	Transformation and transport of sediment, ions and suspended nutrients that are a function of the geology, hydrology and land cover of water basins	Material contribution areas, bend range, riparian wetlands, floodplains, terraces. Material climate, contribution areas, bend
Heat regulation	Maintaining daily and seasonal temperatures of stream water affected by climate, hydrology, river canopy, and valley/stream morphology Nutrient sources and energy	range, riparian wetlands, floodplains, terraces.
The transfer of energy	inputs, primarily sun position and changes in organic compounds by bond breaking (respiration) and bond aggregation (production or photosynthesis)), and ecosystem associated such as changes in oxygen solubility and pH	Bending range, riparian wetlands, floodplains, material contribution areas.

C. Michael Barton, Isaac I. Ullah and Sean Bergin . Land use, water and Mediterranean landscapes: modelling long-term dynamics of complex socio-ecological systems. Phil. Trans. R. Soc. A (2010) 368, 5275–5297.

This type can be modeled by relying on the density of the first ranks of the watercourses, as in Figure (1), whose total lengths are (525.60) km, out of the total total runoff network, which amounts to (1079.73) km, and thus it is approximately half of its lengths.

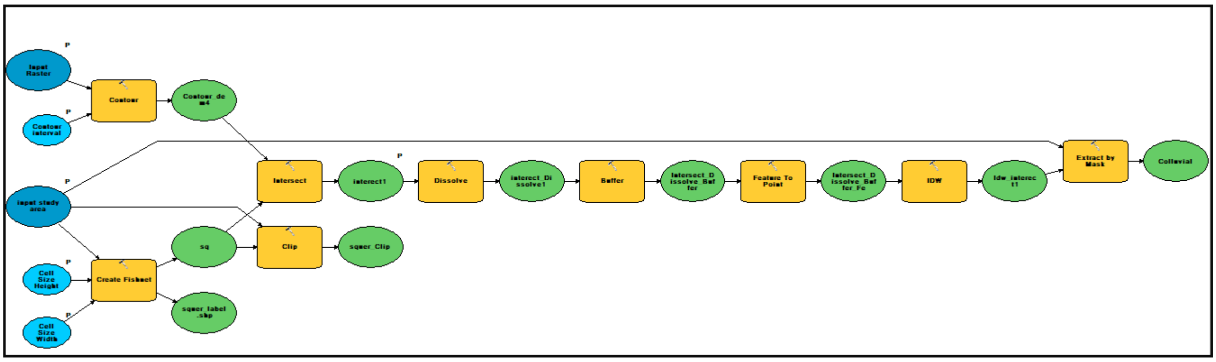

Figure 3. Derivation model of material contribution densit

Source: Based on the ranks of the first water network, and the ARC GIS10.6.1 program
From the application of the above model, map (2) appears, which shows the density of materials.

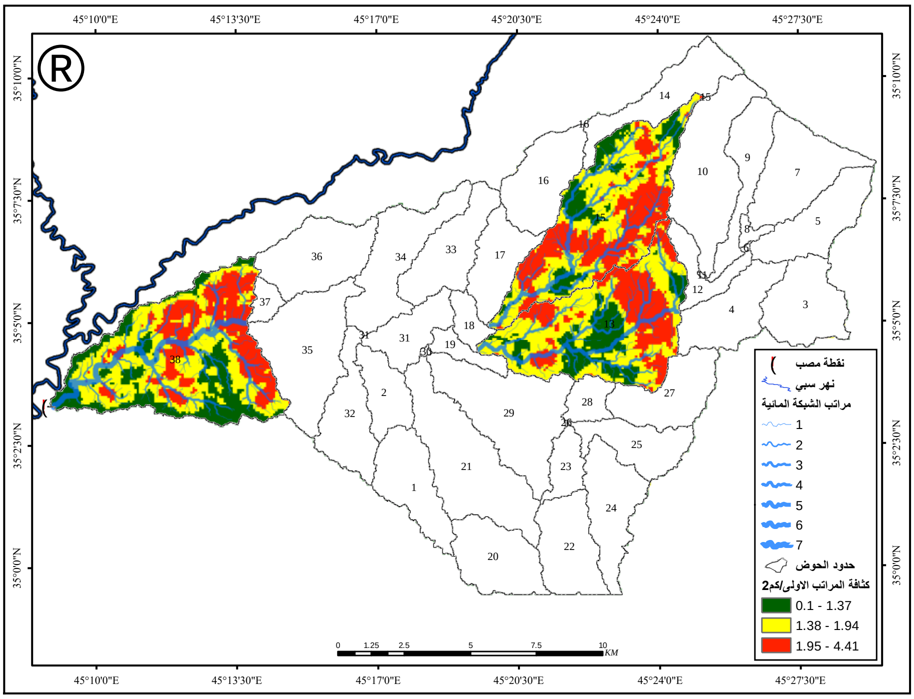

Figure 4. Density of areas contributing materials. Source: Based on the water network ranks, using ARC GIS10.6.1 software. The application of this model has added spatial accuracy to build the model in spatial fit and to determine which basins are more active, and the possibility of exploiting them in order to reach sustainable development depending on the ideal results in the outputs of this model.

3.2.2. The Meander Belt

It is the ratio of the distance between the channel to the bottom of the valley, in other words, the ratio between the length of the channel and the length of the valley where the length of the channel is determined by the length of the channel between two points on the river, and the length of the valley is the straight line distance between two points. And the density of the river bends will be extracted, by modeling it, and extracting which areas have the most bends, as they are the most stable areas for population and agricultural activity.

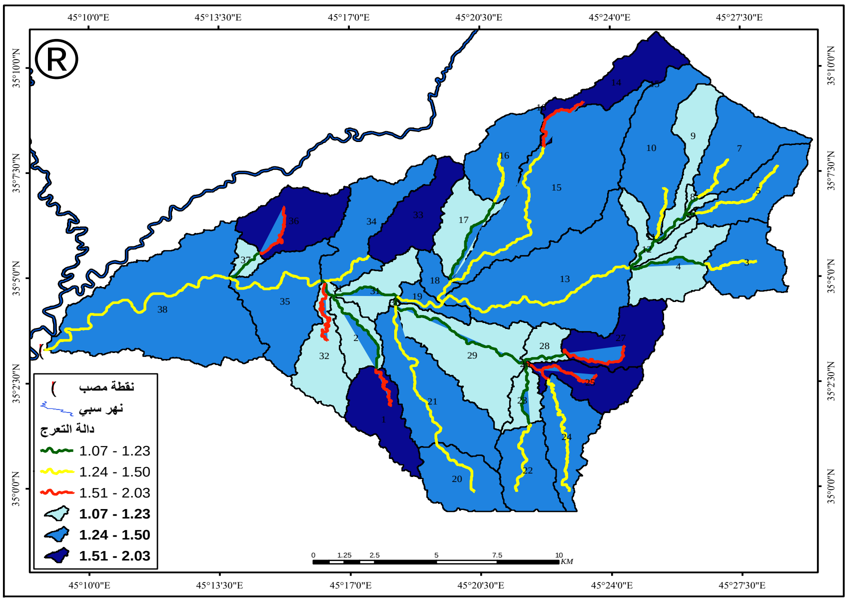

Figure5. Meandering levels according to the main channels and secondary basins

Source: Based on the implementation of the aliasing equation, using ARC GIS10.6.1 software.

3.2.3. Floodplains and traces

Floodplains are usually large, low-sloping areas, often formed with multiple channels and deep accumulations of sediment and other material. Nanson and Crook (1992) define a floodplain as “the alluvial form with a horizontal layer largely abutting the channel, separated from the channel banks, and built of sediments transported by the current runoff system (). The modeling of the high and high-altitude floodplains was based on the level of the secondary basin with its channels The main one is based on the dem digital elevation model with a discriminatory resolution of 12.5 m, with a high-resolution quick bird visual, based on the global mapper program, and then determine the contour line of the high floodplain, then determine the contour line of the low plain and deduct the floodplains area in the light of the line Contouring and identifying the largest area of the floodplains, because they reflect the most active areas for the human side, as shown in Table (2) and Map (4).

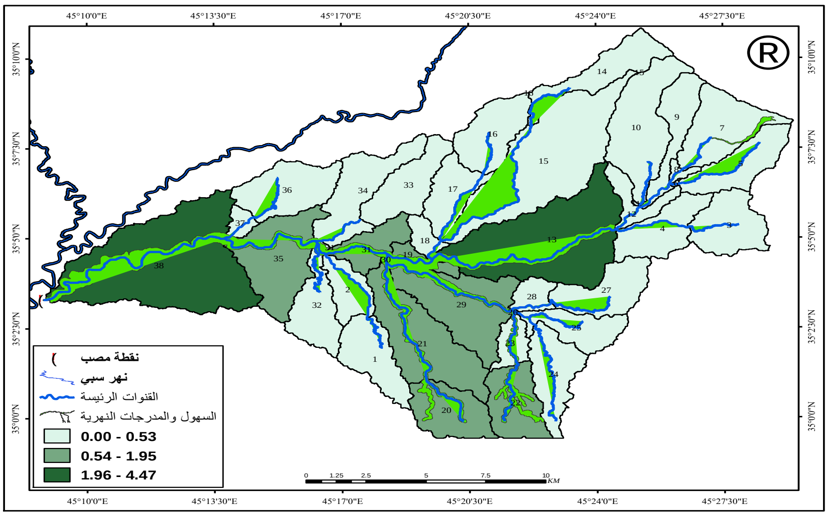

Figure 6. River plains and terraces according to secondary basins

Source: Based on Dem digital elevation model, using ARC GIS10.6.1 software

The river terraces are the former plains of the river when it was flowing at higher levels. In other words, the high floodplains are the river terraces in the mountainous basins, and because the study area is one of the highly intrusive mountainous areas, it did not leave clear river terraces, but they are floodplains on one level, so they were merged with the floodplains to achieve the perception and the comprehensive picture of the map, and as in the map (4).

Table 2. Area of floodplains with river terraces according to secondary basins

The percentage of the floodplain of the basin area is	The total basin area/km2	Area / km	no
0	7.682	0	1
0.18	4.732	0.008	2
0	8.167	0	3
0	7.656	0	4
0	7.768	0	5
0	0.091	0	6
3.67	9.945	0.365	7
0	0.755	0	8
0	6.286	0	9
0	13.369	0	10
0	0.053	0	11
0.01	3.471	0.001	12
12.12	25.602	3.104	13
0	7.781	0	14
0	25.651	0	15
0	8.18	0	16
0	6.273	0	17
1.02	2.108	0.022	18
39.73	2.116	0.841	19
13.8	7.966	1.1	20
10.01	15.134	1.515	21
18.94	7.8	1.478	22
17.78	2.97	0.528	23
0.13	7.985	0.01	24
0.05	5.977	0.003	25
83.8	0.024	0.02	26
0	7.703	0	27
0.47	2.559	0.012	28
13.49	14.461	1.951	29
93.67	0.121	0.113	30
16.93	5.107	0.865	31
4.52	7.393	0.334	32
0	7.816	0	33
0.31	10.04	0.031	34
11.74	13.122	1.54	35
0	9.435	0	36
4.08	1.483	0.06	37
13.8	32.397	4.47	38
5.98	307.2	18.371	Total

Source: Based on the dem digital elevation model, using ARC GIS10.6.1 software.

3.2.4. Riparian Wetlands

They are generally low-sloping lands with flooded or moist soils that support all types of vegetation. Its moisture is derived from stream and river water levels or as a result of rising groundwater levels, or both. It should be noted that we can derive the modeling of these areas depending on the density of the vegetation cover, as the dense areas indicate the existence of areas with high humidity. Therefore, the visualizations of Landsat in its eighth edition for the fourth and fifth packages were relied upon by applying the NDVI vegetative index equation, to reach the wetland model within the secondary basins based on the digital matching or the intersection of linear features within the GIS program environment, specifically the intersect tool based on the spatial correspondence language of geographical phenomena from In order to reach building relationships. Then, its results are extracted from Table (3) and Map (5)

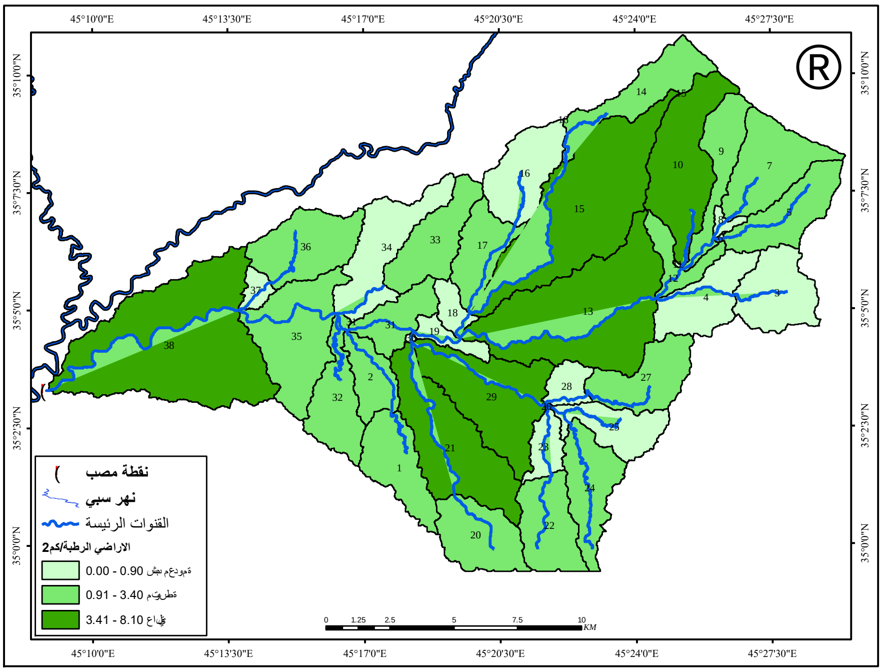

Figure 7. Distribution of wetland levels according to secondary basins
Source: Based on the ndvi equation, and the intersect tool, using ARC GIS10.6.1 software.

Table 3. The spatial correspondence of the secondary basins with the area of the wetlands

%Percentage of wet land from the basin	Wetland area/km2	Basin area/km2	Basin number
20.83	1.6	7.7	1
50.71	2.4	4.7	2
6.12	0.5	8.2	3
10.45	0.8	7.7	4
38.62	3	7.8	5
0.00	0	0.1	6
34.19	3.4	9.9	7
13.25	0.1	0.8	8
30.23	1.9	6.3	9
28.42	3.8	13.4	10
0.00	0	0.1	11
37.46	1.3	3.5	12
17.97	4.6	25.6	13
21.85	1.7	7.8	14
18.32	4.7	25.7	15
11.00	0.9	8.2	16
25.51	1.6	6.3	17
23.72	0.5	2.1	18
14.18	0.3	2.1	19
16.32	1.3	8.0	20
25.11	3.8	15.1	21
15.38	1.2	7.8	22
6.74	0.2	3.0	23
20.04	1.6	8.0	24
15.06	0.9	6.0	25
0.00	0	0.0	26
20.77	1.6	7.7	27
27.35	0.7	2.6	28
36.65	5.3	14.5	29
0.00	0	0.1	30
27.41	1.4	5.1	31
28.41	2.1	7.4	32
17.91	1.4	7.8	33
7.97	0.8	10.0	34
21.34	2.8	13.1	35
21.20	2	9.4	36
13.48	0.2	1.5	37
25.00	8.1	32.4	38
22.30	68.5	307.2	المجموع

Source: Based on ARC GIS10.6.1

3.3. Human Settlers.

Water plays an important role in determining the pattern of distribution of human settlements and their number in the study area. As it provides fresh water supplies for drinking and agriculture, specifically in the mountain basins, since most of its inhabitants practice the craft of grazing. These practices come with nature as a necessary step to make villages more resilient to the harmful effects of climate change. Similar to the oscillating geomorphological processes that shape the earth's surface, the river processes reflect their influence in shaping villages continuously.

In the study area, there are many randomly distributed villages whose population is dominated by the grazing craft, which prevails in the areas adjacent to the main streams, specifically within the floodplain and river bends.

The villages were modeled using modern high-resolution visualizations and distributed according to the secondary basins, to find out which basins are more active in housing, as shown in Map (6). The number of villages in the study area was (26), as shown in Table (4).

Table 4. The number of human settlements according to the secondary basins

Number of villages	Basin No	Number of villages	Basin No
0	21	1	1
0	22	1	2
0	23	1	3
2	24	1	4
0	25	1	5
0	26	0	6
2	27	0	7
0	28	0	8
2	29	1	9
0	30	1	10
0	31	0	11
0	32	1	12
0	33	3	13
2	34	0	14
2	35	1	15
1	36	0	16
0	37	0	17
3	38	0	18
		0	19
26	Total	0	20

Source: Based on Quick Bird visualization, with a resolution of 60 cm, using Arc Gis 10.6.1.

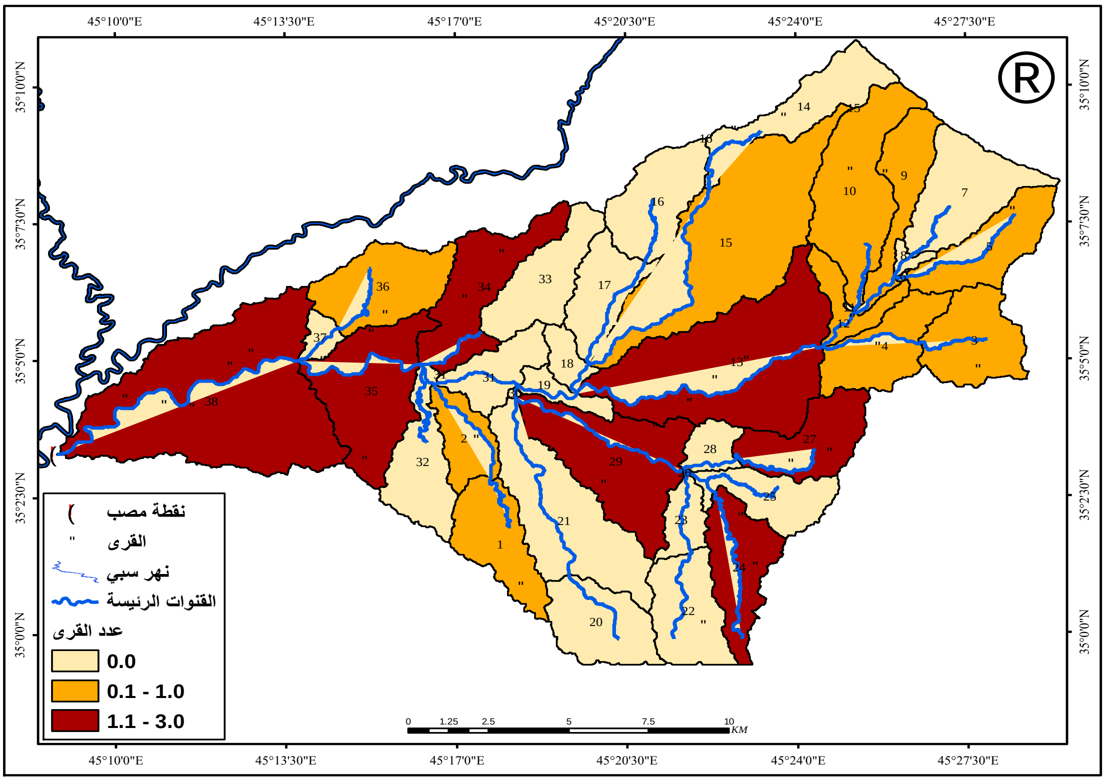

Figure8. Distribution of human settlements at the basin level

Source: Based on Quick Bird visualization, with a resolution of 60 cm, using Arc Gis 10.6.1.

4. conclusions

The study showed that the most stable and important areas in management and can be used for sustainable use are located in the mouth and middle of the basin, according to the modeling results, and are the most responsive.

GIS software has the ability to design and build models of hydrological hydrological characteristics, based on Boolean Algebra, in the environment of (ARC GIS) program, and its goal is accuracy in the results first, and preparing the first step for designing a program in this regard second, and supporting the concerned parties in this regard. Planning templates III.

The application of the derivation of the contribution density model has added spatial accuracy to build the model in spatial fit and to determine which basins are more active, and the possibility of exploiting them in order to reach sustainable development depending on the ideal results in the outputs of this model.

Recommendations

1. Researching the design of several models to simulate the hydrological characteristics of the basin and building layers in the form of maps that reveal facts for all phenomena within the basin unit, and then analyze and interpret these maps.

2. Using (AGWA2) in hydrological studies in consulting projects within mountainous and semi-mountainous regions, as it is one of the most accurate methods because it estimates the volume of water and sedimentary revenues, and this depends on the accuracy of the data.

3. Building high-tech hydrological models for all variables through which decision makers can be supported in setting up investment projects to serve people.

4. Removing the isolation from the villages that live in mountainous areas, by providing them with basic services in order to achieve security and well-being for their residents, as they are isolated areas and the nature of their inhabitants is dominated by instability, due to their practice of grazing.

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Monitoring of Water Quality: Review

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Abstract: Different methods and criteria are used to assess the water quality in the world. In this research, 45 types of research published worldwide were highlighted to determine the best method for assessing water quality worldwide. We classified the methods/tools applied to assess water pollution into five main groups: (GIS, remote sensing, laboratory analysis, traditional method, and artificial neural networks). The results were that the percentage of research for each group (method) applied in 45 articles is: 31% for remote sensing, 29% for GIS, 21% for laboratory analysis, 12% for the traditional method, and 7% for artificial neural networks. Traditional methods are complicated and require time and cost, so we recommend using remote sensing and GIS as quick methods with high-accuracy results. As for parameters, the highest parameters used by the researchers are (Turbidity, Dissolved Oxygen, and chlorophyll-a) with a percentage of 8%, and the lowest parameters used by the researchers were (Potassium, Alkalinity, and Manganese), and the percentage is 2%.

1. Introduction

The water supply of various bodies of water, such as rivers, streams, springs, and lakes, is often referred to as surface water. Due to the presence of pollutants and anthropogenic influences, it is considered a critical issue in several countries [1,2]. The effect of anthropogenic factors, the chemical composition of the river basin, and natural processes such as the interaction of water with a lithogenic structure are some of the factors that have been studied [3,1]. Surface water quality has been degraded to such an extent that it is unsuitable for drinking water, agriculture, and industry [4-6].

The river's water quality is affected by various natural processes and anthropogenic activities, such as the discharge of industrial and agricultural wastes into the river[7]. Industrial and agricultural wastes are the primary sources of pollution affecting the river [8-10]. Since rivers are the main source of freshwater for humans, they must be protected from pollution. Having reliable information about the river's water quality is also essential to manage them effectively. Monitoring and assessing rivers' water quality is also necessary to ensure that they are protected from further degradation [11,10]. The various characteristics of water, such as its physical, chemical, radiological, and aesthetic properties, are known as water quality [12,13].

Due to the increasing vulnerability of developing nations to pollution, and the need to protect freshwater, regular assessments of its quality are essential [14,15]. A water quality index is a quantitative method used to evaluate the water's characteristics. It is derived from a complex process involving the analysis of various water quality parameters [16,17]. Although individual parameters can be used to evaluate the water quality of a river, this method could be more practical due to the high concentration of variables involved [18]. Most countries prefer to use the WQI method to evaluate the water quality of their rivers. It is effortless to understand and is single-valued [19].

Date: October 2023

Several agencies and authors have also integrated different water quality parameters into their WQIs. This method yields different and varying indices [20-22]. Most of the WQIs currently used by governments are based on a single index developed by the US National Stopping Foundation [23].

In Iraq, rapid development and the river discharge decrease are causing severe water shortages. The increasing prevalence of water contamination and pollution also worsens the country's water problems. Traditional methods of water sampling, which involve in-situ measurements, are very time-consuming and costly. The development of remote sensing techniques has made it possible to perform water quality assessments using RS data. This method allows for establishing a model that can easily follow the water quality parameters. Proper in-situ validation is required to improve the accuracy of the data collected by remote sensing systems [24].

Scientists have also made various labors to improve the models' accuracy in water quality assessments. Four different methods can be used for analyzing and monitoring water quality [25]. One of these is the statistical method, commonly used in the semi-analytical and analytical methods. The data collected by remote sensing systems can then be used to establish a model that can follow the water quality parameters. To perform an inversion algorithm, the relationship between the characteristics and feature bands of the data can be analyzed [26]. Typical empirical methods involve linear regression, band combination, single-band, artificial neural network, and so on.

Although there is a wide variety of methods and criteria used in water quality assessments, little attention has been paid to the effectiveness of these tools in assessing the effects of pollution on the water supply. This study aimed to analyze the data collected from various sources over the past three decades. We collected and analyzed 45 studies published in scientific journals, reports of international organizations, or sources of information obtained from practitioners. The increasing attention paid to the issue of water pollution has prompted the development of new procedures and techniques for assessing it. Introducing new technologies, such as remote sensing systems, geographic information systems (GIS), and computer technology, has led to the development of more accurate and timely methods for monitoring and assessing water pollution. Section 2. summarizes the various criteria and methods used in water quality assessments.

2. Materials and Methods

Different methods can be utilized for water pollution assessment. The number of research for each type, such as Remote Sensing (RS) (22), Geographic Information System(GIS) (20), Traditional method (8), Laboratory analysis (15), and Artificial Neural Networks (ANNs) (5). We have classified the methods for water pollution assessment into five main groups: 1) Remote Sensing (RS) (e.g., [27-34] Geographic Information System(GIS) (e.g. [35- 40]) 3) Traditional method (e.g. [41- 44]) 4) Laboratory analysis (e.g. [45]) and 5) Artificial Neural Networks (ANNs)(e.g. [46]). As shown in figure 1, the percentage of each method utilized by the 45 articles was: 31% for group remote sensing, 29% for set GIS, 21% laboratory analysis, 12% traditional method, and 7% ANNs. The following sections include a description of each method individually, data and systems requirements, applicability and limitations, and Examples of studies that have used these methods in evaluating water pollution.

2.1 Remote Sensing (RS)

RS stands for remote sensing, the measurement and observation of objects that are not touched [27]. RS also refers to the acquisition of data about a thing that is not directly connected. This is done using sensors without direct contact with the body [28]. According to Bachiller Jareno, RS is regarded as the art and science of collecting data about surface phenomena that are not contact with the body [29]. Through sensors, remote sensing systems can collect data about surface phenomena that emit or reflect energy. This information can then be used to develop new and valuable applications [30,31]. Remote sensing systems use aerial platforms and satellites to collect images of the Earth. Using different image processing techniques, they can also distinguish the other features of the planet's surface. In addition to monitoring the water levels in small dams, remote sensing can also be utilized to analyze the quantity of water stored in them [32]. Through remote sensing, one can now gain valuable information on soil characteristics on different spatial scales [33]. In Iraq, remote sensing techniques have allowed authorities to address the country's water scarcity. This method can also help farmers and commercial entities meet their water needs [34].

2.2 Geographic Information System(GIS)

In 1963, Roger Tomlinson created the Geographic Information System, a computer-based device. This device usually stores and visualizes geographic information [35-37]. A GIS is a computer system that manages, analyzes, and visualizes geographic information [38]. A spatial data set comprises the coordinates of various points in a geographic area. This information can be used to develop new and useful applications related to urban planning, agriculture, and water management.

According to a recent study, the use of geographic information systems (GIS) for analyzing water supply projects has allowed authorities to make informed decisions and improve the efficiency of their operations [39]. Modern technology can help address the data shortage related to water resources management. It will allow authorities to develop a more accurate runoff estimate [40].

2.3 Traditional method

Traditional field methods for monitoring various environmental parameters, such as water quality, were time-consuming and expensive. They required a lot of specialized equipment and personnel, and they did not provide a comprehensive view of the water quality in a region [41]. Due to the complexity of the task and the time involved in monitoring water quality, traditional field methods could not provide a complete view of the condition of the water [42-44].

2.4 Laboratory analysis

A broad description of the various procedures involved in analyzing water quality is provided in Water Quality Testing. These procedures are performed to ensure that the water is safe to drink [45].
Besides testing for drinking water, water testing also involves monitoring other environmental parameters, such as industrial effluents, groundwater, and domestic wastewater.

2.5 ANNs

One of the most essential advantages of using a neural network method for analyzing water quality is its ability to retrieve various parameters simultaneously without requiring prior knowledge about the relationships between them. This is very important to minimize the uncertainties caused by the different background factors affecting water quality. The main advantage of using a neural network technique is that it can process information in a similar manner to that of the human brain. This type of system was developed using inspiration from how our nervous system works [46].

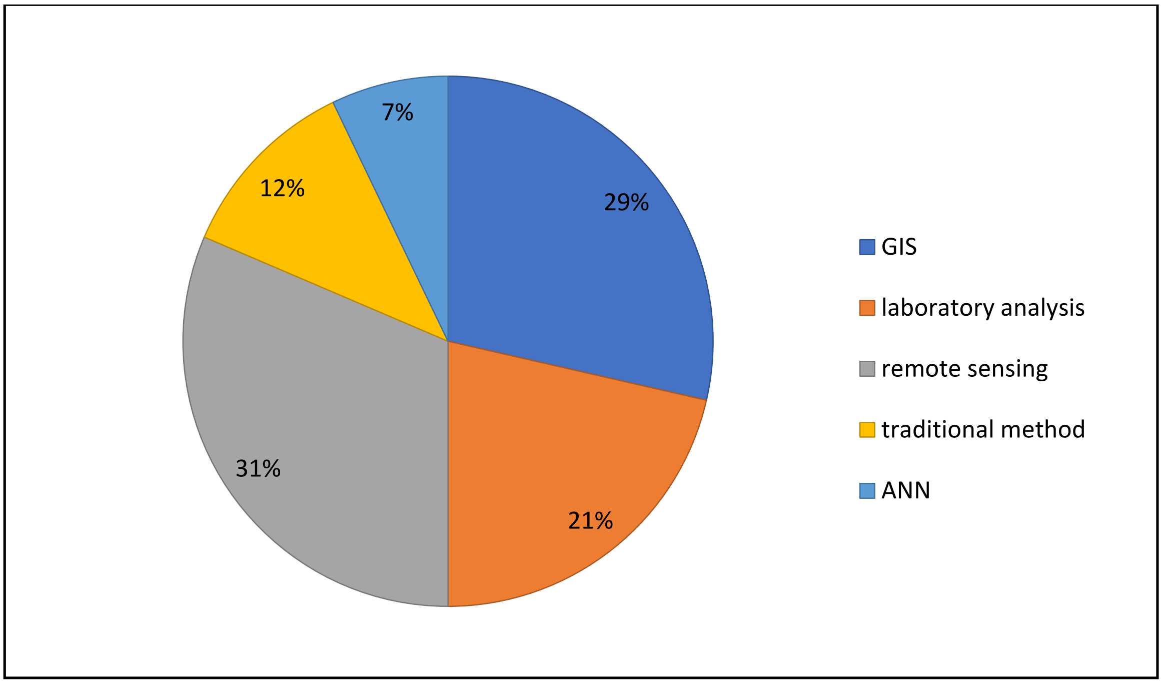

Figure 1. The percentage of methods.

3.Results and Discussion

The assessment of water pollution depends on several parameters. Several studies in the world used different parameters with various methods. The most communal parameters used in water pollution assessment were applied as a percentage of the article reviewed: turbidity (8%), Total Suspended Solids (TSS) (5%), Total Dissolved Solids (TDS) (6%), Dissolved Oxygen (DO) (8%), Water temperature (7%), Biochemical Oxygen Demand (BOD) (5%), Chemical oxygen demand (COD) (5%), Chlorophyll-a (Chl-a) (8%), PH (7%), Conductivity (6%), Nitrate (NO 3) (6%), Total phosphorus (TP) (6%), Alkalinity (2%), Chlorides (5%), Hardness (3%), Manganese (2%), Magnesium (3%), Calcium (4%), Potassium (2%), Sodium (3%) (Show in the figure 2). A description of each parameter individually that has been used in evaluating water pollution is in the following sections.

1.1. *Turbidity*

The term turbidity refers to the cloudiness or haziness of a fluid. This is a vital parameter that determines the quality of water. The scattering of particles or light absorption can cause it [47]. (8%) of the reviewed article adopted the Turbidity factors e.g. [47].

3.2 Total Suspended Solids (TSS)

The amount of suspended particles in a sample is called the dry weight. This is determined by a filter that can be used to analyze the water [47]. (5%) of the reviewed article adopted the Turbidity factors e.g. [47].

3.3 Total Dissolved Solids (TDS)

The total dissolved solid measures a liquid's organic and inorganic substances. It can be measured by comparing the total dissolved solids in a sample with the total dissolved content in a liquid [47]. (6%) of the reviewed article adopted the Turbidity factors e.g. [47].

3.4 Dissolved Oxygen (DO)

The level of free oxygen present in a water sample is known as dissolved oxygen. This is a vital parameter that can be used to determine the water quality because it can affect the organisms that live in the water [47]. (8%) of the reviewed article adopted the Turbidity factors e.g. [47].

3.5 Water temperature

Temperature is a vital factor affecting water's various biochemical, physical, and chemical processes [48]. (7%) of the reviewed article adopted the Turbidity factors e.g. [48].

3.6 Biochemical Oxygen Demand (BOD)

The BOD or Biochemical Oxygen Demand is a measure of the level of oxygen that water-borne bacteria require to survive and thrive in conditions that are favorable to their growth. Some food sources these organisms can rely on are organic waste from septic systems and industrial facilities [48]. (5%) of the reviewed article adopted the Turbidity factors e.g. [48].

3.7 Chemical oxygen demand (COD)

The chemical oxygen demand or COD is a measure of the quantity of matter that's required to be oxidized in water. In the case of chemical oxygen demand, there is no difference between inert and biological materials. The total amount of oxygen required to break down all organic materials into water and carbon dioxide [48]. (5%) of the reviewed article adopted the Turbidity factors e.g. [48].

3.8 Chlorophyll-a (Chl-a)

The Chl-a form of chlorophyll is a proxy for phytoplankton concentration in surface waters [49,50]. In coastal and open oceans, chlorophyll-a's presence can be considered an important optical active variable [51]. (8%) of the reviewed article adopted the Turbidity factors e.g.([49],[50],[51]).

3.9 pH

The pH level is a vital factor that can affect the properties of a liquid. For instance, a low pH can make certain elements, such as metals and minerals, more available to the body. On the other hand, a high pH can make heavy metals less toxic. In addition, a low pH can negatively affect certain applications of water [52]. (7%) of the reviewed article adopted the Turbidity factors e.g. [52].

3.10 Conductivity

The Conductivity of a liquid is a measure of how it can pass an electrical current. When a sample's level of dissolved salts increases, this can result in higher Conductivity. Conductivity can also be affected by temperature. For instance, if the water's temperature is higher, this can lead to a higher conductivity [53]. (6%) of the reviewed article adopted the Turbidity factors e.g. [53].

3.11 Nitrate (NO_3)

In addition to being present in our diet, nitrate is also found in nature. It can naturally occur and be made by humans. Nitrate can be found in various bodies of water, such as rivers, lakes, and groundwater [54]. (6%) of the reviewed article adopted the Turbidity factors e.g. [54].

3.12 Total phosphorus (TP)

When it comes to monitoring the health of a waterway, total phosphorus or TP is a measure of the amount of phosphorus found in a sample. This is commonly used in wastewater treatment. In addition to being present in our diet, phosphates can also be found in various compounds. One of these is the phosphate ion, which can be found in soil, water, and sediments [55]. (6%) of the reviewed article adopted the Turbidity factors e.g. [55].

3.13 Alkalinity

A measure of the water's ability to neutralize various chemicals is known as its alkalinization. It can be determined by comparing the level of these chemicals with the amount of acid in the water. A water body's ability to maintain a low pH level is referred to as its buffering capacity [56]. (2%) of the reviewed article adopted the Turbidity factors e.g. [56].

3.14 Chlorides

One of the most common water pollutants is chlorides. An overabundance of these chemicals in ocean water can lead to their non-applicability to drinking water. Due to the development of desalination techniques, this hurdle has been reduced significantly. The accumulation of salt in nearby areas and the dissolution of industrial wastes are some factors that can cause the presence of chlorides in surface waters. They can also contribute to the formation of well water pollution. Although chlorides have a mild effect on living organisms, excessive consumption can lead to severe poisoning or damage [57]. (5%) of the reviewed article adopted the Turbidity factors e.g. [57].

3.15 Hardness

The presence of two non-toxic chemicals in drinking water, magnesium, and calcium, can cause hardness. The water is considered hard if these chemicals are present in large amounts. This is because washing your hands or making a soap-like product can be hard. Water with little magnesium or calcium is referred to as soft [58]. (3%) of the reviewed article adopted the Turbidity factors e.g. [58].

3.16 Manganese

Minerals, soil, and rocks can also contain manganese, which is a common element. Although manganese is naturally found in groundwater, its levels can increase due to mining and steel production activities. In Wisconsin, manganese can cause the water to turn brown or rust color. It can also cause staining of various surfaces, such as faucets and sinks. Varying levels of manganese can be found in the state's groundwater [59]. (2%) of the reviewed article adopted the Turbidity factors e.g. [59].

3.17 Magnesium

The presence of alkali earth metals, such as magnesium, can also cause water hardness. Water with significant amounts of these minerals is called hard water. On the other hand, water that has low amounts of these minerals is called soft water [60]. (3%) of the reviewed article adopted the Turbidity factors e.g. [60].

3.18 Calcium

It is also helpful to determine the calcium content of water. This can help one decide if the water is soft or hard [61]. (4%) of the reviewed article adopted the Turbidity factors e.g. [61].

3.19 Potassium

The presence of potassium can also be used as an indicator of potential contamination. It can be attributed to the activities of industrial and agricultural facilities [62]. (2%) of the reviewed article adopted the Turbidity factors e.g. [62].

3.20 Sodium

The presence of sodium compounds in water is usually caused by the salt found in rocks and soils. Not only oceans but also bodies of water such as lakes and rivers contain large amounts of this chemical [63]. (3%) of the reviewed article adopted the Turbidity factors e.g. [63].

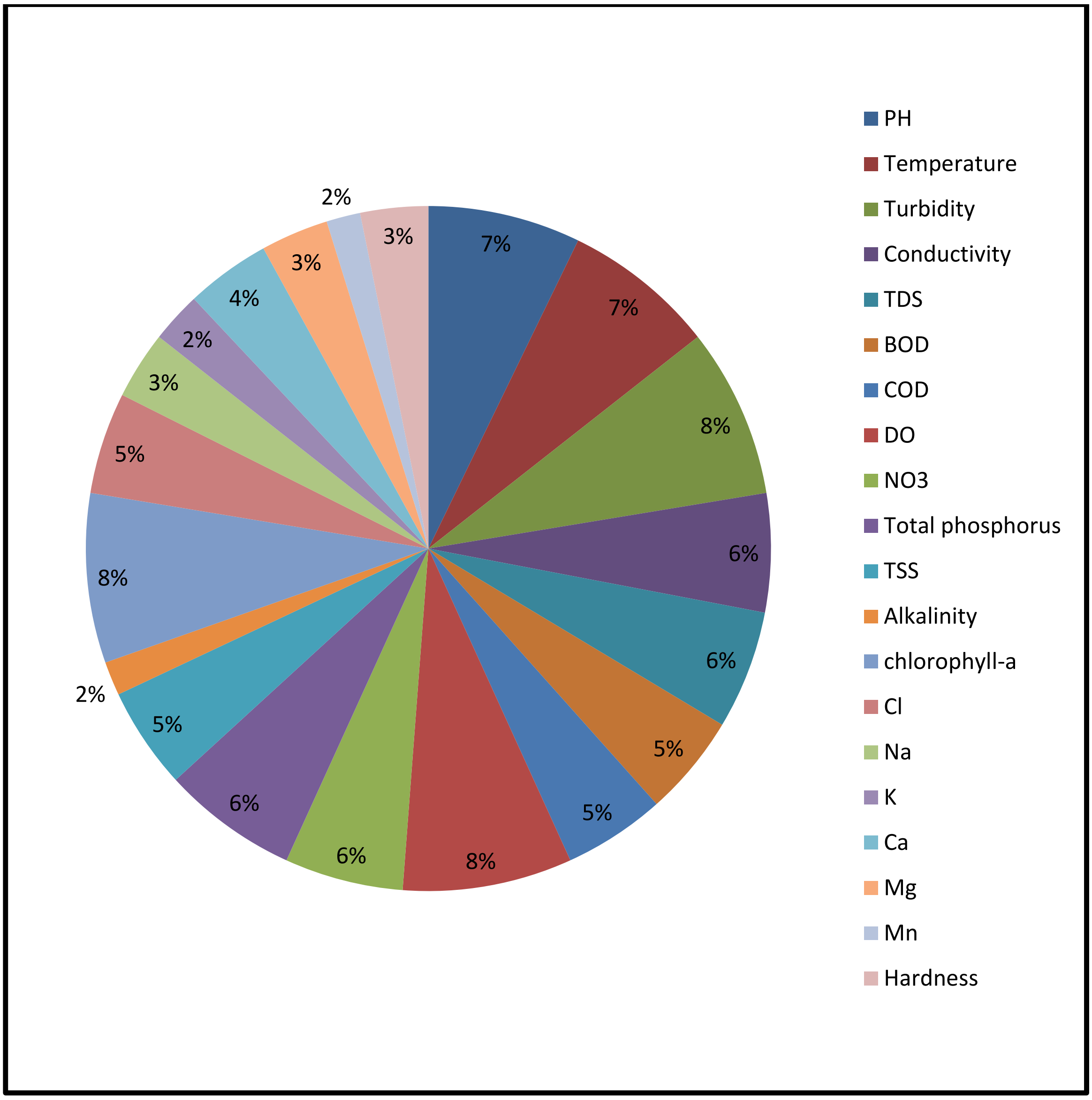

Figure 2. The percentage of parameters.

4.Conclusion

The main objective of this study is to define general methods and criteria used to assess the water quality in the world throughout the last three decades. This study concluded: Various techniques were included in water quality assessment, such as laboratory analysis, traditional methods, remote sensing, laboratory analysis, and artificial neural networks , Using GIS with modern technologies can help improve water quality management's efficiency and cost-effectiveness. It is not feasible to implement the traditional technology due to the time and expense involved in data collection, This research suggested using artificial neural networks for water quality assessment because they can work with inadequate data. The artificial neural network can still produce outputs even if the collected information is incomplete. This is why the country's scientists and engineers must be trained in using these new tools.

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Irrigation Water Requirements in Regions along Euphrates River in Iraq: Role and implications of Climate Change

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Abstract. This research aimed to predict how projected climate change will affect the quantity of water needed for irrigation. The case study focused on the Iraqi cities of Anbar and Babylon, located in the Euphrates River Basin (ERB). The CROPWAT model was fed by current and future climate data. Three climate change scenarios for the reference period from 1995-2014, SSP1-2.6 (2020-2039) and SSP2- 4.5 (2040-2059), were implemented in this research. The obtained results showed that annual increases in the temperature for Anbar are 1.1 and 1.85 °C, and for Babylon, they are 0.9 and 1.88 °C for the two scenarios SSP1- 2.6 and SSP2-4.5 concerning the reference period scenario. In addition, the annual decrease in precipitation is 3.61 and 4.63 mm for Anbar and 3.61 and 2.66 mm for Babylon Province. The average annual reference evapotranspiration for the three climate scenarios is 157, 202, and 206 mm for Anbar and 187.5, 195.6, and 224 mm for Babylon Province. The total annual irrigation water requirements for the crop growth cycle are 1.10, 1.43, and 1.46 for Anbar and 3.96, 4.13, and 4.76 billion cubic meters for Babylon.

1.Introduction

For long-term water resources management and planning, estimating agricultural water demand in the context of changing environmental conditions is crucial [1]. Due to increasing levels of greenhouse gases (GHGs) in the atmosphere, the world is confronting a significant climate change catastrophe [2]. Decreasing precipitation levels and decreasing runoff, coupled with higher evapotranspiration due to regional warming, lead to reduced soil moisture and groundwater recharge. The rain-fed and irrigated agriculture in the Euphrates basin is affected by climate change [3]. Growing climate-related water risks will increase the demand for adaptation to climate change. It will also make cross-border water cooperation more complex. High dependence on freshwater resources from outside the territory of any country increases vulnerability to water insecurity. Water stress is boosting the incentives for upstream governments to make maximum use of water resources in the face of growing demand and shortage [4]. The Iraqi population will increasingly face water shortages due to the country's location in a semi-arid zone highly vulnerable to climate change [5]. Iraq experiences high evaporation losses in its dams despite the construction of most of the capacity of major dams and the high potential for water storage per person [6]. Iraq now faces significant challenges due to global climate change [7].

Iraq's water supply decreased by about 30% in the 1980s and 50% in 2030. The global water supply is expected to decrease by up to 60% between 2015 and 2025. In 2018, there was a dry summer, and the following winter of 2017-2018 is expected to be abnormally dry, with rainfall approximately a third below average. Additionally, a harvest loss of approximately 30% compared to the previous year is anticipated [8]. Al-Faraj et al. [9] showed that climate change influences the availability and consumption of water when developing strategic plans. For both riparian nations to benefit from favorable water resource conditions, particularly in transboundary basins, a shared understanding and the establishment of cooperative actions are crucial. The effects of future climate change on the Great Zab River have been assessed by [10]. The watershed studied is in northern Iraq, where the river flow is crucial for the subsistence of the local population. The objective is to examine the effects of climate

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change in the short, medium, and long term to inform the water management authority in the catchment of their future to determine agricultural water demand and climatic water availability (CWA). Salman et al. [11] conducted a research study to explain future agricultural water stress in Iraq for various Radiative Concentrating (RCP) methods. RCP8.5 showed that CWA will decline at a rate of up to -34 per year from 2010 to 2099. The most significant decline would occur in the summer -29 per year, while the smallest decline would occur in winter. Crop water stress would increase significantly in Iraq due to a decrease in CWA and an increase in crop water demand (CWD).

The CROPWAT model is beneficial in calculating agricultural irrigation needs for proper water resource management [12]. The CROPWAT model has been used by many researchers to calculate and evaluate water needs and schedules irrigation for different agricultural crops [13,14,15,16].

Ewaid et al. [17] used CROPWAT 8.0 software to estimate the quantities of the four primary cereal crops imported into Iraq and assess the impacts on water footprint and land savings over the ten years from 2007 to 2016. Saeed et al. [18] used CROPWAT 8.0 software to estimate the net demand variation for irrigation water of the North Jazeera project, the Kirkuk Irrigation, the Upper Khalis Irrigation Project, and the Dalmaj Irrigation Project. Saeed et al. [19] used the CROPWAT to predict future crop evapotranspiration and net irrigation water requirements.

Several studies have been conducted in Iraq on the impact of climate change on water availability [20,21,10]. A few studies have also assessed the impact of climate change on irrigation water demand in Iraq [11,18]. However, no study focused on assessing the impact of future climate variability on irrigation water demand in the Euphrates River Basin (ERB). This study aimed to predict climate change scenarios' impact on irrigation water requirements for the Iraqi provinces of Anbar and Babylon within ERB. The collected climate data of 1995 - 2014 is the basis and the reference period for the projection climate data of the two scenarios, SSP1-2.6 (2020-2039) and SSP2-4.5 (2040-2059), respectively. This data includes temperature, precipitation, and relative humidity. The CROPWAT model was implemented to calculate net irrigation during the same periods. This approach is used to analyze and estimate the future influence of climate change on water demand in the ERB.

2. Materials and Methods

2.1. Study Area

The province of Anbar is one of the biggest in terms of land area in Iraq, where equal to 137,808 km2 or 31.7% of Iraq's total area which is 435052 km2. Anbar province is in the western portion of the country. The Longitudes (40°,28',12") and (41°,25',48") of the east and the Latitudes (34°,24',54") and (34°,11',6") of the north [22]. Babylon province is located in central Iraq, south of Baghdad, The Longitudes (43° 58' 10") and (44° 38' 35") east of Greenwich and Latitudes (32° 7' 25") and (33° 0' 35") north of the Equator. The area of the Babylon province equals 1.18 % of Iraq's total area. Anbar and Babylon are located throughout the length the Euphrates River Basin [23]. Figure 1 depicts the layout map for Anbar and Babylon provinces.

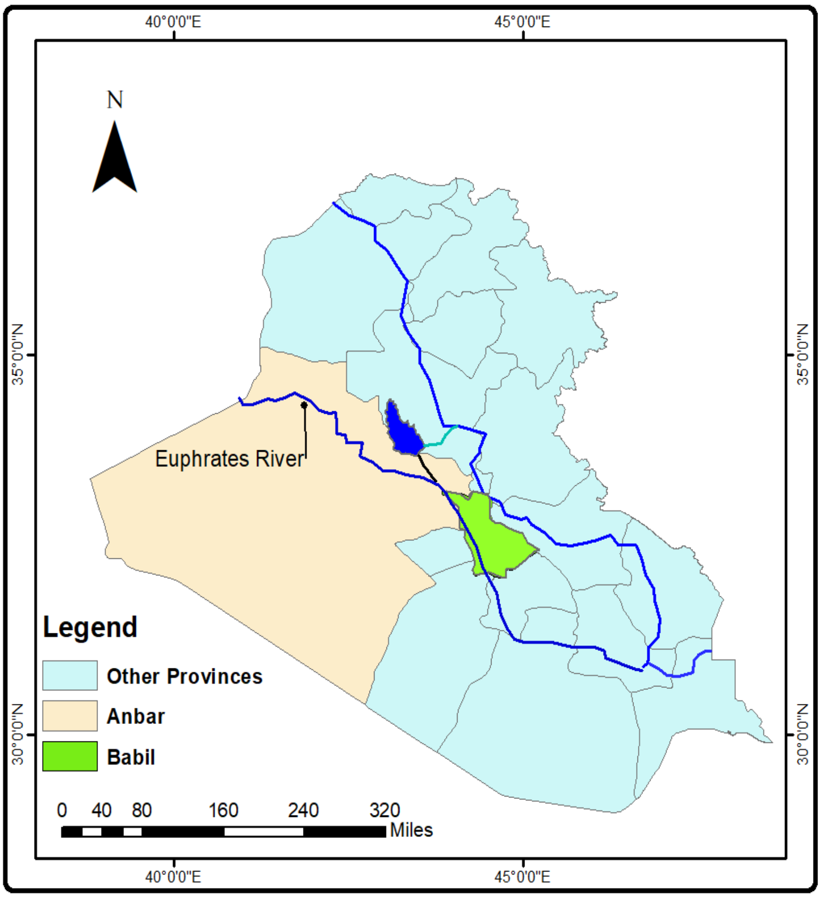

Figure 1. Layout map for the study area.

2.2. Estimation of the Net irrigation water demand

The CROPWAT software depends on the climatic data to calculate the monthly and annual reference evapotranspiration by applying the Penman-Monteith. The Penman-Monteith method can be determined as the reference surface evapotranspiration (ETo) [24]. This method of estimation can be expressed as follows:

$$ETo = \frac{0.408\Delta(R_n - G) + \gamma\left(\frac{900}{T+273}\right)u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \quad (1)$$

Where R_n is the net radiation at the crop surface ($MJm^{-2}day^{-1}$), G is the soil heat flux density ($MJm^{-2}day^{-1}$), T is the average daily air temperature at 2 m height °C, u_2 is the wind speed at 2 m height $m\ s^{-1}$, e_s is the saturation vapour pressure KP_a, e_a is the actual vapour pressure (KP_a), ($e_s - e_a$) is the saturation vapor pressure deficit (KP_a), Δ is the slope vapor pressure curve(KP_a°C $^{-1}$), γ is the psychrometric constant (KP_a°C $^{-1}$). The equation of crop evapotranspiration can be represented mathematically as the following:

$$Etc = Kc \times ETo \quad (2)$$

Where Etc is the crop evapotranspiration ($mm\ day^{-1}$), Kc is the crop coefficient [24]. Net irrigation water requirements were evaluated by using the equation:

$$NIWR = Etc - Re \quad (3)$$

Where Re: is the effective rainfall ($mm\ day^{-1}$), and NIWR is net irrigation water requirements ($mm\ day^{-1}$)[25].

2.3. Irrigated Area and Crops Data

The net irrigation area for Anbar and Babylon is equal to 115310.5 and 345675 Hectares, respectively. Thirty-two seasonal and annual crops, including wheat, barley, vegetables, rice, and citrus, were strategically planted in the provinces of Anbar and Babylon [23]. The crop coefficient reflects the difference in evapotranspiration between field crops and the reference grass surface. It varies even during the growing period of the same crop, as the ground cover changes with crop development stages. The crop coefficient curve, which only has three values, illustrates typical trends during the growing season. The crop coefficient, maximum crop height, and the plant growth development stages for various planting periods were according to [24] and the database of the CROPWAT software. Table 1 shows the crop coefficients for 32 strategic crops and average maximum plant heights: Table 2 illustrates the lengths of crop development stages for various planting periods.

Table 1. FAO coefficients crops and maximum plant heights

Crop	**Coefficient Crop (Kc)**			**Max. Crop Height (m)**
	Initial Stage	**Medium Stage**	**EndStage**	
Barley	0.3	1.15	0.25	1
Broad Bean	0.5	1.15	1.1	0.8
Cabbage	0.7	1.05	0.95	0.4
Cauliflower	0.7	1.05	0.95	0.4
kidney Beans	0.5	1.05	0.9	0.4
Onion	0.7	1.05	0.75	0.3
potato(spring)	0.5	1.15	0.75	0.6
Wheat	0.7	1.15	0.25	1
Cotton	0.35	1.2	0.6	1.5
Cucumber	0.6	1	0.75	0.3
Eggplant	0.6	1.05	0.9	0.8
Groundnut	0.4	1.15	0.6	0.4
Maize(spring)	0.7	1.2	0.6	2
Okra	0.4	1	0.9	2
sweet pepper	0.6	1.05	0.9	0.7
Rice	1.1	1.2	1.05	1
Sesame	0.35	1.1	0.25	1
Sorghum	0.3	1	0.55	2
soya bean	0.4	1.15	0.5	1
Sunflower	0.35	1.15	0.35	2
Tomato	0.6	1.15	0.7	0
Tobacco	0.5	1.15	0.8	1.2
Watermelon	0.4	1	0.75	0.4
Alfalfa	0.4	1.2	1.15	0.7
Citrus	0.7	0.65	0.7	4
date palm	0.9	0.95	0.95	8
Grape	0.3	0.85	0.45	2
Olives	0.65	0.7	0.7	5
Sugarcane	0.4	1.25	0.75	3
Pomegranate	0.6	0.95	0.75	3
stone fruit trees	0.4	0.9	0.65	3
green gram	0.5	1.05	0.9	0.4

Table 2. The lengths of crop development stages for various planting periods (Days)

Crop	Initial	Development	Mid-season	Late-season	total
Barley	24	55	73	48.48	202
Berseem	46	69	69	45.8	229
Broad Bean	84	43	38	0	165
Cabbage	52	78	65	19.53	217
Cauliflower	41	59	48	18.15	165
kidney Beans	16	27	27	10.53	81
Onion	25	43	132	53.13	253
Potato	28	33	33	32.76	126
Wheat	21	63	74	32.3	190
Cotton	23	39	47	42	150
cucumber	21	30	42	16.5	110
eggplant	25	38	34	21.24	118
groundnut	44	56	44	31.5	175
Mung bean	19	43	29	18.7	110
Maize	23	36	40	26.25	125
Okra	22	30	83	22.4	160
sweet pepper	20	29	38	28.75	115
Rice	19	38	42	18.88	118
sesame	21	39	50	32.89	143
sorghum	20	30	60	25.84	136
soya bean	27	36	52	26.6	140
sunflower	29	39	39	24.7	130
tomato	30	25	35	25.3	115
tobacco	17	33	33	49.4	130
watermelon	21	41	41	20.91	123
Alfalfa	all seasons*	all seasons	all seasons	all seasons	all seasons
Citrus	all seasons	all seasons	all seasons	all seasons	all seasons
date palm	all seasons	all seasons	all seasons	all seasons	all seasons
Grape	all seasons	all seasons	all seasons	all seasons	all seasons
Olives	all seasons	all seasons	all seasons	all seasons	all seasons
pomegranate	all seasons	all seasons	all seasons	all seasons	all seasons
stone fruit trees	all seasons	all seasons	all seasons	all seasons	all seasons

*This note pertains to crops that can be grown and harvested in all seasons.

2.4. Climate Change Knowledge Portal (CCKP)

The sixth Climate Model Intercomparison Project (CMIP6) is a standard experimental framework for studying the output of coupled atmosphere-ocean general circulation models. Assessing the strengths and weaknesses of climate models can enhance and focus the development of future models [26]. In this study, the source of the climate change data is the Climate Change Knowledge Portal [27]. The General page of the CCKP presents the latest CMIP collection, CMIP6 data derived from the IPPC's Sixth Assessment Report. Several researchers used this method (CCKP) to project climate data, including [28,29, and 30]. The level of global radiation forcing by 2100, five scenarios with predicted temperatures are presented, ranging from "extremely low" SSP1-1.9 to "very high" SSP5-8.5. Calculation of the irrigation demand of crops in Anbar and Babylon by CROPWAT model depends on three scenarios of climate change data. The first is the reference period (RP) according to the collected data from 1995 to 2014. The second and third scenarios SSP1-2.6, and SSP2-4.5, represent the climate change data through the two periods, 2020 - 2039 and 2040 - 2059, respectively.

2.5. Reliability Analysis

The last step in their application will be to evaluate the performance of a measurement system after projecting the climate change data and simulating the agricultural model with CROPWAT software. Some fundamental statistics for calibration and verification measures are: (1) Coefficient of determination R2 describes the proportion of the variance in measured data explained by the model. R2 varies from 0 to 1, with higher values signifying less error variance, and typically values greater than 0.5 are considered acceptable [31]. R2 is used to evaluate the model's calibration and validation results [32]. With the assistance of Microsoft Excel, R2 was graphically derived.

(2) Nash-Sutcliffe Efficiency (NSE), called the coefficient of efficiency, demonstrates how closely the observed vs projected data plots the 1:1 equal value line. The Nash−Sutcliffe coefficient is like the coefficient of determination. However, instead of using the linear regression line of best fit, NSE compares the observed values to the 1:1 line of measured versus projected data [33]. The NSE evaluates the conformance between projected and observed data [32]. NSE is computed as shown in the following equation:

$$NSE = 1 - \frac{\sum_{i=1}^{n}(X_{obs} - X_{sim})^2}{\sum_{i=1}^{n}(X_{obs} - \bar{X}_{obs})^2} \tag{4}$$

X_{obs} is the observed value variable, X_{sim} is the simulated value variable, and $\overline{X}_{obs}$ is the mean of the observed values variable [31].

NSE ranges between −∞ and 1.0 (1 inclusive), with NSE = 1 being the optimal value. Typically, performance levels between 0.0 and 1.0 are considered acceptable, whereas values ≤ 0.0 demonstrates that the mean observed value is more accurate than the predicted value, which indicates unacceptable performance [31].

(3) The root mean standard error (RMSE) is a generally used error index statistic. If the RMSE recorded a lower value is better for the model performance [33]. The ratio between RMSE and the standard deviation of the observation data (STD_{obs}) is called (RSR). RSR standardizes RMSE using the observation's standard deviation and mixes an error index and the additional information recommended by [34]. RSR is calculated as the ratio of the RMSE, and standard deviation of measured data as shown in the equation:

$$RSR = \frac{RMSE}{STD_{obs}} = \sqrt{\frac{\sum_{i=1}^{n}(X_{obs} - X_{sim})^2}{\sum_{i=1}^{n}(X_{obs} - \bar{X}_{obs})^2}} \tag{5}$$

3. Results and Discussion

2.6. The Climate Change Effects

Figures 2 and 3 show the climate change data variation for Anbar Province for the three scenarios. Also, Figures 4 and 5 show the climate change data variation for Babylon Province. Figures 2 and 4 show the annual increases in the temperature for Anbar are 1.1 °C and 1.85 °C, and for Babylon, they are 0.9°C and 1.88 °C for the two scenarios SSP1- 2.6 and SSP2 - 4.5 concerning the reference period scenario. Figures 3 and 5 show the annual decrease in the precipitation are 3.61 mm and 4.63 mm for Anbar and 3.61 and 2.66 mm for Babylon, respectively. The maximum temperature variation for scenarios SSP1-2.6 and SSP2-4.5 in January equals 9.1 % and 17.5 % for Anbar province, and they were equal to 8.8 and 16 % in January for Babylon Province, respectively. The minimum temperature variation for scenarios SSP1- 2.6 and SSP2- 4.5 equals 4.3 % and 6.5 % in June for Anbar province, and they were equal to 4.3 % and 6.7 % in August for Babylon Province, respectively. The maximum variation of the precipitation for the scenarios SSP1-2.6 and SSP2-4.5 in October equals 10.1% and 4.5 % for Anbar province, and in September, they were equal to 86.8 % and 33.3 % for Babylon Province, respectively. The minimum variation of the precipitation for the scenarios SSP-2.6 and SSP-4.5 in February are equal to 2.36 % and 2 % for Anbar province and in April are equal to 4.5 % and 2.8 % for Babylon Province, respectively.

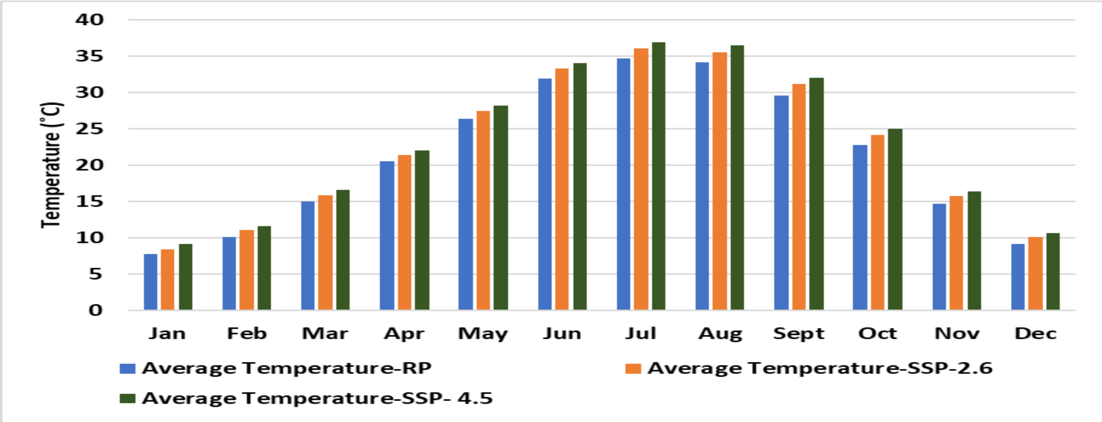

Figure 2. The projected temperature for the Anbar province.

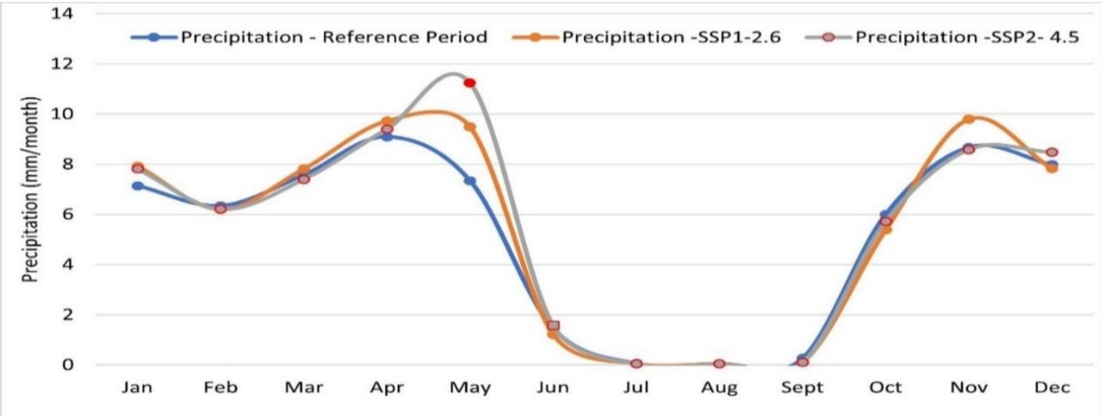

Figure 3. The projected precipitation data for the Anbar province.

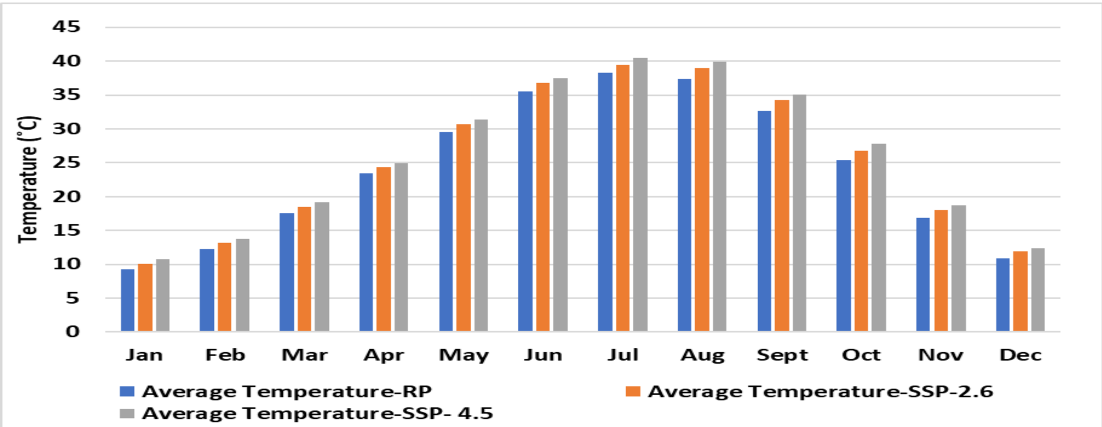

Figure 4. The projected temperature for the Babylon province.

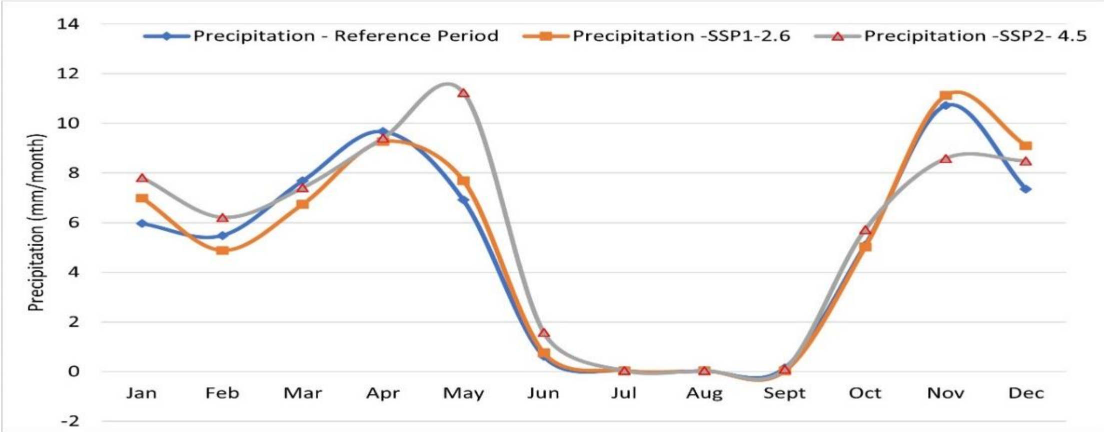

Figure 5. The projected precipitation data for the Babylon province.

2.7. Projection of The Irrigation Water Demand

Figure 6 shows the projected ETo for the three scenarios of the climate change RP, SSP1-2.6, and SSP2-4.5, for Anbar province, respectively. The months of May to September have relatively high values, equal to or more than 200 mm/month, and the months of October to April showed the lowest ETo, equal to or less than 150 mm/month, coinciding with the dry and rainy seasons, respectively. Figure 7 shows projected ETo the three scenarios of the climate change RP, SSP1-2.6, and SSP2-4.6 for Babylon province. The ETo from May to September was more than 240 mm/month, and the months of October to April showed the lowest ETo, equal to or less than 200 mm/month, coinciding with the dry and rainy seasons, respectively. In the dry season, the resulting low relative humidity combined with high temperatures led to increased evapotranspiration. Inversely the low values of ETo in the rainy season may be due to the high frequencies of rainfall combined with high relative humidity and relatively low temperatures. With the variations of these parameters, ETo will vary significantly within and between seasons. Figure 8 shows the mean value of the Anbar irrigation water demand for the three climate change scenarios. The total irrigation water was estimated at 730,944 and 966 mm for the dry season from May to September and, 227, 297 and 306 mm for the rainy season from October to April. The change in water irrigation demand for the dry and rainy seasons concerning the RP scenario is 29.2 and 32.2 % and 30.6 and 34.6 % for SSP1-2.6 and SSP2-4.5, respectively. Figure 9 shows the mean value of the Babylon irrigation water demand for the three climate change scenarios. The total irrigation water was estimated at 853,884 and 1036 mm for the dry season from May to September and 294.8, 312.5, and 341.8 mm for the rainy season from October to April. The change in water irrigation demand for the dry and rainy seasons is 3.6 and 21.4 % and 6 and 15.94 % for SSP1- 2.6 and SSP2-4.5, respectively. The high irrigation requirements during the dry season may be explained by the severe drought conditions and the resulting low relative humidity due to the lack of rain combined with high temperatures, which led to increased evapotranspiration. High evaporation occurs as a result to temperature increases, consequently increasing in agricultural water requirements. Figures 3 and 5 show no rainfall from July and August. The changes in irrigation water demand indicate the differences in water requirement even in the same season; this illustrates the importance of using scientific planning to effectively manage irrigation needs.

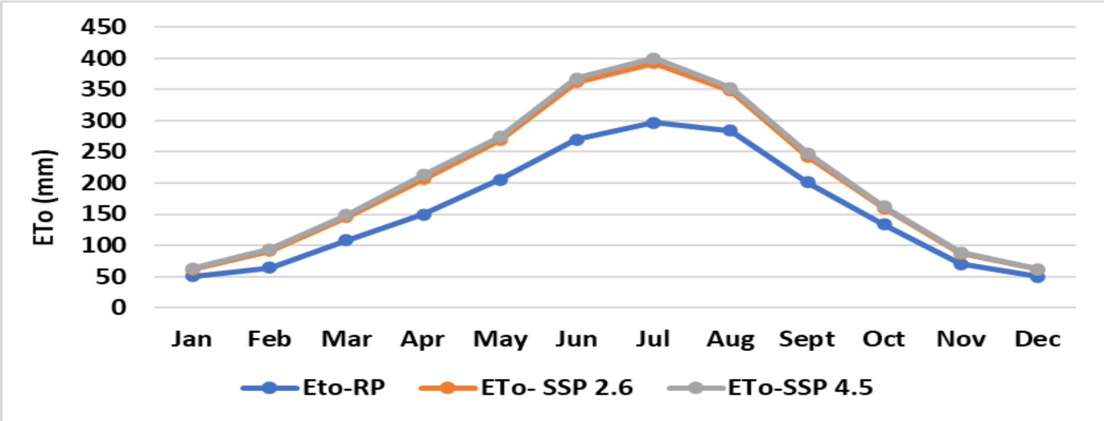

Figure 6. The projected ETo values for Anbar province climate change scenarios.

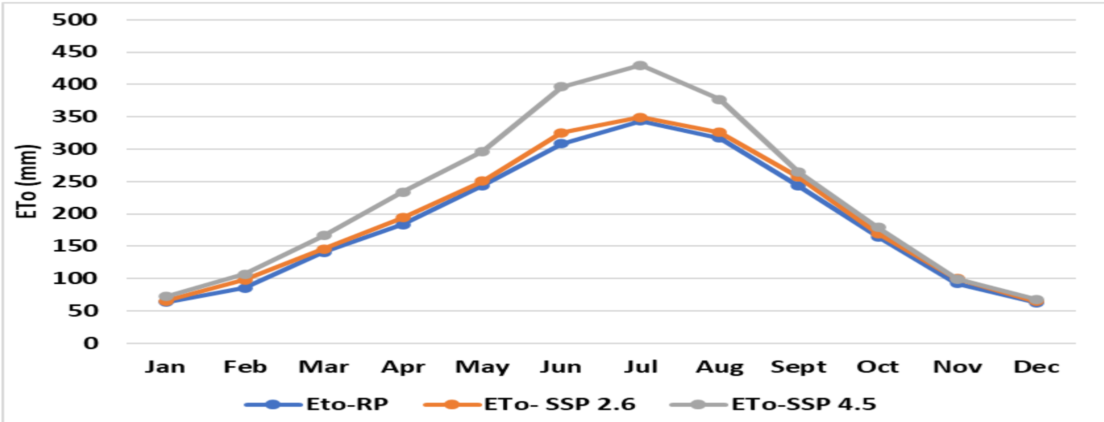

Figure 7. The projected ETo values of the climate change scenarios for Babylon province.

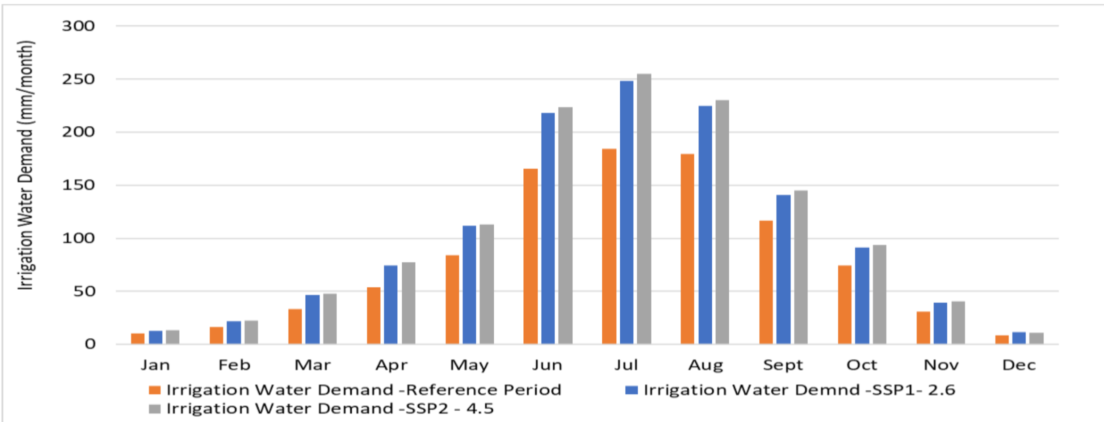

Figure 8. The projected irrigation water demand of the climate change scenarios for Anbar province.

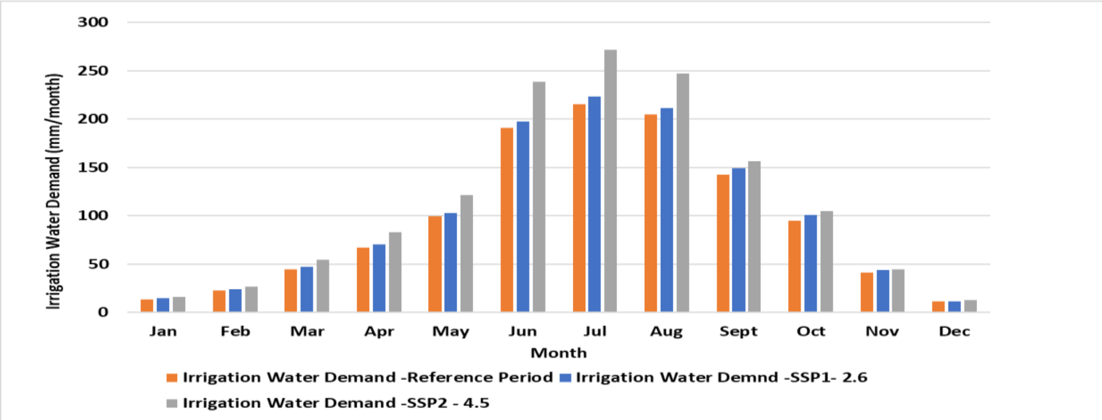

Figure 9. The projected irrigation water demand of the climate change scenarios for Babylon province.

2.8. The Annual Trend of the Water irrigation Demand

It is necessary to illustrate the analysis of the trend of the annual water demand. This trend will compare with the average observed water demand by the Ministry of Water Resources in Iraq (MoWR), which were equal to 1.28 and 3.98 billion cubic meters for the Anbar and Babylon provinces [23]. Figures 10 and 11 show the trend of the present and future irrigation water demand for Anbar and Babylon, respectively. Figure 10 shows that the annual demand for irrigation water increases slightly from 1.168 billion cubic meters in 2022, to 1.466 billion cubic meters in 2059. Figure 11 shows that annual demand for irrigation water increases rapidly from 4.16 billion cubic meters in 2022 to 4.76 billion cubic meters in 2059. Figure 10 shows a low deficit between the observed and projected water demand, where the deficit equals 0.037 billion cubic meters. Figure 11 shows a high deficit between the observed and projected water demand, which equals 0.47 billion cubic meters. The reason for this difference in the deficit is that the irrigated area of Babylon is three times greater than Anbar province. Also, Babylon will become hotter than Anbar in the future, and the projected precipitation of Babylon would be less compare to Anbar province. In general, the reason for the deficit is the climate change impact on Anbar and Babylon. The low precipitation, low relative humidity, high temperature, and expansion of crop cultivation in quantity and quality led to this water shortage.

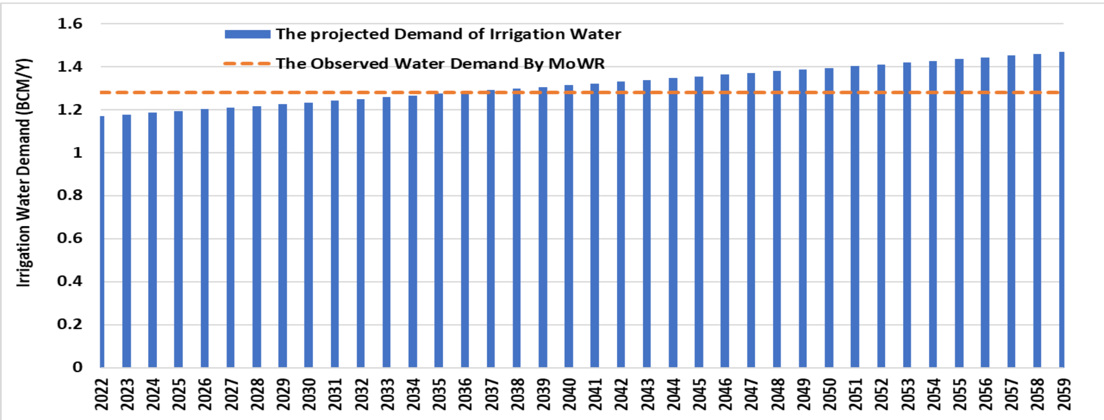

Figure 10. The present and future irrigation water demand trend for Anbar.

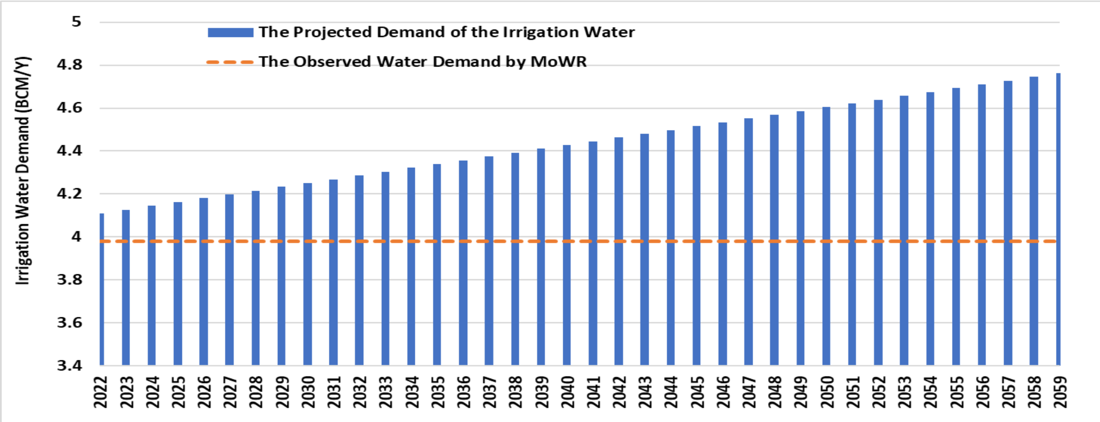

Figure 11. The present and future irrigation water demand trend for Babylon.

2.9. Verification of the agricultural model

The reference evapotranspiration is one of the essential variables calculated by the CROPWAT model, so it was chosen for the program verification process. The three statistical Parameters R2, NSE, and RSR can be used in calculating the differences between the observed values of ETo by New Eden Master Plan (NIMP) [35] and simulated values of ETo by the CROPWAT program. Table 3 shows the values of the coefficient of determination R2, NSE, and RSR for the Anbar and Babylon provinces. The comparison between the measured and simulated results demonstrated a strong level of agreement, particularly in terms of R2 and NSE. R2 values ranged from 98 to 97 %, while NSE values ranged from 91 to 67 %. Additionally, the RSR values ranged from 0.41 to 0.22.

Table 3. Three statistical parameters of the assessment of the performance for the agricultural model.

	Anbar Province		
	ETo (RP) Scenario	**ETo (SSP1-2.6) Scenario**	**ETo (SSP2-4.5) Scenario**
R^2	0.98	0.97	0.97
NSE	0.80	0.78	0.78
RSR	0.34	0.34	0.34
RMSE	34.4 mm	35.65 mm	39.42 mm
	Babylon Province		
	ETo (RP) Scenario	**ETo (SSP1-2.6) Scenario**	**ETo (SSP2-4.5) Scenario**
R^2	0.98	0.98	0.97
NSE	0.67	0.73	0.91
RSR	0.41	0.37	0.22
RMSE	47.74mm	47.74mm	27.36 mm

4. Conclusion

This study presents a method for predicting reference crop evapotranspiration (ETo) and irrigation water demand based on annual climate conditions. Three climate scenarios have been considered for the provinces of Anbar and Babylon, which have average annual ETo equals 157, 202, and 206 mm and 187.5, 195.6, and 224 mm, respectively. Anbar and Babylon's average irrigation water requirements were 1.10, 1.43, and 1.46 billion cubic meters and 3.97, 4.13, and 4.766 billion cubic meters. The predicted results indicate that the need for irrigation water will increase in the future, as a results to temperature increasing, a decrease in rainfall and humidity, and an increase in evaporation as the causes. Depending on the weather, the mean values of reference evapotranspiration ETo and net irrigation water requirements (NIWR) change over the development of a crop's growth cycle and across seasons. Additionally, these results demonstrated the significance of the need for irrigation scientific planning, which can be applied for the most efficient use of water.

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Removal of the Minerals Salts from Water Wells by Using the Solar Distillation

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Abstract. Using groundwater optimally is a science in itself if this process is used or applied correctly. Distillation is a series of industrial processes carried out to remove all or part of excess salts and minerals dissolved in water so that such water can be used in practical life such as agriculture, drinking and industry. Desalination requires expensive and highly energy-consuming techniques that have adverse effects on the environment. The amount of energy consumed in the desalination is an important problem that needs to be overcome. In this study, we aim to investigate the solar desalination by using samples of wells water to determine the concentration of some of the most important physical and chemical properties and salts in these wells. A solar distillation device was manufactured locally for this purpose .Two samples were taken monthly from five wells for period of three months, and 6 of the physical and chemical tests were carried out. The results show the water obtained from this method suitable for domestic human use, such as cleaning and washing, but not suitable for drinking due to its high hardness and unless submit to sterilization. solar distillation is a simplified system; materials are locally available and inexpensive. It does not require large capital upon installation and operation and maintenance .

1. Introduction

People get their water needs from two main sources: surface water sources, including rivers, lakes, etc.; and ground water sources, including wells, springs and caves. Because surface water can be clearly seen and because of the high money spent on the construction of reservoirs, dams, and channels for the use of this water, it was believed that surface water is the main source of the world's water. In fact less than 3% of the earth's fresh water exists in rivers and lakes. The larger part, which is 97%, is located in the ground and is estimated at about 100,000 km3, which has accumulated over many centuries, with slight additions of rain falling annually [2, 5 ,10 ,11, 13]. In light of the great development in the world, the increase in the population and pollution in general, and the decrease in water in our country, especially water crisis in the south of the country; there has been an urgent need to resort to water distillation for public uses. Water quality varies depending on the chemical composition resulting from dissolving many elements, including gases, plankton, the products of erosion of rocks and soil, sedimentation and replacement reactions, as well as the human activities on the earth [1, 2, 5 ,10,]. The rapid development of industry and the need to release industrial pollutants have polluted the water body, whether surface or underground, with heavy elements. [16].

This is a real environmental problem that not only threatens the environment and the ecosystem but also humans when they consume polluted drinking water. Water desalination: It is a convert of salt water to fresh water suitable for human use, and this is done by many desalination methods [8, 15]. Humans have used solar distillation for thousands of years from early Greek sailors' time to the Persian one. In 1870, the first US patent for solar distillation was given to Norman Wheeler and Walton Evans[15]. There is almost no water left on earth that is safe to drink without purification after 20-25 years from today. This is a seemingly bold statement, but it is unfortunately true. Only 1% of Earth's water is in a fresh, liquid state, and nearly all of this is polluted by both diseases and toxic chemicals. For this reason, purification of water supplies is extremely important. Keeping these things in mind, we have devised a model which will convert the dirty/saline water into pure/potable water using the renewable source of energy (i.e. solar energy). The basic modes of the heat transfer involved are radiation, convection and conduction. The results are obtained by evaporation of the dirty/saline water and fetching it out as pure/drinkable water. The designed model produces 1.5 litres of pure water from 14 litres of dirty water during six hours. The efficiency of plant is 64.37%. The TDS(Total Dissolved Solids) in the pure water is 81ppm [8].The objective of the study is to test the distillation process by using a locally manufacturing solar distillation device to distill well water by examining the physical, chemical and salts properties that were previously tested in the raw water. The research also studies the extent to which it is possible to use this water for different purposes and normal human daily use by comparing the results of distilled water with the Iraqi public standards allowed for human use table 11[19, 20].

2. Materials and Methods

2.1 Study Area

The samples taken from 5 different wells from Al-Alam region in Salahuddin governorate , in this region a large proportion of the population there depend on well water for multiple uses. The study focuses on investing groundwater in Al-Alam region due to population increase, urban and agricultural expansion, and the need for water sources for developing irrigation and various daily needs [4].

2.2. Solar distillation device

Figure 1 shows a double-basin still of solar distillation device (locally manufacturing) . The main features are the same for all solar stills. The solar radiation is transmitted through the glass cover and captured by a black surface at the bottom of the still. A shallow layer of water absorbs the heat which then produces vapour within the chamber of the still. This layer was 20mm deep for best performance. The vapour condenses on the glass cover, which is at a lower temperature because it is in contact with the ambient air, and runs down into a gutter from where it is fed to a storage tank. Daily output as a function of solar irradiation is greatest in the early evening when the feed water is still hot but when outside temperatures are falling. At very high air temperatures such as over 45ºC, the plate can become too warm and condensation on it can become problematic, leading to loss of efficiency [8]. The distillation water will flow into channels manufactured from PVC installed on the inside of the device. These channels are designed to collect distilled water after evaporation. The dimensions of the device are 50 * 50 * 60 cm and coated with a dielectric cork, painted in black to increase heat absorption and thus evaporation.

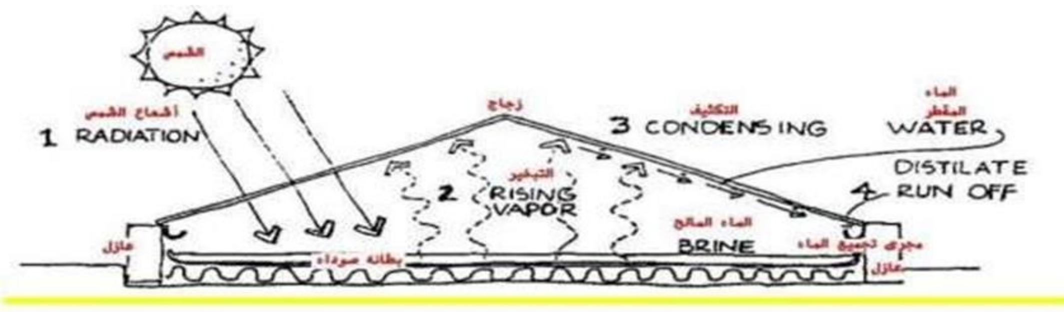


Figure. 1. The distillation device

2.3. Product capacity of device

The quantity of distillation water produced by this process is proportional to the (1) surface area of the device, so that the distilled water production can be increased by enlarging the surface area on which the steam is collected. In average, the amount of fresh water produced by the solar distillation is approximately 2-3 liters per square meter of the surface area. This proportion might change depending on weather conditions.(2) The energy required to evaporate water, called the latent heat of vaporization of water, is 2260 kilojoules per kilogram (kJ/kg). This means that to produce 1 liter (i.e. 1kg as the density of water is 1kg/liter) of pure water by distilling brackish water requires a heat input of 2260kJ. This does not allow for the efficiency of the system sued which will be less than 100%, or for any recovery of latent heat that is rejected when the water vapor is condensed. It should be noted that, although 2260kJ/kg is required to evaporate water, to pump a kg of water through 20m head requires only 0.2kJ/kg. Distillation is therefore normally considered only where there is no local source of fresh water that can be easily pumped or lifted [3, 15].

2.4. Sampling and Tests

Sampling was carried out from well No. 1 to well No. 5 twice a month for three months. The well water was pumped for ten minutes so that the contaminated and stagnant water can be disposed of. The bottles are then filled directly from the wells with minimal air space to maintain the physical and chemical properties of the sample water during transportation. 5-liter bottles were used for laboratory chemical and physical testing, taking into account washing all bottles with sample water three times before sampling. Physical and chemical tests were conducted in which pH was recorded on site, and the concentrations of total hardness, calcium, magnesium, bacteria and TDS were measured in laboratory [6, 7, 10].

The analyzes were carried out later in the central laboratories - University of Tikrit, Environmental Engineering and Chemical Engineering. All the bottles used in the analyzes were thoroughly washed at first using distilled water and dried using an electric oven. As mentioned before, this research was based on two parts of tests. The first test was to examination the properties of the raw material taken from the wells and measure the most important physical and chemical properties of the samples as show in the tables 1, 2, 3,4 and 5. The second test is to measure the same characteristics of samples taken from the wells after being subjected to the process of solar distillation within the device (each sample was left for three days before it is tested again) as in the tables (6, 7, 8, 9, 10).

3. Results and Discussion

The average results obtained from the examination of raw water before being subjected to distillation, which was collected from five wells by two samples per month for the period from November to February as shown in the tables below:

3.1Tables for raw wells

Table 1. Average chemical and physical tests of the first well

PH	TDS	Total hardness	Hardness of calcium	Hardness of magnesium	Bacteria
5.22	2505	596	376.66	225.866	existing

Table 2. Average chemical and physical tests of the second well

PH	TDS	Total hardness	Hardness of calcium	Hardness of magnesium	Bacteria
6.60	2511	603.3	383.5	219.71	existing

Table 3. Average chemical and physical tests of the third well

PH	TDS	Total hardness	Hardness of calcium	Hardness of magnesium	Bacteria
7.3	2020	586	389	197	existing

Table 4. Average chemical and physical tests of the fourth well

PH	TDS	Total hardness	Hardness of calcium	Hardness of magnesium	Bacteria
5.02	3750	634.7	410	224.7	existing

Table 5. Average chemical and physical tests of the fifth well

PH	TDS	Total hardness	Hardness of calcium	Hardness of magnesium	Bacteria
6.2	2530	613.5	390	223.5	existing

The average results obtained from testing the samples, after leaving each sample in the distillation device for a period of 3 days so that the samples can benefit from sunlight and evaporate, leaving behind the impurities and suspended materials, are shown in the tables below:
Tables of wells after distillation.

Table 6. Average chemical and physical tests of the first well after distillation

PH	TDS	Total hardness	Hardness of calcium	Hardness of magnesium	Bacteria
6.2	1202.5	181.68	110	71.68	Little

Table 7. Average chemical and physical tests of the second well after distillation

PH	TDS	Total hardness	Hardness of calcium	Hardness of magnesium	Bacteria
6.2	1240	167.5	110	57.5	Little

Table 8. Average chemical and physical tests of the third well after distillation

PH	TDS	Total hardness	Hardness of calcium	Hardness of magnesium	Bacteria
6.89	1285	253.8	177	76.8	Little

Table 9. Average chemical and physical tests of the fourth well after distillation

PH	TDS	Total hardness	Hardness of calcium	Hardness of magnesium	Bacteria
6.7	1130	217.9	164	53.9	Little

Table 10. Average chemical and physical tests of the fifth well after distillation

PH	TDS	Total hardness	Hardness of calcium	Hardness of magnesium	Bacteria
5.3	1235	203.6	164	39.6	Little

3.1 Total dissolved salts

Salinity is measured to reflect water quality, which represents the total concentration of dissolved chemicals in water. Water is acceptable for many uses when the concentration of dissolved solids is low. The permitted values for human drinking should not exceed 500 to 1500 mg / l. As for the use for livestock drinking and industrial use, permissible limits should not exceed 2000 mg / l. Water quality is important for industrial purposes, especially those that require water purer than natural drinking water, such as pharmaceutical or textile industries [19, 20 ,21]. In the current study, the raw well water is classified as highly salty according to Food and Agriculture Organization. The results in tables 1, 2, 3, 4 and 5 indicate that the average salinity concentration ranges from 2020-3750mg/l in the wells, and this value exceeds the permissible limits. The results indicated that after the sample is exposed to solar distillation, as in tables 6, 7, 8, 9 and 10, average salinity ranges between 1130-1285 mg/l. According to the Food and Drug Organization, distilled water should contain a small percentage of salts as it gives a sense of complacency. Salt-free water quickly activates ion exchange, which occurs immediately after drinking salt-free water and soon begins to attract salts in the human body to be expelled later by sweating or urinate. Therefore, the human body cannot benefit from salt-free water.

3.2 PH

The value of pH is an important indicator of the chemical, physical and biological systems in groundwater because of its impact on the nature of the ecosystem. The results of the present study indicate that the of pH values of raw water ranged between 5.02-7.3. The low pH values in well water may be due to salts and chloride and sulfur, which reduce the pH value to a level near to parity. In

General, most natural waters tend to be Alkaline water due to carbonate ions and Bicarbonate. In this study, pH values are high may be due to watering farmlands by farmers. Water increases the solubility of carbon dioxide which converts insoluble calcium carbonate into dissolved bicarbonate [6,7,9,10,11,13,14]. The results obtained by exposing the samples to the distillation process shows a slight rise in the pH value. The distilled water is supposed to have a pH neutral 7, which is not acid or alkaline because the distilled water has been purified from any sediments, salts and dissolved or volatile materials. When water is first produced, it is neutral. However, water soon absorbs carbon dioxide from the atmosphere. Thus, the results indicated the presence of little acid with a pH value of 5.3 - 6.89. According to the standard specifications of 6.5-9.2[20] the distillation process is effective in making the sample within the acceptable specifications of pH value.

3.3 Total hardness

The concentration of total hardness of natural water varies greatly depending on the nature of the geological formations that the water passes through. Calcium and magnesium are one of the most common ions found in natural waters. The well water of the current study has been classified as very hard Because the total value of hardness in this water is more than 500 mg/l [19,20,21]. Hardness varies depending on the water source: surface water is less hard than groundwater. This hardness is due to the geological characteristics of the land on which the water passes or soil minerals it comes in contact with. Furthermore, this groundwater is not exposed to rain water, which can reduce its hardness [16,17,18]. The results of the current study indicated that the values of average hardness of raw water ranged between 586-634.7 mg/l, as shown in the tables. After the solar distillation, the results shown that the values of total hardness decreased significantly.

This is due to the fact that the process of evaporation of hard water, leaving behind deposits of calcium and magnesium that formed a white crust at the bottom of container. The results showed that average hardness became 167.5-253.8 mg/l. In comparison with the standard specifications, we find that it exceeded the permissible limits of 150-200 mg/l [20]. Accordingly, it can be said that the distillation device significantly reduced the amount of total hardness and is effective in reducing it, but the water is still classified as hard water.

3.4 Hardness of calcium

Average calcium concentrations in raw water ranged between 376.66-410mg/l. After distillation, the results showed that the average hardness of the calcium was 110-177 mg/l, which makes the water hard according to [10]. However, in comparison with the standard specifications of the values of calcium of 200 mg /l [19,20,21] the water was close to the permissible values because these ions need high degrees of heating to be deposited. In this experiment, ions are deposited in the form of white crust on the sides of the heating container, so this hardness needs chemical additives to be removed.

3.5 Hardness of magnesium

The average concentrations of magnesium hardness ranged between 209.34-224.86 mg/l. The concentrations of magnesium ions are high in most studied well water compared to the permissible limits of 150 mg / l, which is due to the geological nature of the study area. Dolomite rocks, which are dissolved in groundwater, are the main source of magnesium ions.

The presence of magnesium in the water is due to the direct contact between water and dolomite rocks or with fossil rocks, which are rich in magnesium. The high percentage of calcium carbonate and magnesium is one of the reasons leading to temporary hardness. After distillation, the final results of the samples indicate that the average hardness of magnesium has significantly decreased to become 39.6-76.88 mg/l, which is in accordance with standard specifications [19,20,21].However, this water is still classified as hard due to the presence of calcium ions and other ions, which causes the hardness. Therefore, for the reasons mentioned above, this hardness needs chemical additives to be removed.

3.6 Bacteria

Well water is not suitable for human consumption and drinking because it contains quantities of microorganisms such as bacteria form its direct contact with soil, rocks, external air, etc. It cannot be claimed that there is a device capable of purifying drinking water by 100% of living organisms. Distillation makes water free from impurities, volatile organic matter, salts. In this research, the total numbers of bacteria in raw water samples was estimated by counting the dishes. In this way, we can estimate the number of cells that can reproduce in one cc of water in appropriate conditions. Through microscopic examination of dishes, test results indicated that raw water samples contained bacterial contamination .This is due to the fact that most of the wells were uncovered, which led to direct pollution from organic pollutants such as animal residues and plant residues. Bacterial growth, especially when there are conditions suitable for growth, such as temperatures and organic matter and others [6,12]. After distillation, the results indicated that the percentage of bacteria growing on the dishes in the distilled water is very little. However, this does not mean that this water has become suitable for drinking but it is good for washing and rinsing pots and floors.

Table 11. Iraqi standard guide and the World Health Organization Specifications [20]

Parameters	Iraqi Standard (IQS)	WHO standards
pH	6.5-8.5	6.5-8.5
TDS mg/l	1000	1000
TH as CaCo3 mg/l	500	500
Ca mg/l	50-150	75-200
Mg mg/l	50-100	30-150

4. Conclusion

Solar distillation is a simplified system. Most of the manpower and materials used can be local and inexpensive and do not require large capital for installation. Most repairs and maintenance can be done by unskilled workers. Groundwater is a water source; if utilized and purified, it will compensate lack of water now. The locally produced distillation device was effective in removing most of the salts and suspended materials. This indicates the possibility of using this device to purify groundwater using simple materials. The use of insulating cork is effective in isolating sun heat during the day and containing the heat at night, causing condensation of steam. Painting the cork in black is very effective in the process of heat absorption, which increases the effectiveness and performance of the device during the day, and it is better than keeping the insulating cork in its original color (white). Using laboratory tests, water obtained from this solar distillation device was proved to be suitable for domestic human use, such as cleaning and washing. The water obtained unsurprisingly contains a percentage of bacteria due to microscopic living organisms in air, the glass of the device, the water used, and even in the people who deal with the device while inserting and emptying the samples. Thus, the water is not suitable for human consumption unless one of the known sterilizers, including chlorine, is used for the purpose of sterilization.

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Drought Assessment Using Two-Variate Modelling

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Abstract. Drought is a natural hazard that mainly threatens water resources and food security. Due to climate change, an increase in drought events that may adversely affect various sectors is expected. Therefore, a reliable analysis of drought events is important. However, there is a deficiency in research works which deals with two-variate drought assessment and monitoring. This paper focused on drought assessment based on modelling the effective precipitation and runoff variables simultaneously. Drought indices are widely utilized to assess droughts in many regions around the world. The copula method was used to modelling a two-variate drought index based on the effective precipitation and runoff variables in northern Iraq as a case study. It was found that Frank is the optimal copula function to model the joint cumulative distribution function of effective precipitation and runoff. To assess the performance of the proposed two-variate index, it was compared with the widely used standardized precipitation index SPI and Standardized Runoff Index SRI. Where the Pearson correlation coefficients between 2-variate index and SPI, SRI were 0.78 and 86, respectively, for 3-month time scale, and were 0.83 and 82, respectively, for 6-month time scale. The results revealed that the proposed index is applicable and can comprehensively and effectively characterize drought events.

Introduction

Drought is considered the most complex and costly natural hazard which affects economic, agriculture and environment [1]. Drought effects are cumulative, extending for months or years over a large spatial extent [2,3]. Drought assessing is important in water resources planning and management [4]. Generally, Palmer (1965) [5] defined the drought as a water deficiency.

Drought can be categorized into four types, Meteorological drought means a precipitation deficiency, hydrological drought means a surface water deficiency, agricultural drought means a soil moisture deficiency and socioeconomic drought means a water supply deficiency [4, 6].

Various indices are successfully applied for assessing of drought risk. Some commonly used indices around the world include, Palmer Hydrological Drought Severity Index PHDI [5], Standardized Precipitation Index (SPI) [7], Reconnaissance Drought Index (RDI) [8], Standardized Runoff Index (SRI) [9], Joint Deficit Index (JDI) [10], Multivariate Standardized Drought Index (MSDI) [11].

One-variate analysis may result an unreasonable assessment of hydrological phenomena associated with more than one variable, such as drought phenomena [4, 12, 13]. A fully assessment of drought phenomena requires a comprehensive analysis of more than one variable.

Copula method considered a useful tool for combining the individual variables for comprehensive hydrological phenomena analysis [14]. Numerous research works have verified the applicability of copula method for two-variate modeling of drought [15, 16, 17]. Sherly et al. (2015) [18] and

Bageshree et al. (2022) [19] found that copula method performs better than the generalized least squares regression method the principal component analysis method for tow-variate drought analysis. Evkaya et al. (2019) [20] developed a two-variate copula-based drought index that combines the precipitation and potential evapotranspiration variables. The results show that the composite drought index could be used as an integrated tool to describe drought events. Feng et al. (2020) [21] combined the standardized runoff drought index and the standardized groundwater level drought index into a two-variate hydrological drought index for a comprehensive assessment of drought.

Streamflow and precipitation are the most important water resources in Iraq for various purposes such as irrigation, drinking water, rainfed agriculture and hydroelectric power generation. Drought is a major concern in Iraq, which has major water resources and large rainfed agricultural areas. After reviewing the literature, there was no study that simultaneously assessed drought using multiple hydrometeorological variables in Iraq.

The present study aims to employ the copula methodology for Comprehensively assess and monitoring drought risk based on effective precipitation and runoff variables simultaneously. Firstly, suitable marginal distribution function is determined for each of effective precipitation and runoff variables separately. The optimal copula function is selected for modeling the two-variate drought index based on the root mean square error RMSE and Bayesian information criteria BIC tests. Finely, the applicability of the proposed two-variate drought index was evaluated by comparing it with SPI and SRI based on the Pearson correlation coefficients.

Materials and Methods

Study area and Data

The study area is considered as a semi-arid region and located in the northern part of Iraq. Geographically, Tigris river basins at Tusan station are located between latitudes of 36° 31' N to 38° 52' N, longitudes of 40° 05' E and 44° 07' E Figure 1. It covers a total area of about 473,103 square kilometers, in which 255,000 square kilometers is located in Iraq, and the remaining is located in Turkey. The mainstream river length is approximately 1,400 km inside Iraqi border. Tigris river joins the Euphrates river at Al-Qurna city, then empties into the Arabian Gulf.

The climate of study area is characterized by hot summers and cold winters with seasonal pattern precipitations. Most of the annual precipitation occurs during November to May. The mean annual precipitation ranges between (350 – 550) mm. The average maximum monthly temperature is 46 °C during the summer season.

The available monthly precipitation and runoff data for 50 years were used in this study. The available data for Tusan station at Tigris river were obtained from United States Geological Survey (USGS) Data Series No.540 [22] and Iraqi Meteorological Organization and Seismology. The Simplified United States Department of Agriculture (USDA) method proposed by Tigkas et al. (2019) [23] was used to calculate the monthly effective precipitation dataset based on the total monthly precipitation.

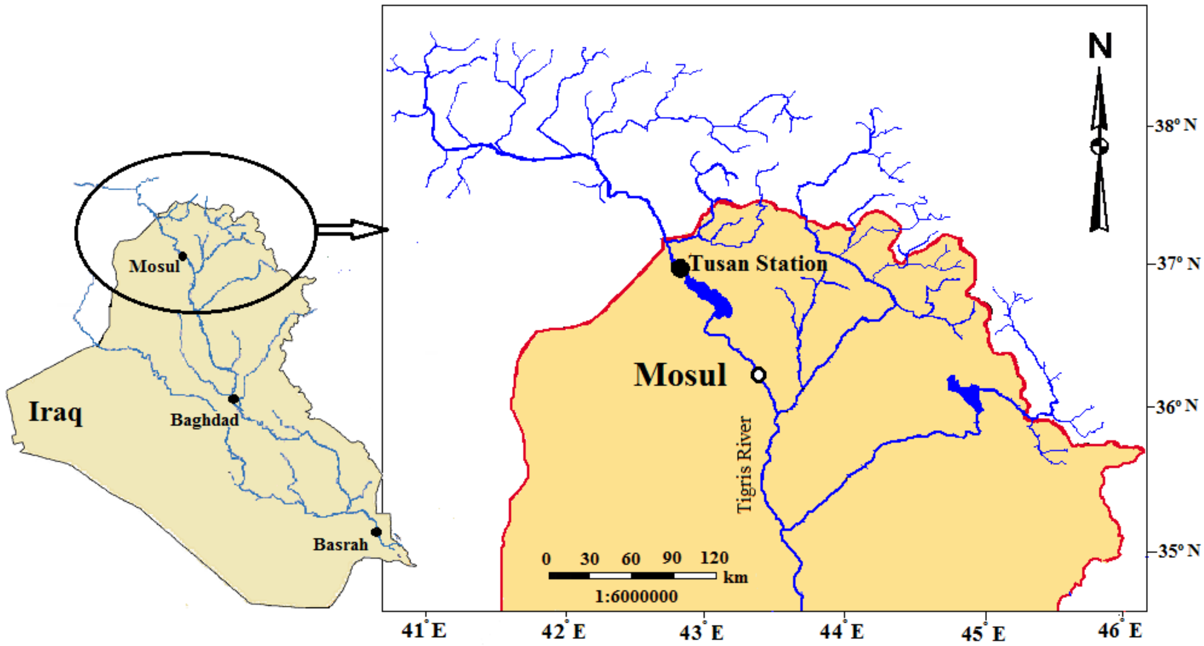


Figure 1. The study area and Tusan station location.

Two-Variate Drought Index Using Copula Method

The perception of copula first defined by Sklar (1959) [24] as powerful tools to connect the corresponding marginal distributions of two variables. The joint cumulative distribution function $F_{X,Y}(x, y)$ of effective precipitation (X) and Runoff (Y) variables with a copula C can be expressed as [25],

$$F_{X,Y}(x, y) = C(F_X(x), F_Y(y)) = P(X \leq x, Y \leq y) = p \quad (1)$$

$F_X(x)$ and $F_Y(y)$ are the marginal distributions of effective precipitation and runoff, respectively.

The proposed two-variate drought index is defined by taking the inverse normal distribution function φ^{-1} of the joint cumulative distribution function as,

$$\text{Two-Variate Drought Index} = \varphi^{-1}(p) \quad (2)$$

The first step of the copula method is to examine the correlation between the effective precipitation and runoff variables using statistical correlation criteria.

After the correlation examination, a suitable marginal distribution function among the candidate of Gamma Eq. (3), Exponential Eq. (4), Lognormal Eq. (5) and Generalized Pareto Eq. (6) functions should be selected to each variable individually using the Anderson-Darling (A-D) and Kolmogorov-Smirnov (K-S) tests. The parameters of the marginal distributions valued by maximum likelihood method. The above candidate marginal distribution functions F(x) are expressed as follows,

$$F(x) = \frac{\Gamma_{x/\beta}(\alpha)}{\Gamma(\alpha)} \quad (3)$$

$$F(x) = 1 - \exp(-\lambda x) \quad (4)$$

$$F(x) = \Phi\left(\frac{lnx - \mu}{\sigma}\right) \quad (5)$$

$$F(x) = 1 - \left[1 + k\frac{(x-\mu)}{\sigma}\right]^{1/k} \quad (6)$$

where Γ, gamma function. Φ, Laplace Integral. x, drought variable (effective precipitation or runoff). β, α, λ, μ, σ, parameters.

Finely, the optimal copula function among the candidate of Clayton, Frank and Gumbel functions should be selected to model the joint cumulative distribution function of effective precipitation and runoff variables. The root mean square error (RMSE) and Bayesian information criteria (BIC) were used as a statistical tests to select the optimal copula function. The Excel and MATLAB software were used to perform all statistical analysis.
The two-variate drought index has a statistical structure similar to SPI, therefore the drought and wet classification is represented according to the McKee et al. (1995) [7] classification system as given in Table 1.

Table 1. drought severity classification.

Index Value	Category
≥ 2	Extreme wet
1.5 ≤ SPI ≤ 1.99	Very wet
1.0 ≤ SPI ≤ 1.49	Moderate wet
0.0 ≤ SPI ≤ 0.99	Mild wet
-0.99 ≤ SPI < 0.0	Mild drought
-1.49 ≤ SPI ≤ -1.0	Moderate drought
-1.99 ≤ SPI ≤ -1.5	Severe drought
≤ -2	Extreme drought

Results and Discussion

In order to build the joint distribution functions using copula method, the correlation between the effective precipitation and runoff variables was examined using the Pearson's (r), and Spearman's rho (ρ) correlation coefficients at significance level of 5% as given in Table 2. Results exposed that the correlations between effective precipitation and runoff were positive and statistically significant at 5% significant level, indicating that two-variate drought index modeling between effective precipitation and runoff using copula functions is suitable.

Table 2. Correlation coefficients values between considered variables.

Time scale	(*r*)	p-value	(*ρ*)	p-value
3-month	0.40	0.00	0.43	0.00
6-month	0.42	0.00	0.41	0.00

Based on the A-D and K-S tests presented in Table 3, the results show that the Exponential and Lognormal distributions are more suitable distributions for modelling the effective precipitation and runoff data, respectively, for 3-month time scale. while Generalized Pareto and Gamma distributions are more suitable for modelling the effective precipitation and runoff data, respectively, for 6-month time scale.

Table 3. Selected marginal distributions for effective precipitation and runoff data.

Time scales		distribution	parameters
3-month	Effective precipitation	Exponential	λ = 37.8
	Runoff	Lognormal	σ = 0.82 μ = 6.1
6-month	Effective precipitation	Generalized Pareto	k = -0.37 μ = 0.00 σ = 50.9
	Runoff	Gamma	α = 2.7 β = 23.2

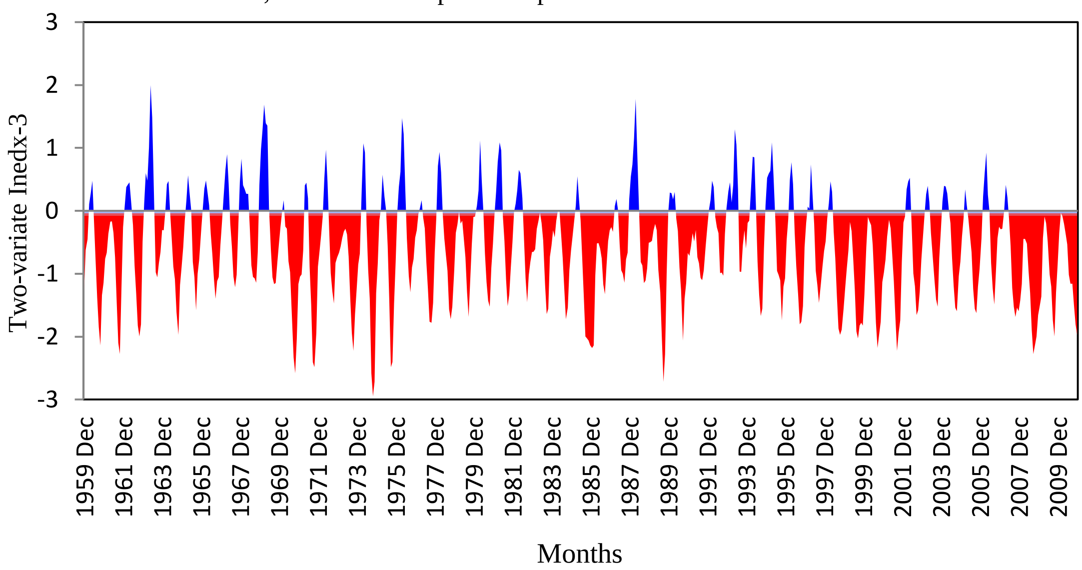
Based on the result of RMSE and BIC tests Table 4, Frank copula showed better performance than Clayton and Gumbel copulas for both 3-month and 6-month time-scales at Tusan station. The lowest value of RMSE and BIC tests is considered the optimal copula function.

Accordingly, the Frank copula was used to model the two-variate drought index by combining the optimal marginal distribution functions of the effective precipitation and runoff, given in table 3, for both 3-month and 6-month time-scales. Figure 2 shows the time series of the two-variate drought index composed from effective precipitation and runoff variable for the 3 and 6-month time scales. The red color represents dry events and the blue color represents wet events.

Table 4. Statistical test results of used copulas.

Time scale	Copula	RMSE	BIC
	Clayton	0. 320	-692.0
3-month	**Frank**	**0. 221**	**-921.7**
	Gumbel	0. 405	-552.2
	Clayton	0. 478	-453.8
6-month	**Frank**	**0. 210**	**-944.4**
	Gumbel	0. 237	-876.1

Notes, Bolded is the optimal copula.



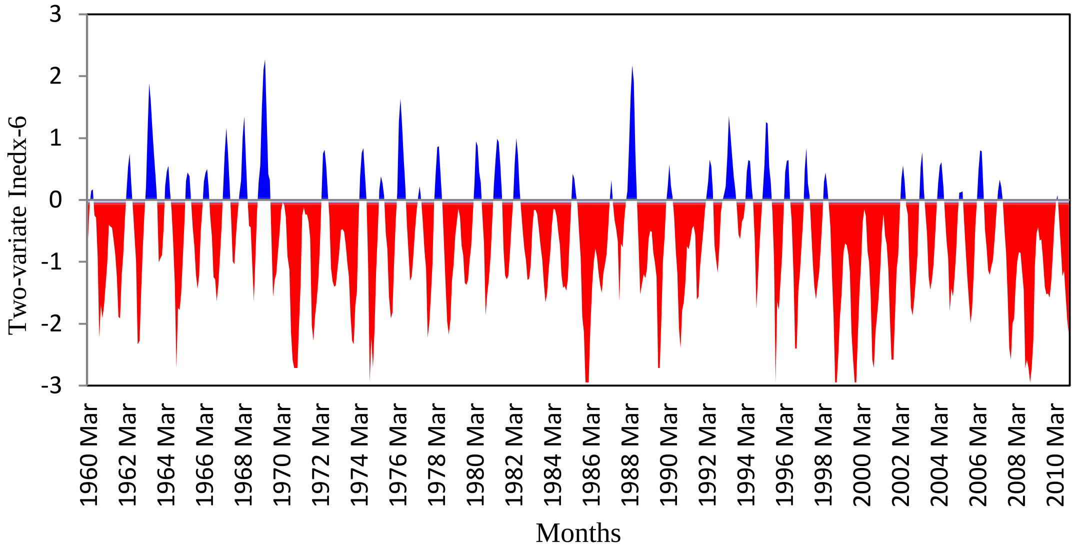
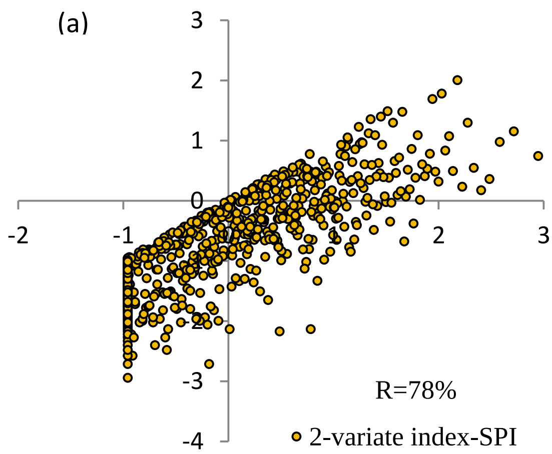
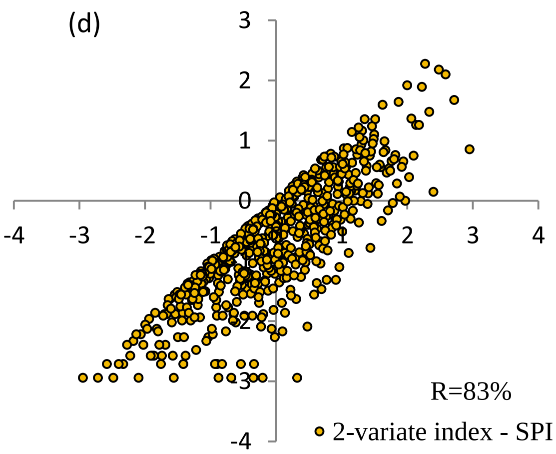


Figure 2. Monthly time series of two-variate drought index for 3 and 6-month time scales.

Figure 2. shows that the total number of drought events (red color) were 39 and 37 for 3-month and 6-month time scales, respectively. The severest drought event was occurred from June 1998 to February 2002 for 3-month time scale, and the severest drought event was occurred from July 1998 to March 2002 for 6-month time scale.

To assess the performance of the two-variate drought index, it was compared to SPI, and SRI at the same time scales (3-month and 6-month) as shown in Figure 3. The pairs scatterplots allow to understand the pairwise relationship between different variables. From Figure (3a and 3b) for 3-month time scale and (3d and 3e) for 6-month time scale, we can conclude that the relationships between two-variate drought index and SPI, SRI were generally positive and linear. The Pearson correlation coefficients between two-variate drought index and SPI, SRI were also estimated. The correlation between two-variate drought index and SPI, SRI were 0.78 and 86, respectively, for 3-month time scale, and were 0.83 and 82, respectively, for 6-month time scale. Through the Pearson correlation coefficient and the range of data scattering, the correlations between two-variate drought index and SPI, SRI were higher than the correlation between SPI and SRI. This is because the two-variate drought index combines the two SPI and SRI indices through effective precipitation and runoff variables. Which indicates the reliability of the proposed two-variate drought index for combining multiple drought variables.





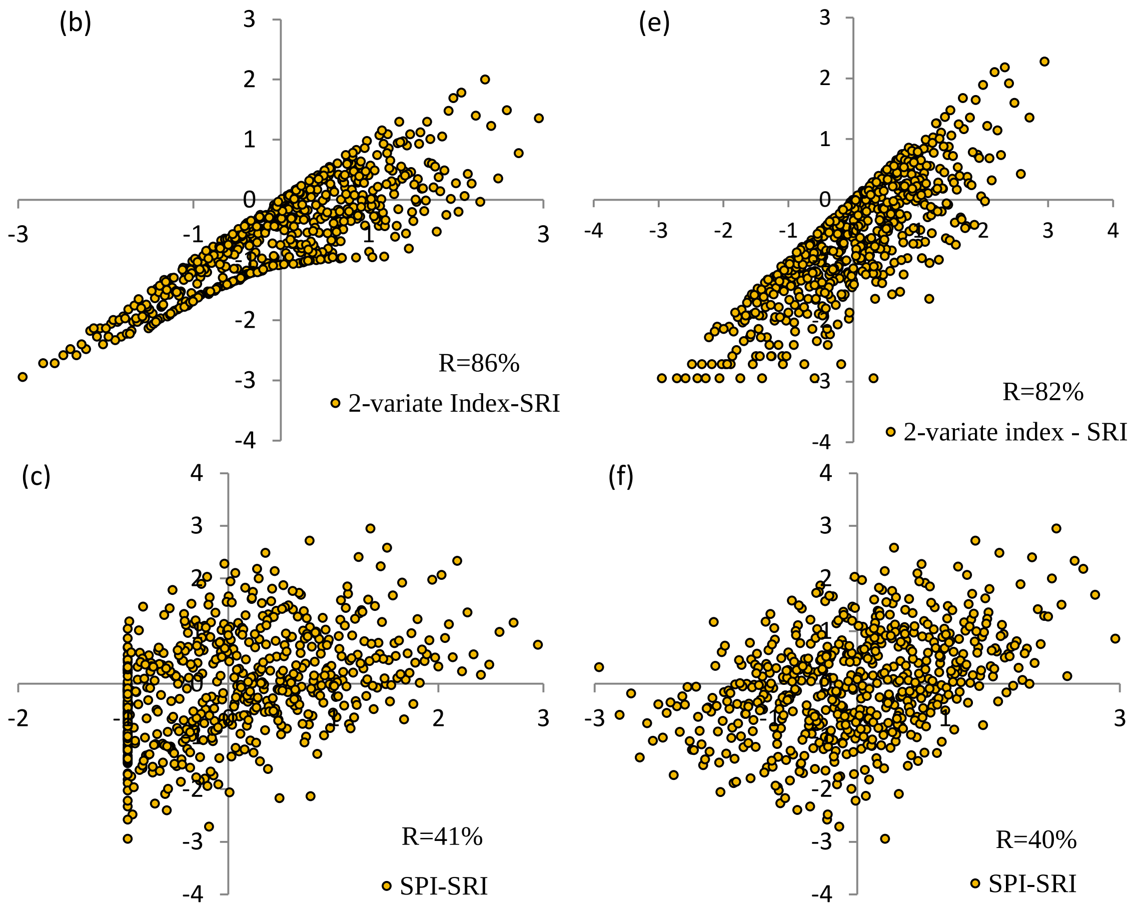


Figure 3. Scatter plots of the relationship between two-variate drought index and SPI, SRI (a, b, c), 3-month and (d, e, f), 6-month.

Conclusion

In the current study, the two-variate drought index of effective precipitation and runoff variables was modelled using copula method. The main conclusions of the present study are as follows.Based on the A-D and K-S tests, Exponential and Lognormal distributions were chosen as optimal marginal distributions for the effective precipitation and runoff data, respectively, for 3-month time scale. while Generalized Pareto and Gamma distributions were chosen as optimal marginal distributions for the effective precipitation and runoff data, respectively, for 6-month time scale.The results exhibited that Frank copula was the optimal copula function for modeling the two-variate drought index for both 3-month and 6-month time-scales at Tusan station.The two-variate drought index performed well when compared to SPI and SRI. The Pearson correlation coefficients between two-variate drought index and SPI, SRI were strong and significant. which indicates the reliability of the proposed two-variate drought index for combining multiple drought variables.The frequency of drought events was high and severe, where the total number of drought events were 39 and 37 for 3-month and 6-month time scales, respectively. The proposed two-variate drought index can be considered as an additional drought index for drought detection and not as a substitute for any other drought index.

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The Water Footprint and Virtual Water and Their Effect on Food Security in Iraq

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Abstract. The study aimed to explaining the concepts of water footprint and virtual water and how these two concepts could use to achieve water savings at the local level to meet the water supply deficit in Iraq, which is expected to increase in the coming years and influence of that on food security in Iraq by using these concepts when drawing production, irrigated and import plans in Iraq. The study aimed to studying the water footprint and virtual water and their impact on the foreign trade for wheat and rice crops during the period 2000-2022 and estimating the most important indicators of virtual water and the water footprint of the study crops due to the importance of these criteria in determining the amount of increase or decrease in the area of the studied crops, according to the foreign trade policy. This study was concluded that the average total water footprint of the wheat and rice crops during the study period is (20.27,13.89) billion m3 respectively, and the average percentage of dependence on external water resources for both crops are (20.49%,67.98%) respectively, and the average percentage of self-sufficiency in water resources are (79.51%,32.01%) respectively, and the average unit productivity of irrigation water for both crops is (0.19,0.10) kg/m3 respectively during 2000-2022.The average for the water needs of wheat and rice crops during the study period were (6.04,10.19) m3/kg respectively , the average amounts of water used in local production for both crops are (14.23,4.01) billion m3 respectively, the average amounts of virtual water imported for both crops are (6.19,10.03) billion m3 respectively, and the average value of the imported virtual water for both crops is (382,529) thousand dollars during the period 2000-2022. The study recommended to taking in account these concepts in plans of production and distributing irrigation water.

1. Introduction

Iraq suffers a severe declining catastrophic in water resources; due to disagreement share water to the neighboring countries Turkey, Syria and Iran. The water crisis has turned into a global problem with the effects of both economic and social growth and climate change. The researchers came up with important water concepts and terms that not only have an environmental dimension, but also carry important political and economic dimensions. Among these concepts, the concept of "water footprint" appeared in 2002 [1]. The water footprint defined as the amount of fresh water used in the production of a particular product, directly or indirectly, from the moment of production and processing of the raw materials constituting the product until it reaches to the final consumer [2]. Just as the production of any goods or service must require water, the water that enters the production process called virtual water, and the term virtual water means the amount of water requires producing a commodity [3,4]. The importance of foreign trade in the economies of different countries around world is due to the difficulty of dispensing any country from the rest of the world, regardless of their level of development and to live in isolation from the outside world and that developing countries vary in terms of natural or relative and absolute advantages that are specialized in producing certain types of goods and they works to export the surplus out of it, which allows them to cover the other imported goods[5]. The foreign trade in agricultural products form an important factor for developing countries, including Iraq, because of their great importance in the conduct of agricultural products to regional and global markets and supply their agricultural products from the world [6]. Foreign trade in general and in agricultural products in particular especially in Iraq has a vital role in growth of the agricultural sector, which it means that they have a long-term co integration relationship between agricultural growth and foreign trade [7]. Water is one of the important and vital issues to achieve economic development and agricultural development, and the world facing in recent times scarcity on the one hand and the growing of needs requirements of it on the other hand. Since the demand for food is in essence a demand for water in one way or another, which led to the emergence of the concept of virtual water [8]. The issue of water scarcity is one of the major challenges facing Iraq, due to the severe shortage of imports of the Tigris and Euphrates rivers and the lack of rain and snow [9]. Wheat and rice crops were chosen from among the strategic crops, due to their importance in the livelihood of the Iraqi citizen, and no Iraqi table is devoid of one of the derivatives of these two crops, and the government policy focused on these two crops, especially in providing support and attention to each of them, for this reason they were chosen to be the focus of this study. The research started from a problem that could be identified that Iraq has been suffering for years from a continuous decline in water revenues across the Tigris and Euphrates until it entered the stage of water scarcity, and several factors stand behind this critical water situation, the most important of which are climatic changes represented in the lack of rainfall and the drought of rivers, in addition to the factors negatively affect water imports from the two rivers and This calls for focusing on concepts related to the water footprint and virtual water for its important role in the production of strategic crops, which are among the most important crops for food security, especially since Iraq is almost a net importer of these agricultural commodities. This study was aimed to, Estimating the most important indicators of the water footprint of the study crops (wheat and rice) due to the importance of these criteria in determining the amount of increase or decrease in the area of the studied crops in accordance with the food security policy and estimating the most important indicators of virtual water for the study crops (wheat and rice).

2. Materials and Methods

There is no doubt that any agricultural policy will not achieve success if water policy and foreign trade policy do not have a presence based on economic and environmental foundations. Structure of foreign agricultural trade in Iraq and foreign Iraq's agricultural trade, in both exports and imports, is highly volatile due to its many factors, political and economic and their association with the economic conditions of the major rowers, making them susceptible to the effects of extreme fluctuations in the prices of international commodities and the volatility of the world economy [4]. Water footprint studies have different multiple purposes and are applied in many contexts. Each purpose requires its own scope analysis. Water footprint can be estimated for different entities, so it is very important to determine which water footprints can studied and estimated. Estimating the water footprint of a consumer or a group of consumers or an entire economic sector of consumers has become a matter of interest, and this done within a specific geographical area such as a governorate or a country, and for surface water collection basins or river basins. The water footprint of a region is the product of compiling a number of water footprints for a number of products, goods and services in this region, and the water footprint as an analytical tool that can be useful in understanding the activities and services related to the scarcity and pollution of fresh water and the expected effects, as well as understanding what can be done to ensure that these activities and products do not affect the sustainability of fresh water in terms of quantity or quality, and it is a tool that provides a vision for learners, helping them understand what needs to be done [10]. The data was obtained from its official sources represented by the Ministry of Planning / Central Statistical Organization and the Iraqi Ministry of Water Resources Estimating and measuring the actual water content of a product or commodity is not an easy task, because there are many factors that affect the amount of water used in production processes, and the following factors should at least taken into consideration when estimating and calculating the virtual water content of any product or commodity,

- The place and time period (season) for the production of the product, commodity or crop.

- Measuring the quantities of water used in the case of irrigated crop production, as well as the quantities of water polluted because of irrigation, if any.
- Measuring the efficiency of water use in the production of goods, products and crops.
- Calculation and inclusion of wasted and polluted water in the estimation.
- Calculating the virtual water ratios of the intermediate inputs to the virtual water content of the commodity, final product or crop. To achieve its objectives, the study relied on the descriptive economic analysis method in explaining some economic aspects in addition to quantitative economic analysis, as some indicators and standards applied in calculating the water footprint and virtual water. The study relied mainly on the exploitation of blue water in irrigated lands. The virtual water and the water footprint were calculated and estimated, and their most important indicators are,
  - Amount of water used in local production.
  - Water requirements for the production of the crop.
  - Default amount of imported water.
  - Default value of imported water.
  - External water footprint.
  - Internal water footprint.
  - Total water footprint.
  - Percentage of dependence on external water resources.
  - Percentage of self-sufficiency from the local water resources.
  - Unit productivity of irrigation water.

3. Results and Discussion

3.1. Estimation of the water footprint and its indicators for the study crops in Iraq for the period 2000-2022,

The water footprint has an important impact in shaping agricultural policy, especially with regard to production policy, irrigation policy and foreign trade policy for agricultural products. The study estimated the most important indicators of the water footprint of the study crops during the period (2000-2022).

3.1.1.Wheat,

Wheat is strategic economic and food security crop, so various development projects adopted by the government to improve the level of production of this crop[11]. Despite the efforts to increase the production of grain crops, especially the wheat, the total production is still insufficient to meet the growing consumption needs, which led to widening of the food gap in addition to the increase in population and the increasing demand for food [12]. By studying and reviewing the data of table 1 and figure 1, found that the external water footprint of wheat crop reached its lowest in 2003, estimated at 0.01 billion cubic meters, and reached its highest value in 2008 when it was estimated at 34.48 billion cubic meters, with an average of 6.19 billion cubic meters. It also found that the internal water footprint reached its lowest in 2000, estimated at 4.04 billion cubic meters, and reached maximum in 2020, when it estimated at 21.85 billion cubic meters, with an average of about 14.08 billion cubic meters. The total water footprint of the wheat crop ranged between a minimum of about 4.07 billion cubic meters in 2000, as this year was scarce of rain and a maximum of about 49.08 billion cubic meters in 2008, with an average of about 20.27 billion cubic meters. The total water footprint is the sum of the internal water footprint and the external water footprint, the water footprint of the wheat crop may be large, because it is the most important cereal crop in Iraq and cultivated in large areas as well as the exposure of its cultivated areas to high evaporation rates. It was also found that the percentage of dependence on external water resources for the wheat crop ranged between a minimum of about 0.06 % in 2003 due to lack of imports or not being recorded in this year due to abnormal conditions, and a maximum of about 70.25 % in 2008, with an average of about 20.49% , while the percentage of self-sufficiency of the local water resources for the wheat crop ranged between a minimum of about 29.75 % in 2008, and a maximum of about 99.94 % in 2003, with an average of about 79.50 %. This represents a great pressure on Iraqi water resources, which have already entered the stage of water scarcity. The unit productivity of irrigation water for wheat crop ranged between a minimum of 0.09 kg/m3 in 2000 and 2008, and a maximum of 0.32 kg/m3 in 2016, and an average of 0.19 kg/m3, which is low productivity.

Table 1. Water footprint and its indicators for the wheat crop in Iraq during the period 2000-2022

Years	**External water footprint (1)**	**Internal water footprint (2)**	**Total water footprint (3) (1+2)**	**Dependence rate on external water resources (%) (4)**	**Self-sufficiency rate from local water resources (%) (5)**	**Unit productivity of irrigation water (kg/m3) (6)**
2000	0.03	4.04	4.07	0.82	99.18	0.09
2001	0.02	5.35	5.37	0.34	99.66	0.17
2002	0.02	16.69	16.71	0.09	99.91	0.15
2003	0.01	16.54	16.55	0.06	99.94	0.13
2004	0.02	13.64	13.66	0.16	99.84	0.12
2005	0.02	16.31	16.33	0.11	99.89	0.14
2006	0.02	14.03	14.05	0.14	99.86	0.15
2007	0.02	15.99	16.01	0.11	99.89	0.14
2008	34.48	14.60	49.08	70.25	29.75	0.09
2009	23.06	12.86	35.92	64.21	35.79	0.13
2010	9.53	14.12	23.65	40.29	59.71	0.19
2011	17.16	16.68	33.84	50.70	49.30	0.17
2012	13.95	17.61	31.56	44.20	55.80	0.17
2013	10.09	18.81	28.90	34.92	65.08	0.22
2014	4.84	21.72	26.56	18.22	81.78	0.23
2015	1.69	10.56	12.25	13.81	86.19	0.25
2016	0.54	9.42	9.96	5.42	94.58	0.32
2017	1.76	10.74	12.50	14.10	85.90	0.28
2018	6.90	8.04	14.94	46.21	53.79	0.27
2019	2.12	16.13	18.25	11.61	88.39	0.27
2020	3.74	21.85	25.59	14.62	85.38	0.29
2021	9.10	20.33	19.12	13.55	82.88	0.24
2022	7.66	19.90	11.55	12.30	83.77	0.21
Average	6.19	14.08	20.27	20.49	79.51	0.19

Source, Calculated by the researchers according to the following equations,
Column (1) External Water Footprint = Virtual amount of imported water.
Virtual amount of imported water = Amount of imports in tons * Water needs.
Column (2) Internal water footprint = Amount of water used in production - Amount of virtual water exported.

Amount of virtual water exported = Amount of exports in tons * Water needs.
Column (4) Dependence rate on external water resources = (External water footprint / Total water footprint) * 100.
Column (5) Self-sufficiency rate from local water resources = (Internal water footprint / Total water footprint) * 100.
Column (6) Productivity of irrigation water unit = Crop productivity per dunum / Water needs per crop dunum.

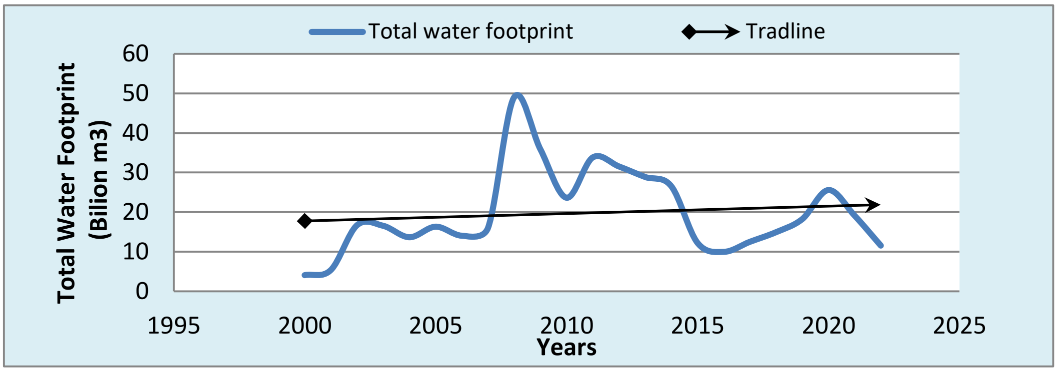

Figure 1. The total water footprint of the wheat crop in Iraq for the period 2000- 2022. Source, Prepared by the researchers based on the data in table 1.

3.1.2 Rice,

2. By studying and reviewing the data of table 2 and figure 2, it found that the external water footprint of the rice crop reached its lowest in 2000, estimated at 0.01 billion cubic meters, and reached its maximum in 2001, when it was estimated at 25.23 billion cubic meters, the reason for this difference was the reliance on the cultivated area, with an average of about 9.90 billion cubic meters. It also found that the internal water footprint reached its lowest in 2018, estimated at 0.31 billion cubic meters, and reached its maximum in 2019 when it estimated at 7.34 billion cubic meters, with an average of about 3.99 billion cubic meters. The total water footprint of the rice crop ranged between a minimum of about 1.18 billion cubic meters in 2000, and a maximum of about 29.23 billion cubic meters in 2001, with an average of about 13.89 billion cubic meters. It was also found that the percentage of dependence on external water resources for the rice crop ranged between a minimum of about 0.85% in 2000, and a maximum of about 97.39 % in 2018 due to the dependence on imports in this year because the production was only 30 thousand tons, because of limiting the water quota and preventing its cultivation in the governorates of AL-Najaf and AL-Qadisiyah for this year, with an average of about 67.98% , and this percentage was high in most years of study, while the percentage of self- sufficiency of the local water resources for the rice crop ranged between a minimum of about 62.1% in 2018, and a maximum of about 99.15% in 2000, with an average of about 32.01%. This represents a great pressure on Iraqi water resources due to the high-water requirements for rice. The unit productivity of irrigation water ranged between a minimum of 0.05 kg/m3 in 2001 and a maximum of 0.15 kg/m3 in 2014, with an average of 0.10 kg/m3. Thus, we see that the productivity of the water unit considered low for the rice crop.

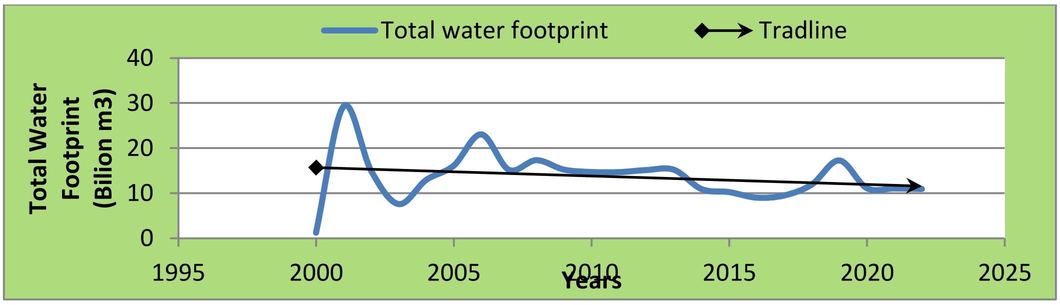

Figure 2. The total water footprint of the rice crop in Iraq for the period 2000-2022.Source, Prepared by the researchers based on the data in table 2.

Table 2. Water footprint and its indicators for the rice crop in Iraq during the period 2000-202

Years	**External water footprint (1)**	**Internal water footprint (2)**	**Total water footprint (3) (1+2)**	**Dependence rate on external water resources (%) (4)**	**Self-sufficiency rate from local water resources (%) (5)**	**Unit productivity of irrigation water (kg/m3) (6)**
2000	0.01	1.17	1.18	0.85	99.15	0.09
2001	25.23	4.00	29.23	86.32	13.68	0.05
2002	11.08	3.87	14.94	74.11	25.89	0.10
2003	5.62	1.92	7.54	74.54	25.46	0.08
2004	7.89	5.02	12.90	61.12	38.88	0.08
2005	9.92	6.15	16.06	61.73	38.27	0.08
2006	15.82	7.20	23.02	68.72	31.28	0.08
2007	8.02	7.14	15.16	52.90	47.10	0.09
2008	12.42	4.86	17.28	71.88	28.13	0.09
2009	12.04	3.15	15.19	79.26	20.74	0.09
2010	11.91	2.75	14.66	81.24	18.76	0.09
2011	10.84	3.79	14.63	74.09	25.91	0.10
2012	10.52	4.58	15.09	69.67	30.33	0.13
2013	9.64	5.51	15.15	63.63	36.37	0.14
2014	6.31	4.55	10.86	58.10	41.90	0.15
2015	8.62	1.58	10.20	84.51	15.49	0.11
2016	6.76	2.21	8.97	75.36	24.64	0.14
2017	6.26	3.19	9.45	66.24	33.76	0.14
2018	11.56	0.31	11.87	97.39	2.61	0.10
2019	9.88	7.34	17.22	57.38	42.62	0.13
2020	7.58	3.50	11.08	68.41	31.59	0.13
2021	7.44	3.10	11.02	65.66	22.15	0.12
2022	7.12	3.09	10.90	69.11	27.32	0.11
Average	9.90	3.99	13.89	67.98	32.01	0.10

Source, Calculated by the researchers according to the following equations,
Column (1) External Water Footprint = virtual amount of imported water.

- Virtual amount of imported water = Amount of imports in tons * Water needs.

Column (2) Internal water footprint = Amount of water used in production - Amount of virtual water exported.

- Amount of virtual water exported = Amount of exports in tons * Water needs.

Column (4) Dependence on external water resources = (External water footprint / Total water footprint) * 100.
Column (5) self-sufficiency rate from local water resources = (Internal water footprint / Total water footprint) * 100.
Column (6) Productivity of irrigation water unit = Crop productivity per dunum / Water needs per crop dunum.

3.2Estimation of virtual water and its indicators for the study crops in Iraq for the period 2000-2022,

Virtual water is an innovative economic idea that searches for invisible water. People do not only consume water for drinking, bathing, etc., but there are other implicit aspects that were not previously appreciated, especially in the areas of food production. According to this concept, a cup of coffee consumes about 140 liters of water was used in irrigation, production and preparation of coffee tree, and producing one kilogram of rice consumes about 300 liters of water, and producing one kilogram of beef needs 15000 liters of water on average, so virtual water is the total amount of water used in the production of food, especially for imported and exported agricultural products. Therefore, the concept of virtual water has become an economic concept as long as it relates to quantities for an important aspect in foreign trade (exports and imports) [13].

3.2.1 Wheat,

By studying and reviewing the data of table 3 and figures 3,4,5 and 6, it found that the water needs used in wheat production ranged between a minimum of about 3.08 m^3 / kg in 2016, and a higher limit of about 11.63 m3 / kg in 2008 because it was a year of scarce rain and therefore wheat production in it was less than usual, with an average of about 6.04 m3/kg. The amount of water used in wheat production ranged between a minimum of 4.04 billion cubic meters in 2000, and a maximum of 21.85 billion cubic meters in 2020, with an average of 14.23 billion cubic meters. While the amount of imported virtual water ranged between a minimum of 0.01 billion cubic meters in 2003, and a maximum of 34.48 billion cubic meters in 2008, with an average of 6.19 billion cubic meters. The value of imported virtual water ranged between a minimum of about 140 thousand dollars in 2016 and a maximum of about 14,460 thousand dollars in 2008, with an average of about 3820 thousand dollars.

Table 3. Virtual water and its indicators for wheat crop in Iraq for the period 2000-2022

Year	**Water needs (m^3/kg) (1)**	**Amount of water used in local production (billion m^3) (2)**	**Imported virtual water quantity (billion m^3) (3)**	**Imported virtual water value (thousand dollars) (4)**	**Imported quantities of wheat (ton) (5)**
2000	10.53	4.04	0.03	7880	3185
2001	6.00	5.42	0.02	5000	3000
2002	6.48	16.79	0.02	2950	2417
2003	7.49	17.45	0.01	1980	1276
2004	8.55	15.66	0.02	3510	2501
2005	7.32	16.31	0.02	3630	2535
2006	6.74	14.06	0.02	3920	2833
2007	7.26	15.99	0.02	5720	2423
2008	11.63	14.60	34.48	14460	2963320
2009	7.56	12.86	23.06	6020	3050409
2010	5.14	14.12	9.53	2400	1854525
2011	5.94	16.68	17.16	6800	2888833
2012	5.75	17.61	13.95	4730	2425381
2013	4.50	18.81	10.09	3660	2241683
2014	4.30	21.72	4.84	2420	1126009
2015	3.99	10.56	1.69	540	423744
2016	3.08	9.42	0.54	140	175087
2017	3.61	10.74	1.76	460	488187
2018	3.69	8.04	6.9	2000	1870612
2019	3.71	16.13	2.12	890	570646
2020	3.50	21.85	3.74	1060	1068000
2021	3.21	21.44	3.09	1022	1053000
2022	3.12	21.35	2.56	989	192800
Average	6.04	14.23	6.19	3820	1007933.8

Source, Calculated by the researchers according to the equations,
Column (1) Water needs = Water ration per unit area / Crop productivity.
Column (2) Amount of water used in production = Amount of production in tons*Water needs (total).
Column (3) Virtual amount of imported water = Amount of imports in tons * Water needs (total).
Column (4) Value of imported virtual water = Amount of imported virtual water * Price of the imported unit.

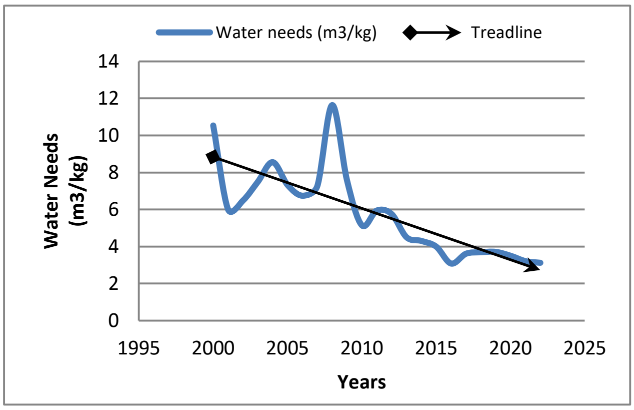

Figure 3. Water needs of wheat crop in Iraq for the period 2000-2022.
Source, Prepared by the researchers based on the data in table 3.

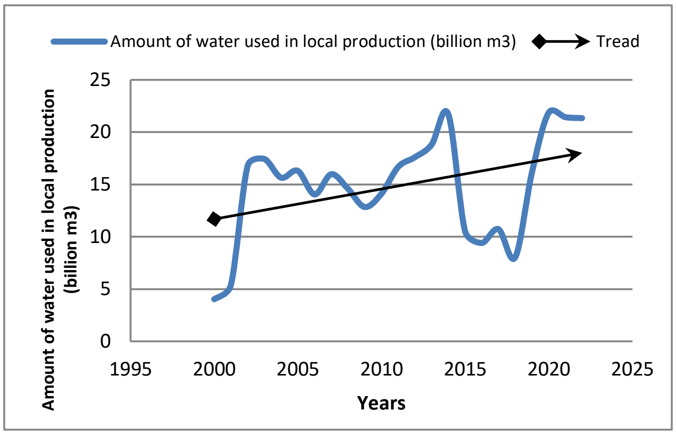

Figure 4. Amount of water used in the local production of wheat in Iraq for the period 2000-2022.
Source, Prepared by the researchers based on the data in table 3.

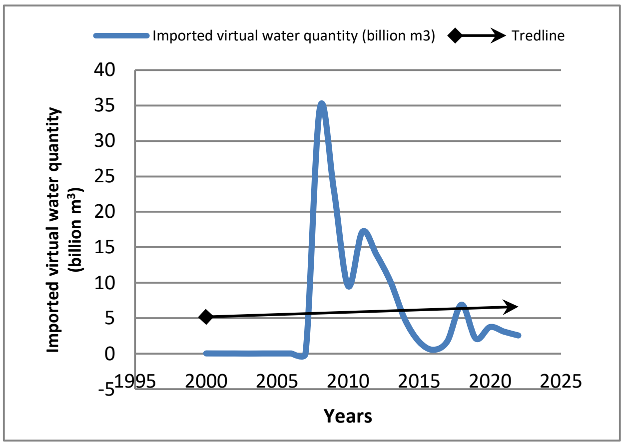

Figure 5. Amount of virtual water imported for the wheat crop in Iraq for the period 2000-2022.
Source, Prepared by the researchers based on the data in table 3.

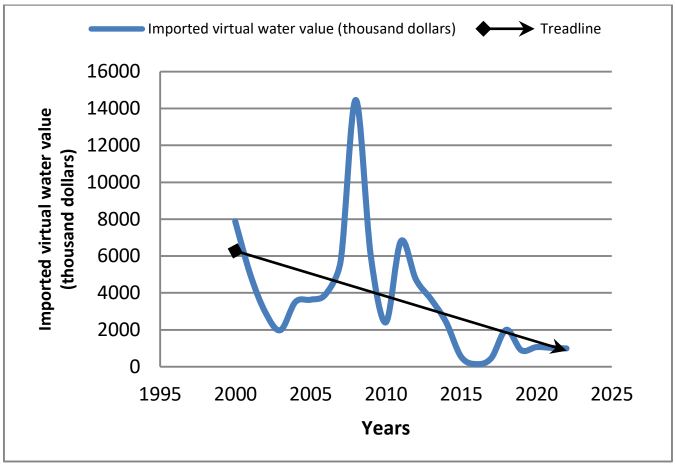

Figure 6. Value of the virtual water imported for the wheat crop in Iraq for the period 2000-2022.
Source, Prepared by the researchers based on the data in table 3.

3.2.2Rice,

By studying and reviewing the data of table 4 and figures 7, 8, 9 and 10, it found that the water needs used in rice production ranged between a minimum of about 6.78 m3 / kg in 2014, and a higher limit of about 19.74 m3/kg in 2001, with an average of about 10.19 m3/kg. The amount of water used in rice production ranged between a minimum of 0.31 billion cubic meters in 2018, the year in which rice cultivation was determined in the governorates of AL-Najaf and AL-Qadisiyah due to water scarcity, and a maximum of 7.34 billion cubic meters in 2019, with an average of 4.01 billion cubic meters. While the amount of imported virtual water ranged between a minimum of 0.01 billion cubic meters in 2000, and a maximum of 25.23 billion cubic meters in 2001, with an average of 10.03 billion cubic meters. The value of imported virtual water ranged between a minimum of about 2060 thousand dollars in 2003, and a maximum of about 9690 thousand dollars in 2018, with an average of about 5293.3 thousand dollars, which is the highest study crop in terms of water needs and the amount of imported virtual water and its value.

Table 4. Virtual water and its indicators for rice crop in Iraq for the period 2000-2022

Year	Water needs (m3/kg) (1)	Amount of water used in local production (billion m3) (2)	Imported virtual water quantity (billion m3) (3)	Imported Virtual water value (thousand dollars) (4)	Imported quantities of rice (ton) (5)
2000	11.66	1.16	0.01	3560	1200
2001	19.74	4.21	25.23	6390	1278167
2002	9.53	3.97	11.08	3240	1162000
2003	12.96	1.94	5.62	2060	433512
2004	12.11	5.04	7.89	2100	651654
2005	11.94	6.15	9.92	3460	830645
2006	11.90	7.20	15.82	5540	1329113
2007	10.89	7.14	8.02	3320	736039
2008	11.76	4.86	12.42	6950	1056016
2009	10.92	3.15	12.04	6230	1102263
2010	10.60	2.75	11.91	6220	1123199
2011	9.66	3.79	10.84	6180	1122245
2012	7.60	4.58	10.52	7150	1384191
2013	7.31	5.51	9.64	7000	1317874
2014	6.78	4.55	6.31	3060	930487
2015	8.70	1.58	8.62	6430	991063
2016	7.32	2.21	6.76	4270	923484
2017	7.19	3.19	6.26	5110	870730
2018	10.27	0.31	11.56	9690	1126193
2019	7.66	7.34	9.88	7350	1290124
2020	7.54	3.50	7.58	5850	1004345
2021	7.34	3.10	6.55	4890	997100
2022	6.90	2.67	6.12	4769	878050
Average	10.19	4.01	10.03	5293.3	984025.9

Source, Calculated by the researchers according to the equations,
Column (1) Water needs = Water ration per unit area / Crop productivity.
Column (2) Amount of water used in production = Amount of production in tons*Water needs (total).
Column (3) Virtual amount of imported water = Amount of imports in tons * Water needs (total).
Column (4) Value of imported virtual water = Amount of imported virtual water * Price of the imported unit.

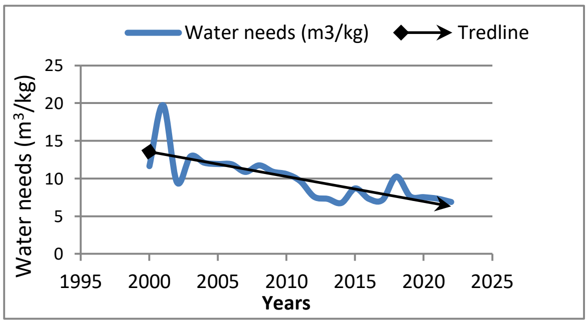

Figure 7. Water needs of rice crop in Iraq for the period 2000-2022.
Source, Prepared by the researchers based on the data in table 4.

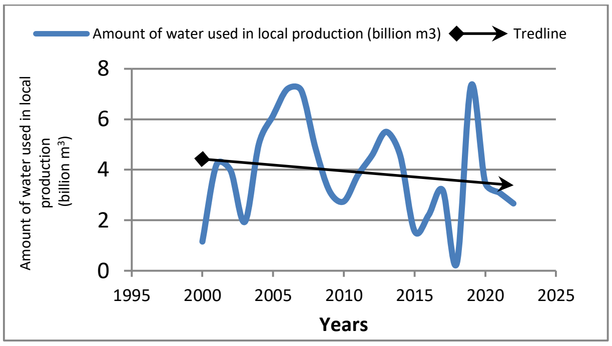

Figure 8. Amount of water used in the local production of rice in Iraq for the period 2000-2022.
Source, Prepared by the researchers based on the data in table 4.

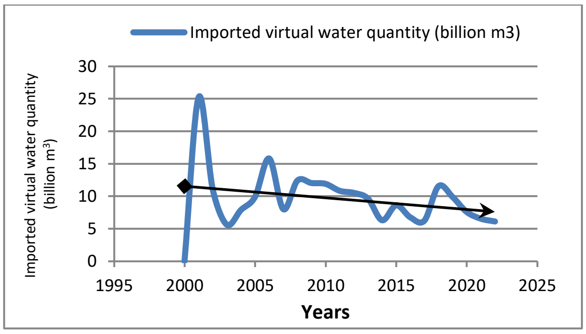

Figure 9. Amount of virtual water imported for the rice crop in Iraq for the period 2000-2022.
Source, Prepared by the researchers based on the data in table 4.

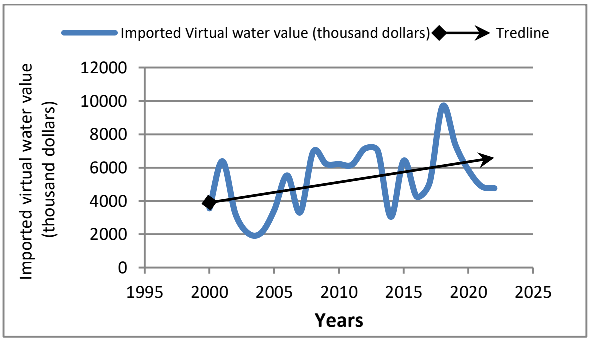

Figure 10. Value of the virtual water imported for the rice crop in Iraq for the period 2000-2022.
Source, Prepared by the researchers based on the data in table 4.

4. Conclusion

The studied cereal crops (wheat and rice) are water-consuming crops, and therefore their water footprint is high, and their virtual water content is also high, so they are consume high percentage of water share which allocated to within the agricultural plan especially rice, especially as they are widely used crops , and importing the crop from a humid country (with large water resources) is more economically and more efficient (cheaper) than importing the same crop from a dry country (which suffers from water scarcity) , and the water footprint of the rice crop was the largest, due to its high need for water and the large quantities imported from it during the study period , and high internal water footprint in water consuming crops such as rice puts great pressure on water resources in Iraq, rate of rice was higher in terms of virtual water indicators (water needs, amount of imported virtual water, value of imported virtual water) because it is a water-consuming crop and is widely used on the table of the Iraqi consumer as well as its considered within the vocabulary of the ration system . High population increase in Iraq leads to double caution, on the one hand, it increases the total water footprint of the study crops and at the same time leads to pressure on water resources and reduces the average share of the Iraqi individual from surface water resources.

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Effect of surface drip irrigation and polymer addition on some physical soil characteristics, growth and yield characteristics of cauliflower

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Abstract, The study was conducted during the fall season at the research station of the University of Anbar - College of Agriculture, cauliflower seedlings were planted on 10/2/2021 in a soil with a sandy loam mixture texture, this research aimed to study the effect of the two irrigation methods, which are surface drip irrigation (IC) and partial drying of the soil surface (IP) and the addition of polymer in the following proportions, They are without adding MO, 0,3%ML, and 0,6%MH in bulk density, porosity, weighted diameter, plant height, leaf area, and total yield, The experimental treatments were distributed using the factorial experiment within the randomized complete block, and the results of the study showed that the method of partial drying of the soil surface was significantly superior to the rest of the treatments by giving it the lowest average of the bulk density values 1,25 mg,g-3 and the highest average of the porosity values at 50,79%, and an increase in the average values of the weighted diameter, plant height, leaf area and total yield at 0,36 mm, 50,33 cm, 10,58 dm plant-1 and 33,61 tons ha-1, respectively, The effect of the polymer treatments on the above traits, the polymer addition treatment was significantly superior by 0,6% by giving it the lowest apparent density at 1,22 Mg,g-3 and the highest mean of the porosity values, which was 52,17%, 11,79 dm per plant-1 and 34,17 tons per hectare-1, respectively,

1,Introduction

Scarcity of fresh water resources and severe drought pose a constant threat to agricultural production in arid and semi-arid regions, preventing the cultivation of more crops or even the provision of existing plant water needs [14], Therefore, attention must be paid to irrigation and raising its efficiency through the introduction of some appropriate technologies, Drip irrigation is one of the fastest growing technologies in modern irrigated agriculture, with a great potential to achieve high water use efficiency, Drip irrigation includes adding water in the form of separate drops, continuous drops, small streams, or miniature sprays, through mechanical devices called drippers located at specific points along the water supply lines as water seeps to the surface of the soil [25], [5]mentioned that drip irrigation improves some of the physical properties of the soil and preserves its structure from deterioration, especially in arid and semi-arid regions, It is major in soil management and the bulk density is affected by many internal factors such as wetness, drying, freezing, thawing, swelling and shrinkage during irrigation, and external factors such as tillage and service operations that are applied in the field, Drip irrigation saves a large proportion of water compared to other irrigation systems, as it can save 30-70% of the irrigation water added [28] and[18], The technique of partial drying of the root zone is an effective strategy to save irrigation water, and requires wetting half of the root system while leaving the other half to a certain level during each irrigation time, i,e, only one side of the plant root is irrigated, and in this way one part of the root absorbs water and the other part It remains dry for the second irrigation and for this reason the partial drying technique of the root zone This technique was developed to partial drying of the soil surface, which is the same technique, except that drying is for the soil surface and not for the root zone [1], [4]found in a previous study that the bulk density value increased to 1,41 Mg, m^{-3} using the surface drip irrigation method compared to the partial drying of the root zone at 1,35 Mg ,m^{-3}, while the porosity was 46% compared to the partial drying method of the root zone, which was 49% [7] showed that the best value of the weighted average diameter was in the partial drying treatments of the root zone was 4,07 mm, compared to the surface drip irrigation treatments, which were 3,72 mm, This was attributed to the low soil moisture content in the superior treatments, which led to the accumulation of salts and materials within root zone, as well as the role of desiccation and wetting cycles that help increase cohesive forces between soil particles, [8] founded the highest mean plant height values 45,40 cm for the root zone drying irrigation treatment, compared to 44,5 and 44,3 cm when treating strip subsurface drip irrigation and conventional subsurface drip irrigation, respectively,[21] found that partial drying of the root zone in the leaf area of the potato crop was significantly superior, which amounted to 372 dm^2 $plant^{-1}$ compared to the deficient irrigation treatment, which was 351 dm^2 $plant^{-1}$, The results of [9] showed an apparent increase in potato yield for the partial drying irrigation treatment of the area rootstock, which reached 3,26 kg m^{-3} compared to 3,21 kg m^{-3} for the surface drip irrigation treatment, Polymer is a compound with a high molecular weight ranging from 1000 to more than 100,000 molecules, It may be organic or inorganic or both, and be natural or synthetic in origin, Polymers are used in many applications such as medical materials, building materials, electrical and electronic equipment and agricultural applications, as shown by[11], [13]mentioned that increasing the percentage of polymer addition to the soil increases the decrease in the bulk density of the soil, due to the increase in the total volume of the soil when mixing the polymer with the soil, [24] indicated a decrease in the average bulk density values with an increase in the proportions of polymer addition mixed with soil by 0,2 and 0,4%, which were 1,29 and 1,26 Mg m^{-3} compared to the treatment without addition, which was 1,47 Mg ,m^{-3} and a significant increase in the rate of the porosity values 49,98% and 49,2% compared to the treatment without addition, which amounted to 40,72%, The addition of polyacrylamide led to a decrease in the bulk density and an increase in the total porosity with an increase in the proportions of its addition to the soil, as it decreased significantly by adding the polymer in proportions of 0,5, 1, and 2 g kg^{-1} by mixing with the soil of the shoulder of the river and amounted to 1,44, 1,38 and 1,37 Mg ,m^{-3} and its porosity is 42,51 And 46,77 and 46,38%, compared to the treatment of the river shoulder soil without addition, which was 1,48 Mg ,m^{-3} and 42,51% attributing the reason for this to the fact that the addition of the polymer to the soil contributed to an increase in the soil porosity per unit volume, leading to a decrease in bulk density [23,]The addition of superabsorbent polymers has a positive effect on the growth of plants, and the improvement of some physical properties of the soil such as aeration and root penetration, as well as its addition increases the stability of aggregates in sandy soils [16,] [22] concluded that the use of liquid polymers had a significant effect on the size of soil aggregates, that is the average weighted diameter compared to a treatment without addition, The results of [10] showed that polymers have an important role in improving soil properties and plant growth in drought conditions, [6] found that the addition of the polymer to the soil at a rate of 0,1% and 0,2% led to a significant difference in the mean values of the height of the yellow corn plant which were 184,5 and 194,7 cm, respectively, compared to the treatment without addition, which amounted to 163,6 cm, [3] concluded that the use of polymer (hydrogel) at three levels 0, 60, and 120 kg ha-1Levels led to an increase in the height of the wheat plant grown in stocks two months after planting to 32,50 and 36,24 cm for the two treatments 60 and 120 kg ha-1- respectively compared with treatment without addition, [29]concluded that the addition of the polymer by 0,4% in the surface layer when using drip irrigation led to an increase in the yield of melon by 58,6%, Cauliflower is from the Brassicaceae family of the important winter vegetable crops due to its high nutritional value, as it contains protein, carbohydrates, fats, and minerals, in addition to containing many vitamins and ascorbic acid [17,]The effect of the two methods of surface drip irrigation on some physical properties, growth and yield of cauliflower,Effect of polymer addition on some physical properties, growth and yield of cauliflower,

2,Materials and Methods

The experiment was conducted on a land of dimensions 12×39 m, i,e,, with an area of 468 m^2, Table 1 shows some of the physical and chemical properties of this soil before planting, and Table 2 shows the symbols and treatments of the experiment and its details, The land was plowed and smoothed, It was divided into 18 treatments distributed over three sectors, each containing 6 treatments, and the distance between the planting lines was 1,5m and between each sector and another 2,5m, After that, a line of pipes was laid for surface drip irrigation and two lines of pipes with a length of 10 m containing inside them GR-type drippers with a drainage of 4 liters per hour 1- for each terrace and the distance between one line and another is 0,30 m for irrigation treatments by partial drying of the soil surface, and the experiment treatments were distributed within a factorial experim ent using the randomized complete block design (RCBD), then seedlings of cauliflower, were planted in the field at a distance of 0,40 m between one seedling and another, at a rate of 25 seedlings per experimental unit, fertilizers were added according to [2]recommendation , and irrigation was done from the Euphrates River, whose salinity 1,14 ds,m^{-1}, and the depth of the total water that was added was 31,74 cm, based on the Kovda equation [19]

$$d = \frac{\theta_{fc} - \theta_{pwp}}{100} * D \ldots\ldots\ldots\ldots\ldots, (1)$$

d, depth of water added (cm),

θ_{fc} , volumetric humidity at field capacity (%),

θ_{pwp}, volumetric humidity at permanent wilting point (%),

D, the depth of the root zone to be irrigated (cm),

Since the water consumed by plant tissues does not exceed 1%,

$$ET_a = d \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

ET_a, evaporation – actual transpiration (mm day^{-1}),

d , depth of water (m),

The addition was made for the partial drying of the soil surface by extending two lines of branch pipes, the distance between them is 0,30 m, and the seedlings were planted in the middle of the distance, Which was determined based on the American evapotranspiration basin class A,

Table 1, Some physical properties of field soil before planting to a depth of 0-30 cm,

Property	Value	Unit	Property	Value	Unit
Sand	684	g kg^{-1}	electrical conductivity	1,62	ds m^{-1}
Clay	112	g kg^{-1}	Ph	7,14	--------
Silt	204	g kg^{-1}	dissolved positive ions		
Texture	Sandy Clay Loam		Ca^{2+}	5,23	mL
Apparent	1,3	Mg m^{-3}	Mg^{2+}	3,89	equivalent\
			Na^{+}	5,6	L^{-1}

density					
Bulk density	2,54	Mg m^{-3}	K^+	1,39	
			dissolved negative ions		
Porosity	48,82	%	SO_4^{-2}	7,52	
Mean Weighted diameter	0,29	Mm	HCO^{-3}	1,69	mL equivalent\ L^{-1}
Water	0,206	%	CO_3^{2-}	NIL	
			CL^-	6,7	

Table 2, Experimental treatments symbols and details

Treatment	Symbol	Details
T1	I_CM_0	Surface drip irrigation without addition
T2	I_CM_L	Surface drip irrigation and 0,3% polymer addition
T3	I_CM_H	Surface drip irrigation and 0,6% polymer addition
T4	I_PM_0	Partial drying of the soil surface without adding
T5	I_PM_L	Partial drying of the soil surface and the addition of 0,3% polymer
T6	I_PM_H	Partial drying of the soil surface and the addition of 0,6% polymer

2,1 Bulk density

The bulk density of the soil was estimated according to[15] and calculated through the following equation,

$$\rho_b = \frac{M_s}{V_t} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3)$$

P_b, apparent density (Mg ,m^{-3})

M_s, dry soil mass (Mg)

V_t, the total soil volume (m^3)

While the porosity was calculated through the following equation according to[15],

$$f = \left[1 - \frac{\rho_b}{\rho_s}\right] \times 100 \dots\dots\dots\dots\dots\dots\dots\dots (4)$$

f, porosity (%)

P_b, apparent density (Mg ,m^{-3})

P_s, bulk density (Mg ,m^{-3})

2,2 *Mean Weighted diameter*

The mean weighted diameter was measured according to [26] method and according to the following equation,

$$M\,W\,D = \sum_{i=1}^{n} X_i W_i \qquad \dots\dots\dots\dots\dots\dots (5)$$

M W D, mean weighted diameter (mm)

Wi, The mass of the assemblies as a ratio to the total sample weight (without units)

Xi, The average diameter of these assemblies (mm),

2,3 Plant height

The height of the plant was measured at the end of the growing season from the point of contact of the shoot system with the root system to the growing apex, according to [12],

2,4 Leaf area

leaf area was estimated by the gravimetric method according to [27] through the following equation,

$$\text{Leaf area (dm}^2\ \text{plant}^{-1}) = \frac{\text{area of leaf disc} \times \text{dry weight of leaves}}{\text{Dry weight of leaf discs}} \quad \ldots\ldots\ldots (6)$$

2,5 Total yield

The yield was harvested after 120 days of planting, as the number of plants per hectare reached 16,667 plants, which were calculated on the basis of the number of plants in the cultivated area, according to [8] through the following equation,

$$\text{Total yield (ton hectare}^{-1}) = \frac{\text{Total yield of 5 plants per experimental unit (kg) X 16667 plants.ha}^{-1}}{\text{5 X 1000}} \quad \ldots\ldots\ldots (7)$$

3,Results and Discussion

3,1,1 Bulck density and porosity for depth 0 – 20 cm

Table 3 shows the effect of the two methods of surface drip irrigation and the polymer addition and the interaction between them on the average values of apparent density and porosity of significant differences in mean values of apparent density and porosity, which amounted 1,25 Mg ,m and 50,79% for partial dry treatment of soil surface compared to values of apparent density and porosity to1,29 Mg m^{-3} and 49,08% for the surface drip irrigation treatment respectively, The reason for this may be due to dividing the net water requirement into two parts by adding water at close intervals and in appropriate quantities that help keep the soil moist, which It leads to an increase in the stability of aggregates in the soil and the improvement of their structure, these results agree with [4],

The treatment of addition polymer addition, the results showed in the same table that there were significant differences in the mean of the bulk density and porosity values, as it reached 1,22 Mg m^{-3} and 52,17% for the 0,6% polymer addition treatment, compared to 1,25 and 1,35 Mg m^{-3} and 50,79%, 46,85 for polymer addition treatments at 0,3% rates and without addition respectively, and the possibility of this may be attributed to the fact that the addition of polyacrylamide to the soil contributed to an increase in the soil porosity per unit volume, leading to a decrease in bulk density [24],

The table mentioned above showed that there were no significant differences between the two methods of surface drip irrigation and polymer addition in the values of bulk density and porosity,

Table 3, The effect of surface drip irrigation and polymer addition methods on the bulk density Mg ,m^{-3} and the total porosity % for a depth of 0-20 cm,

Apparent density (Mg ,m^{-3}) for depth 0 – 20 cm				Porosity (%) for depth 0 – 20 cm		
Polymer addition levels	**Surface drip irrigation methods**		**Mean polymer addition**	**Surface drip irrigation methods**		**Mean polymer addition**
	I_C	I_P		I_C	I_P	
M_O	1,36	1,34	1,35	46,46	47,24	46,85
M_L	1,27	1,23	1,23	50,00	51,57	50,79
M_H	1,25	1,18	1,18	50,79	53,54	52,17
LSD	N,S		0,022	N,S		0,882
Mean of surface drip irrigation	1,29	1,25		49,08	50,79	
LSD	0,018			0,720		

3,1,2 Apparent density and porosity to a depth of 20-40 cm

Table 4 shows the effect of the two methods of surface drip irrigation and the addition of polymer and the interaction between them on the mean values of apparent density and porosity, while the results for the two methods of surface drip irrigation the presence of significant differences in the mean values of bulk density and porosity, as it reached 1,28 Mg m^{-3} and 49,74% for the treatment of Partial drying of the soil surface compared to the average values of apparent density and porosity, which amounted to 1,32 Mg ,m^{-3} and -48,16% for the surface drip irrigation treatment, and the reason for this may be due to the fact that apparent density and porosity are affected by the mechanism and speed of wetting due to the movement of fine soil particles to the large pores, which change the volumetric distribution of soil pores, which works to raise the apparent density of the soil and these results agrees with [5],

The results of polymer addition reveled from the above table that there were significant differences in the mean values of apparent density and porosity, as it reached 1,25 Mg m^{-3} and 50,79% for the treatment of adding 0,6% polymer, compared to the mean values of apparent density and porosity, which amounted to 1,28 and 1,37 Mg ,m^{-3}, 49,80 and 46,26% for the polymer addition treatments at 0,3 rates and without the addition of the polymer respectively, and the reason may be due to the fact that these materials led to the improvement of soil structure and reduced the bulk density through the bonding bridges that they created between the soil particles, which led to an increase in its porosity, due to the increase in the total volume of the soil when mixing the polymer with it, and this is consistent with what was shown by [24] and [13],

The above table showed that there were no significant differences between the two methods of surface drip irrigation and polymer addition in the values of apparent density and porosity,

Table 4, Effect of surface irrigation and polymer addition methods on apparent density Mg ,m^3, and porosity for a depth of 20-40 cm,

Apparent density Mg ,m^{-3} for depth 20 – 40 cm				Porosity (%) for depth 20 – 40 cm		
Polymer addition levels	**Surface drip irrigation methods**		**Mean polymer addition**	**Surface drip irrigation methods**		**Mean polymer addition**
	I_C	I_P		I_C	I_P	
M_O	1,38	1,35	1,37	45,67	46,85	46,26
M_L	1,30	1,25	1,28	48,82	50,79	49,80
M_H	1,27	1,23	1,25	50,00	51,57	50,79
LSD	N,S		0,016	N,S		0,626
Mean of surface drip irrigation	1,32	1,28		48,16	49,74	
LSD	0,013			0,514		

3,2 The weighted diameter mean for depth 0-20 and 20-40 cm

Table 5 shows the effect of the two methods of surface drip irrigation and the addition of polymer and the interaction between them on the mean values of the weighted diameter, the results showed that the two methods of surface drip irrigation, there was a significant difference in the mean values of the mean weighted diameter, at 0,36 and 0,34 mm for the treatment of partial drying of the soil surface for the two depths of 0-20 and 20-40 cm, respectively, compared with 0,30 and 0,34 mm for the surface drip irrigation treatment, respectively and the reason for this may be due to the method of partial drying of the soil surface, as half of the root zone is irrigated and the other half is left without irrigation and as a result the dry part works to withdraw an amount of soil moisture content for the irrigated part, which increases the speed of alternating cycles of drought and wetting and thus increases the stability of soil aggregates, which led to the accumulation of salts and binders within the root zone, and this is consistent with conclusion of [7],

As for the effect of adding a polymer, the same table shows that there were significant differences in the mean values of the weighted diameter, as it reached 0,40 and 0,38 mm for the treatment of adding a polymer at a rate of 0,6%, compared to the mean weighted diameter, which amounted to 0,37, 0,35, 0,26, and 0,25 mm for the treatments of adding the polymer at rates of 0,3, And without adding to the depths 0-20 and 20-40 respectively, and the reason may be due to the fact that these materials led to the improvement of soil structure and reduced the apparent density through bridges to link between the soil particles, which led to an increase in its porosity, and an increase in the linkage of soil particles with each other to form a weld material between soil particles leading to an increase in the stability of soil aggregates [22],

The table above also showed that there were no significant differences for interaction between the two methods of surface drip irrigation and polymer addition in the weighted diameter mean,

Table 5, Effect of surface drip irrigation and polymer addition methods on the mean weighted diameter mm for depths of 20-20 and 20-40 cm,

Apparent density (Mg ,m^{-3}) for depth 0 – 20 cm				Porosity (%) for depth 20 – 40 cm		
Polymer addition levels	**Surface drip irrigation methods**		**Mean polymer addition**	**Surface drip irrigation methods**		**Mean polymer addition**
	I_C	I_P		I_C	I_P	
M_O	0,25	0,27	0,26	0,23	0,26	0,25
M_L	0,34	0,39	0,37	0,32	0,37	0,35
M_H	0,37	0,42	0,40	0,35	0,40	0,38
LSD	N,S		0,016	N,S		0,12
Mean of surface drip irrigation	0,32	0,36		0,30	0,34	
LSD	0,019			0,10		

3,3Cauliflower height

Table 6 shows the effect of the two methods of surface drip irrigation and the addition of polymer and the interaction between them on the mean values of plant height, The results of the two methods of surface drip irrigation showed there were significant differences in the average plant height values, as it reached 50,33 cm for the partial drying treatment of the soil surface, compared to the average plant height values, which reached 46,23 cm for the treatment of surface drip irrigation, and the reason may be due to the partial drying of the soil surface that provides adequate moisture in the root zone, which helps to absorb nutrients well, which increases the activity and vitality of the plant, and this is consistent with [8],

As for the addition of the polymer, the results showed in the same table that there were significant differences in the mean plant height values, as it reached 50,75 cm for the treatment of adding the polymer at a rate of 0,6%, compared to 48,10 and 46,10 cm for the treatments of adding the polymer at a rate of 0,3% and without adding, respectively, and the reason may be due to that the addition of the polymer leads to improving the properties of the soil and increasing the readiness of nutrients in the soil, which increases the rate of absorption efficiency in addition to increasing the ability of the soil to retain water, which stimulates cell division and elongation, and then an increase in plant height and this is consistent with [6] and [3],

The same table shows that there are significant differences between the interaction between two methods of surface drip irrigation and the addition of polymer in plant height values, , were highest value of cauliflower plant height reached 53,00 for the treatment of partial drying of soil surface and 0,6% polymer adding while the lowest value for cauliflower plant height was 44,80 cm for surface drip irrigation treatment without addition,

Table 6, Effect of surface drip irrigation and polymer addition on cauliflower plant height cm,

Polymer addition levels	**Surface drip irrigation methods**		**Mean polymer addition**
	I_C	I_P	
M_O	44,80	47,20	46,00
M_L	45,40	50,20	48,10
M_H	48,50	53,00	50,75
LSD		0,874	0,618
Mean of surface drip irrigation	46,23	50,33	
LSD	0,505		

3,4 Cauliflower leaf area

The table shows the effect of the two methods of surface drip irrigation and the addition of polymer and the interaction between them on the values of leaf area, The results for the two methods of surface drip irrigation showed significant differences in the mean leaf area values, as it reached to 10,85 dm^2 $Plant^{-1}$ for the partial drying treatment of the soil surface, compared to the mean leaf area values, which amounted to 9,71 dm^2 $Plant^{-1}$ for the treatment of surface drip irrigation, and the reason may be due to the segmentation of the irrigation depth and the efficiency of the addition in the partial drying of the soil surface and thus maintaining the appropriate moisture for the necessary water and nutrients absorption, and these results is consistent with [21],

The results of the polymer addition, showed in the table and the appendix above that there were significant differences in the mean values of the leaf area, as it reached 11,79 dm^2 $Plant^{-1}$ for the treatment of adding 0,6% polymer at compared to the mean leaf area values, which amounted to 10,66 and 8,40 dm^2 $Plant^{-1}$ for the treatment of adding the 0,3% polymer by and without adding a polymer respectively, and the reason for this may be due to the fact that moisture is available at its best levels in the root zone and to improve the physical characteristics of the soil, which creates a suitable environment for the growth and branching of the roots, leading to an increase in the vegetative system, which is positively reflected on the values of the leafy area of the plant in addition to the ability of the polymer to preserve large amounts of water,

The above table also showed that there were significant differences between the two methods of overlapping the surface drip irrigation and polymer addition in the value of the leaf area, as the results showed that the highest value of the leaf area was 12,00 dm^2 $plant^{-1}$ for the treatment of partial drying of the soil surface and the addition of polymer by 0,6%, which is superior to all treatments, The other interactions, while the lowest value of leaf area was 7,84 dm^2 $Plant^{-1}$ for surface drip irrigation treatment without addition,

Table 7, Effect of surface irrigation methods and polymer addition on the leaf area of cauliflower dm^2 $plant^{-1}$

Polymer addition levels	Surface drip irrigation methods		Mean polymer addition
	I_C	I_P	
M_O	7,84	8,96	8,40
M_L	9,72	11,59	10,66
M_H	11,58	12,00	11,79
LSD		0,172	0,122
Mean of surface drip irrigation	9,71	10,85	
LSD	0,099		

3,5 Total yield

Table 8 refer to the effect of the two methods of surface drip irrigation and the polymer addition and the interaction between them on the mean values of the total yield, with significant difference in the mean of total yield which reached 33,61 ton $hectare^{-1}$ for the partial drying of soil surface treatment compared with mean values of total yield of surface drip irrigation at 30,67 ton $hectare^{-1}$, and the reason for this may be due to the fragmentation of the depth of the irrigation, the convergence of the irrigation periods, and the succession of the wetting and drying cycles, which results in maintaining adequate moisture for the plant and urging the roots to absorb nutrients from the soil under the drying system of the soil surface, and these results is consistent with results of [9],

The polymer addition results showed in the above table that there were significant differences in the mean values of the total yield, as it reached 34,17 tons $hectare^{-1}$ for the treatment of adding 0,6% polymer compared to 32,08 and 30,17 tons $hectare^{-1}$ for the treatments of adding 0,3% polymer and without polymer addition respectively, this is due to the decrease in the apparent density, the increase in porosity, the improvement of the stability of the aggregates, and the increase in the ability of the soil to conserve water, and these results consistent with [29],

As for the interaction between the two methods of surface drip irrigation and the addition of polymer, the same table shows the presence of apparent differences in the values of the total yield, as the results showed that the highest value of the total yield reached 35,83 tons $hectare^{-1}$ for the treatment of partial drying of the soil surface and the addition of 0,6% polymer, which is superior to all treatments, while the lowest value of the total yield was 28,97 ton ha^{-1} for the treatment of surface drip irrigation without addition,

Table 8, Effect of surface drip irrigation methods and polymer addition on the total yield of cauliflower, ton $hectare^{-1}$

Polymer addition levels	**Surface drip irrigation methods**		**Mean polymer addition**
	I_C	I_P	
M_O	28,67	31,67	30,17
M_L	30,83	33,33	32,08
M_H	32,50	35,83	34,17
LSD	N,S		0,395
Mean of surface drip irrigation	30,67	33,61	
LSD	0,323		

4, Conclusion

Using the method of partial drying of the soil surface led to the improvement of some physical properties of the soil, as the bulk density decreased and the porosity and the weighted diameter increased,Using the method of partial drying of the soil surface led to the improvement of some growth and productivity traits, as the leaf area, plant height and total yield increased,The use of the polymer led to the improvement of some physical properties of the soil, as the bulk density decreased and the porosity and the weighted diameter increased,The addition of the polymer had a positive effect on some growth and productivity traits, as the leaf area, plant height and total yield increased,

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Effect of Date Residues and Organic Acids on Some Physical Properties of Gypsiferous Soil

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Abstract. A laboratory experiment was carried out at the College of Agriculture, University of Anbar, located at 43°20'09.7"E longitude, 33°25'36.7"N latitude for the period from 1/10/2021 to 1/10/2022, to study the effect of date residues, organic acids, and wetting / drying cycles on some physical properties of gypsiferous soil. The soil was selected from the site of the Fallujah palm station that located at longitude 43º51′. 05. 36 E. and latitude 33º17′. 46. 82'N., date residues were added in three levels, without addition (comparison treatment), 0.1% and 0.2% mixed with soil. Organic acids was added at 0% and 0.1% and packaged in plastic cylinders and the treatments were exposed for two levels of wetting and drying cycles (6 and 8) cycles. The stability of aggregates, dispersion ratio, saturated hydraulic conductivity, and cumulative infiltration were measured. The results showed that the addition of date residues by 0.2% improved all the physical properties. Aggregates stability values increased by 13.41% and saturated hydraulic conductivity values decreased, which reached 4.33 cm.h-1. Accumulator infiltration up to 24.01cm and the capillary height reached to 40.0 cm, while the dispersion rate decreased to 37. 27%. The aggregates stability increased and the dispersion ratio, water conductivity and infiltration decreased by adding organic acids when their averages reached 12.12%, 40.77%, 5.19 cm-1 and 21.41cm, respectively. Increasing the number of wetting / drying cycles negatively affected most of the studied properties, as the dispersion ratio increased to 42.08%, and the cumulative infiltration decreased to 21.73 cm.

1. Introduction

Soil is the main source of agricultural production necessary for human food, as it represents the appropriate medium for agricultural and non-agricultural activities. Gypsiferous soil occupies large areas of arid and semi-arid region in which annual precipitation rates are low and a source of gypsum is available. Most studies indicate that gypsiferous soils are spread over of 100 million hectares in the world, and its area in Iraq is about 88,000 km2 [1]. These soils suffer from many problems, including the lack of quantity and readiness of nutrients due to the low content of organic matter and the high solubility of gypsum in water, which is considered one of the important problems facing the exploitation of these soils. There are many factors that play an important role in this area, the most important is the quality of the water used, in addition to temperature, ionic strength, size of gypsum crystals and the irrigation method used, [2].

The presence of gypsum in high proportions is a major reason for its poor physical and chemical properties, which limits agricultural production. Weak structure and low content of organic matter leading to reduce its water retention capacity and a disturbance in the flow of water through it because of the high solubility of gypsum 2.06 g.L-1 in addition to problems with the formation of a hardened subsurface layer that hinders the growth of roots. These soils are less fertile due to the low cation exchange capacity, so understanding the nature and behavior of the water properties of gypsiferous soils is necessary to reach a good management. Recent studies have tended to find solutions, including the addition of soil conditioner to improve their structure by increasing the formation of soil aggregates and creating suitable conditions for plants, as these conditioners aerate and absorb elements as well as the effectiveness of enzymes and microorganisms.

Organic acid affects the physical properties of soils through its high ability to form organic complexes because it contains effective combinations such as carboxyl, which enhance the stability of aggregates. [3] Found that the addition of 5% date residues and 30 kg organic acid improved the productivity and growth of onion plants and attributed this to their role in improving the soil physical properties. [4] Indicted that the addition of sawdust extract improved the physical properties of gypsiferous soil, as the values of the capillary height of the soil increased and reached 30.1 cm, and the aggregates stability increased by 19.37% compared to the Non-addition treatment, as a result of the organic acids role in reducing the pore radius and improving soil structure.

The effect of wetting / drying cycles on the stability of soil aggregates is related to the addition of Cementing material such as soil conditioners and organic components [5, 6] Referred to the role of organic matter and aqueous extracts in coating soil particles, reducing their wetting and increasing the stability of aggregates, because of binding coarse soil particles, improving porosity and increasing their ability to retain water. [7] Found that the addition of molasses factories residues led to an increase in the percolation in the soil. [8] Showed that the ability of the soil to retain water increased with the decrease in the gypsum content of the soil. [9] Studied the effect of wetting / drying cycles on the dispersion rate in gypsiferous soil. They found a significant effect in reducing the dispersion rate, as the highest percentage of decrease amounted to 45.88% in the ninth cycle compared to the first cycle, and they obtained a significant increase in the average weighted diameter at slow wetting by 8.02 %. This study was conducted to improve the physical properties of gypsiferous soil for the possibility of using it for agricultural purposes.

2. Materials and Methods

A laboratory experiment was carried out in the College of Agriculture, University of Anbar, located at 43°20'09.7"E longitude, 33°25'36.7"N latitude for the period (1/10/2021 - 1/10/2022) to study the effect of molasses factories residues, organic acids and wetting / drying cycles on some physical properties of gypsiferous soil. Soil samples was taken from the Fallujah palm site were morphologically classified into subgroup (Haplo gypsid typic) according to the American system [10], soil series (123 XXWG) depending on the classification proposed by [11]. Some physical and chemical properties of the study soil were estimated according to the proposed methods in (Table 1).

Table 1.soil physical and chemical properties

Property	Unit	Value
Sand		760.6
Silt	g kg-1	155.2
Clay		84.2
Texture		Sandy Loam
Gypsum	g kg-1	310
Calcareous		27
Bulk density	µg.m-3	1.61
EC	ds m-1	3.7
PH		7.2
O. M	g kg-1	10.5
Ca+2		46.8
Mg+		7.4
Na+	mmol L-1	2.4
K+		1.7
SO4=		20.4
Saturated hydraulic condectivity	cm h-1	7.60

2.1. Study factors

2.1.1. Dates residual. Dates residues were taken from the molasses factories in Heet, then dried and sifted through a sieve with (1 mm) diameter. They were mixed with the soil at three levels; (D0= without addition), (D1=0.1%), and (D2 =0.2 %).

2.1.2. Organic acid. Organic acids was prepared in the laboratories, as the organic acids were separated according to [12] using (0.1 Eq.L-1) KOH. Organic acid was isolated from fulvic acid by precipitation with HCl using a centrifuge. It was dried and its weight and percentage were calculated. It was added in two levels (H0 = without adding and H1 = 0.2%).

2.1.3. Wetting / drying cycles. The treatments were exposed into two levels of wetting and drying (6 and 8) cycles. This is done by reaching soil moisture to the field capacity limit, then letting it dry until it reaches the permanent wilting point (PWP) (1500 Kpa) and according to [9].

Number of treatments = (3) residues of the molasses * (2) organic acid * (2) wetting / drying cycles = 12

Number of experimental units = (12) treatments * (3) replicates = 36.

2.2. *Treatments preparation.*
Factor experiment was performed as a randomized complete block design with three replications. Plastic pots were using with (40 cm length, 20 cm width and 25 cm depth), with a hole at the bottom. The soil mass for each pot was calculated based on the size of the pot and at a depth of 20 cm. It was filled with samples after the soil was mixed with date residues at 1.30 µg. m-3 bulk density. Organic acid was added to the soil, then soil moisture was reached to the field capacity limits, and the lost water was compensated after 50% of the available water was depleted. The experimental treatments were incubated for two months.

2.3. Physical properties

2.3.1. Dispersion Ratio: Dispersion ratio was estimated, by taking 10 g of soil passing through a 2 mm sieve, and then it is placed in a volumetric cylinder with a 1 L, then completing the volume to a liter with distilled water. The shaking the contents of the cylinder was done by using the plunger and leaving the suspension for some time. Volume of soil aggregates was calculated using (Stokes' law). The process is repeated by taking 10 g of soil passing through a 2 mm sieve, then, an analysis of particle sizes was performed, by removing the organic matter using (OH). Salts were removed using distilled water, and dispersing the soil aggregates using the dispersion solution, then the dispersion ratio was calculated according to the following equation:

DR = (Silt + clay (without remove)) / (% Silt + clay (with remove)) …… 1

Where: Silt (%) + clay (w) are the percentage of clay and silt in distilled water without adding a dispersion solution. Silt (%) + clay (g) is the percentage of clay and silt with the addition of the dispersion solution (some criteria for evaluating the construction of calcareous and gypsiferous soils treated with organic extract of sawdust [13].

2.3.2. Soil aggregates stability. The percentage of aggregates stability was estimated using the wet sieving method according to [14]. Soil sample was taken and passed through a sieve of 2 mm diameter, 4 g sample was placed on 0.25 mm sieve. Special moisture containers were prepared, 100 ml of distilled water was added under the sieve. After that, the sieve still inside the water box for 6 minutes, then removed and placed in the oven at a temperature of 65 m to dry in order to calculate the weight of the soil (WS). The process is repeated with 100 ml of chalcone (2%) concentration, and the sieve begins to move inside the chalcone container for 6 minutes (WC). The percentage of the aggregates stability is calculated according to the following equation

A.S = WC/ (WC+WS) * 100 ……. 2

Since:
A.S = percentage of aggregates stability (%) WS =
Mass of soil was sieved in water (g).
WC =Mass of soil was sieved in chalcone (g).

2.3.3. *Saturated hydraulic conductivity*. The conductivity was estimated by the core sample according to [15]. Unexcited soil samples was taken, moisturized by capillarity, and determined by the fixed water column method. The volume of sinking water was determined after 30 minutes. The process was repeated several times for the same time until reaching two identical readings. The hydraulic conductivity was calculated according to Darcy's law, as follows:

$$Ks = (V.L) / (A.t\ (h+L)) \quad \text{…. …. 3}$$

Since:
KS = Saturated water conductivity, cm. h-1. V =
Volume of water in cm3.
A = Cross-sectional area of a cylinder, cm2.
t = Time, m.
h = Height of the water column, cm.

2.3.4. *Infiltration.* Infiltration was estimate using a Mini Disk Infiltro-meter (MDI). (Fig. 1). The depth of the infiltration was calculated every 30 seconds for 6 minutes, the cumulative infiltration was calculated according to [16] . The infiltration was calculated using the following equation [17]:

$$I = C1\sqrt{T} + C2\ T \quad \text{………. 4}$$

Whereas:

I = Cumulative infiltration (m. sec-1) C1 =
Soil water absorbency (m2 - 0.5)
C2 = Constant related to the hydraulic conductivity of the soil (m.sec-1).

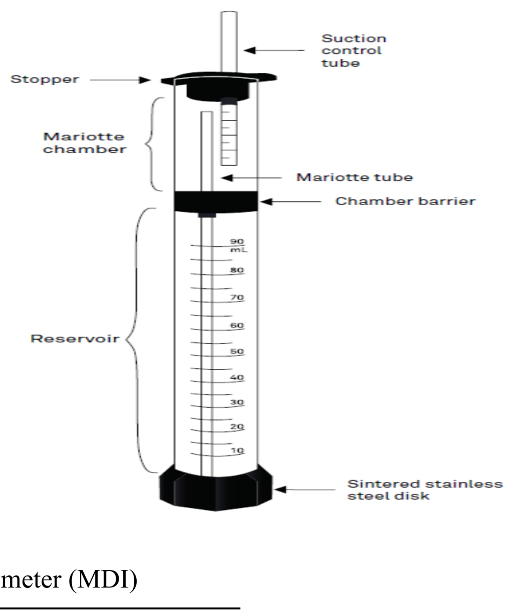

Figure 1. Mini Disk Infiltro-meter (MDI)

3. Results and Discussion

3.1. Effect of date residues, organic acids and hydration cycles on dispersion ratio.

Table (2) shows the effect of date residues, organic acid and wetting cycles on the dispersion rate of the soil. If it is noticed that there is a decrease in the dispersion rate with the addition of date residues, where the highest average was 46.50% without the addition of date residues, and the lowest value amounted to 37.27% when adding 2 % of date residual, a decrease of 24%. The addition of date residual at 2% reduced the dispersion rate, due to its role in improving soil properties and structure, compared to Non-addition treatment. Adding of Organic acid led to reduce the dispersion rate of gypsiferous soil if it reached 73.40%, while the wetting / drying cycles reduced the dispersion rate.

Increasing the wetting / drying cycles result in a decrease in the dispersion ratio to 41.44%, and this is due to the improvement of the physical properties of the gypsiferous soil. This is consistent with [13], this decrease is due to the increase in binding agents and organic carbon. In addition to, an increase in the aggregates stability as a result of the addition of Organic extract and increased microbial activities, [18]. The reason for the decrease is due to the interaction of calcium ions with negatively charge for organic acids during the wetting / drying processes, which form complexes that may contribute to reducing dispersion and establishing a strong bond between soil particles. It also works to transfer binding agents from points within the soil and deposit them on the contacts faces within soil particles depending on the organic matter, soil type, and the amount of biomass, [19].

Table 2. Effect of date residues, organic acid and wetting / dry cycles on dispersion rate

Date residues (D)	Organic acids (H)	Wetting / drying cycles (W)		D * H	
		W1*	W2**		
D0	H0	46. 20	50. 20	48. 20	
	H1	43. 30	46. 30	44. 80	
D1	H0	41. 10	41. 60	41. 35	
	H1	41. 50	41. 87	41. 68	
D2	H0	40. 33	37. 30	38. 82	
	H1	36. 20	35. 23	35. 72	
LSD D*H*W	1. 183			LSD D*H	0. 837
D * W					
D		W1	W2	D means	
D0		44. 75	48. 25	46. 50	
D1		41. 30	41. 73	41. 52	
D2		38. 27	36. 27	37. 27	
LSD D*W				LSD D	
H * W					
H		W1	W2	H means	
H0		42. 54	43. 03	42. 79	
H1		40. 33	41. 13	40. 73	
LSD H*W		0. 683 N. S		LSD H	0. 483
W					
W		W1	W2		
W / D means		41. 44	42. 08		
LSD W		0. 483			

* W1= four cycles, ** W2= eight cycles

3.2. The effect of date residual, organic acids and wetting / drying cycles on aggregates stability.

Table 3 shows the effect of the study factors on the aggregates stability values, which increased with the addition of date residues, and the highest average was 13.37 % when adding 2%, and the increase rate was 35% compared to the Non-addition treatment. The addition of organic acid led to an increase in the stability values of the gypsiferous soil, reaching 12.12 %, while increasing the wetting / drying cycles led to an increase in the aggregates stability, as their average values reached11.78 % at eight cycles.

The addition of date residues and organic acid improved the properties of the soil by improving its structure and increasing its stability for its effective role in linking aggregates and forming cohesive materials upon decomposition and releasing organic acids that bind soil particles together and thus increase its stability, [20]. It is noted from table (3) that the study factors significantly affected the stability values, which reached to highest value (13.62 %) when adding organic acid with date residues in eight wetting / drying cycles. Cycles of wetting / drying with the addition of organic residues play an important role in the formation and stability of aggregates, [21].

Table 3. Effect of date residues, organic acid and wetting / dry cycles on aggregates stability

Date residues (D)	Organic acids (H)	Wetting / drying cycles		D * H	
		W1*	W2**		
D0	H0	9. 21	9. 35	9. 28	
	H1	10. 16	10. 83	10. 50	
D1	H0	11. 61	11. 30	11. 45	
	H1	12. 39	12. 50	12. 44	
D2	H0	13. 57	13. 10	13. 33	
	H1	13. 20	13. 62	13. 41	
LSD D*H*W	0.371N. S			LSD D*H	0.262
D * W					
D		W1	W2	D means	
D0		9. 69	10. 09	9. 89	
D1		12. 00	11. 90	11. 95	
D2		13. 38	13. 36	13. 37	
LSD D*W		0.262		LSD D	0.186
H * W					
H		W1	W2	H means	
H0		11. 46	11. 25	11. 36	
H1		11. 92	12. 32	12. 12	
LSD H*W		0.214		LSD H	0.152
W					
W		W1	W2		
W / D means		11. 69	11. 78		
LSD W		0.152 N. S			

* W1= four cycles, ** W2= eight cycles

3.3. Effect of date residues, organic acids and wetting cycles on saturated hydraulic conductivity values.

Table (4) shows the effect of the study factors on the saturated hydraulic conductivity values, as its values decreased with the addition of date waste, and its lowest value was (4.33 cm. hr-1) at the level of 2% addition. As a result of reducing pore sizes, and reducing the area of the water-carrying section, which reduced the saturated hydraulic conductivity values, and this is correspond with what [22] reached.

The saturated hydraulic conductivity reduced significantly with addition of organic acid compared to the non-addition treatment, which reached 16%. The organic acids coat the gypsum particles and reducing its solubility, which reduced its direct contact with water by increasing the angle of contact. Table (4) shows that increasing the wetting / drying cycles had a significant effect on reducing the saturated hydraulic conductivity from 5.81 cm.h-1 at four cycles to 5.45 cm.h-1 at eight cycles. This led to the movement of the dissolved binders from the organic residues, which improved the aggregates stability and, thus reduced the pores size. The results of table (4) show that there is a significant interaction of the study factors in the saturated hydraulic conductivity values through the interdependence between them in improving the physical properties of the soil.

Table 4. Effect of date residues, organic acid and wetting cycles on saturated hydraulic conductivity values

Date residues (D)	Organic acids (H)	Wetting / drying cycles		D * H	
		W1*	W2**		
D0	H0	8. 17	7. 53	7. 85	
	H1	6. 63	6. 27	6. 45	
D1	H0	5. 73	5. 50	5. 62	
	H1	5. 23	5. 20	5. 22	
D2	H0	4. 87	4. 60	4. 73	
	H1	4. 23	3. 60	3. 92	
LSD D*H*W	0.171			LSD D*H	0.121
D * W					
D		W1	W2	D means	
D0		7. 40	6. 90	7. 15	
D1		5. 48	5. 35	5. 42	
D2		4. 55	4. 10	4. 33	
LSD D*W		0.121		LSD D	0.086
H * W					
H		W1	W2	H means	
H0		6. 26	5. 88	6. 07	
H1		5. 37	5. 02	5. 19	
LSD H*W		0.099 N. S		LSD H	0.070
W					
W		W1	W2		
W / D means		5. 81	5. 45		
LSD W		0.070			

* W1= four cycles, ** W2= eight cycles

3.4. The effect of date residues, organic acidification, wetting / drying cycles on the cumulative infiltration

Table (5) shows the effect of the study factors on the cumulative infiltration values. It is noted that the infiltration values decreased with the increase in the level of addition of date residues, as the lowest value was 20.81 cm at the level of 2% addition, while it was 24.01 cm in the Non-addition treatment. The decomposed organic materials coated the gypsum particles, which reduced the solubility of the gypsum. The results of table (5) confirm that the addition of organic acid has a significant effect in reducing the cumulative infiltration, as the infiltration value was 21.41 for the Non-addition treatment compared to 22. 33 cm for Non-addition treatment. The reason for this may be due to the role of organic acids in reducing the affinity of gypsum for water and reducing its solubility, which led to decrease of pore sizes [16].

It is noted from table (5) that there is a significant interfere of study treatments in the cumulative infiltration values, as the highest value was 24.82 in the Non-addition treatment and four wetting cycles, while the lowest value was 20.15 cm when adding 2% date residues, adding organic acids, and exposing it to eight wetting / drying cycles. The study factors improved the physical properties and reduced the solubility of gypsum, which reduced the speed of advancing the wetting front and thus decreased the ability of the soil to get wet. [23]

Table 5.The effect of date residues, organic acidification, wetting / drying cycles on the cumulative infiltration

Date residues (D)	Organic acids (H)	Wetting / drying cycles		D * H	
		W1*	W2**		
D0	H0	24. 82	24. 62	24. 72	
	H1	23. 41	23. 21	23. 31	
D1	H0	21. 42	20. 66	21. 04	
	H1	20. 65	20. 42	20. 54	
D2	H0	21. 17	21. 30	21. 23	
	H1	20. 62	20. 15	20. 39	
LSD D*H*W	0. 221			LSD D*H	0. 156
D * W					
D		W1	W2	D means	
D0		24. 12	23. 91	24. 01	
D1		21. 04	20. 54	20. 79	
D2		20. 89	20. 73	20. 81	
LSD D*W		0. 156		LSD D	0. 110
H * W					
H		W1	W2	H means	
H0		22. 47	22. 19	22. 33	
H1		21. 56	21. 26	21. 41	
LSD H*W		0. 127 N. S		LSD H	0. 090
W					
W		W1	W2		
W / D means		22. 02	21. 73		
LSD W		0. 090			

* W1= four cycles, ** W2= eight cycles

4. Conclusion

Utilization of gypsiferous soils in agricultural production is an urgent necessity to close the food gap due to the increase in population. Gypsiferous soils occupy large areas of Iraq and the world. These soils suffer from many problems due to their poor physical and chemical properties, so it requires finding scientific solutions to treat them. The addition of molasses factories residues and its recycling and fermentation of plant residues to produce the organic acid is one of the successful solutions to improve the properties of these soils and reduce their negative effects. In this study, we found that mixing these residues with gypsiferous soil improved all the studied physical properties and improved soil structure. The increase in wetting / drying cycles affected most of the physical properties.

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Numerical Modeling of River Training Work: Review

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Abstract. The construction of river training structures has a local influence on hydraulic and sediment regimes. River training is simply to modify the dimensions and patterns of channels, bars, and pools. Many scientists have applied and developed methods to identify suitable techniques for river training. In this paper 60 scientific papers were reviewed, and through this review, the researchers were divided according to the method of using the model and according to the problem that the researcher addressed, as 22% of the researchers tended to solve the sediment problem using the HEC-RAS model, and 45% of the researchers tended to solve the problem floods using the HEC- RAS model, as well as 23% of the researchers tended to refine the river section, while the last part of the researchers, who accounted for 10%, worked to solve the navigation problem by increasing the depth, and the most used model was obtained by the researchers, which is HEC- RAS, and reached. The percentage of researchers who used the model is 93%.

1. Introduction

The change in the course of the river, the abundance of sedimentation, and the lack of capacity of the rivers lead to floods, which all occur due to climatic changes and the increase and decrease in water levels. All these problems make river training very important and in all its details. Also, the problem of lack of data and the difficulty of solving differential equations leads to resorting to programs such as (HEC-RAS and MIKE) to compensate for the lack of field data and thus save effort and money. River training is conducted on rivers according to the problem that appears on the river [1]. . Some rivers have a change in the stream and some others get an increase in sedimentation that reduces the river's capacity and causes navigational problems and also causes the river to flood in the seasons of high flows [2]. Therefore, it has become important to conduct river training on many rivers in which these problems that occur in many rivers of the world, especially the Tigris and Euphrates rivers in Iraq, which needs river training in many areas. River training works is a term used to stabilize a river channel with certain alignments and cross-sections, a river can be trained by diverting its flow into a secondary channel or by making artificial cuts on the main river to reduce flood levels [3].

It also includes the disposal of sediments to increase the river's capacity, and increase the depth of the channel for navigational and other purposes.To reach the goals outlined in the European Union Water Framework Directive, policymakers have a high demand for accurate projections of the effects of climate and land use changes on inundation risk. To help decision-making in the execution of water and flood risk management methods, numerical models are a helpful forecasting tool [4]. While one-dimensional modeling was once the most often utilized method in inundation studies, two-dimensional modeling is now more broadly applied to river inundation modeling. The outputs of a 2D model's water depth and velocity can be effectively coupled with information on land usage in GIS tools to calculate the possible damages brought on by an inundation [5, 6]. The implementation of hydrological and hydraulic models for a better consideration of boundary conditions, as well as the modeling of the interaction between hydrodynamics, solid loads, and morphologic changes during extreme flood events, are some challenges that need to be addressed in current models to increase the accuracy of the numerical predictions. [7].

Ancient civilizations throughout the world rose to prominence in the valleys of significant rivers, including the Tigris and Euphrates in Mesopotamia, the Nile in Egypt, the Indus in modern-day

Pakistan, and the Yellow River in China [8]. It is common knowledge that these valleys served as the foundation for both organized agriculture and towns. They also created the foundation for river engineering, which is less well-known. The first dynasties in Egypt and China were established by early river engineers [8, 9]. To best suit his new city Memphis, the first Egyptian pharaoh Menes (Narmer) diverted the course of the Nile by building a dam between 3100 and 3000 BC. The first Chinese emperor Yu the Great developed a strategy to regulate floods by giving the river additional space rather than only erecting dikes and dams along its banks around 2200–2100 BC. [10] Employees dug the riverbeds, redirected floodwater into a network of irrigation canals, and widened a Yellow River bottleneck at Mount Longmen. [11] Describes how rivers were modified in classical antiquity for military purposes although the precise truth of his accounts is debated. He claims that the engineer-philosopher Thales of Miletus dug a second channel to make it simple for the army of Croesus to cross the Halys River (Kzl Irmak, east of Ankara). Cyrus even spent an entire summer allowing his army to create 360 channels in the Gyndes River (Diyálah, a tributary of the Tigris) so that his army could cross it without the use of boats. Cyrus turned the Euphrates into marshes in 539 BC so that his army could sneak up on the fortified city of Babylon.

The structures used for river training include longitudinal structures such as bank revetments and guide bunds, as well as transverse structures such as groins, and spur dikes. Some useful advice that is not immediately apparent to beginners or laypeople is shared by seasoned river engineers [10]. For example, groins or spurs pointing downstream draw flows to the river bank instead of deflecting them away from it.

This study aims to conduct a comprehensive study on river training and to divide the researchers according to their research and according to the program used into several sections through the study of 60 scientific research published in scientific journals in the last decades for the period from 1992 to 2022 AD and determining the optimal model to solve the river training work.

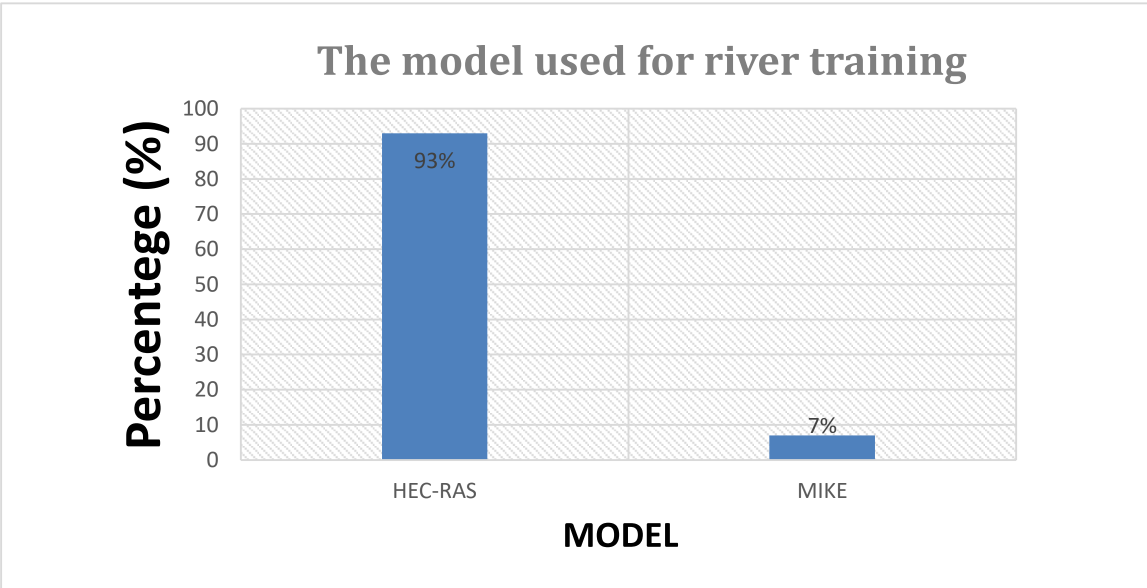

Figure. 1. The following figure shows the percentages of researchers who used the HEC-RAS model and the MIKE model

2. Materials and Methods

2.1. The Models used for River Training the common models that were used and are still being used for river training are (HEC- RAS and MIKE11).

2.2. HEC- RAS

The USACE Hydrologic Engineering Center (CEIWR-HEC) was established in 1964 to institutionalize the technical know-how that later became known as hydrologic engineering. Early software packages were HEC-1 (watershed hydrology), HEC-2 (river hydraulics), HEC-3 (reservoir analysis for conservation), and HEC-4 (stochastic stream flow generation program). Within ten years after its establishment, the technical field of planning analysis, and the application of analytical methods to planning activities are closely associated with hydrologic engineering [12]. Was added to the CEIWR-HEC mission. By that time, the permanent staff had risen to about thirty engineers and computer specialists. CEIWR-HEC permanent staff today is approximately thirty-five.

2.3. MIKE

Water professionals develop MIKE software to help tackle any water challenge. Whether you work with urban or offshore infrastructure, coastal developments, mining operations, or natural resources, MIKE Powered by DHI can give you confidence in your decision-making [13].

By reviewing and studying 60 scientific papers, it was found that the percentage of researchers who used the heck head model is 93%, and the percentage of researchers who used Mike's model is 7%. As shown in figure (1). Because of the ease of using the heck head model in river training operations, it was found that most researchers tended to use this model.

The importance of river training has been apparent since ancient times. The change of the course of the river and the increase in sedimentation cause a major problem to the extent of the river's ability to bear the flood flows, as well as cause navigational problems as well. The programs used to train rivers have evolved over the ages until they reached what they are now of high development, where the researchers were divided into several sections in the study of river training, the first part worked on the study of sedimentation such as [14, 15] two models were used, HEC RAS4 and MIKE11 In preparing the study by the first researcher. To calculate the sedimentation in the study area in Iran between the Mollasani stations, two models were run for five years. As for the second researcher, they conducted their research on the Euphrates River. Suspension and bed material samples were collected for twenty-one cross-sections as part of the study. For estimating the sediment load in this location, the study has developed a novel formula utilizing a dimensional analysis. As for the second part of the researchers, he worked on studying flood risks, such as [16, 17], where the first researcher studied the Jhelum Valley River in Kashmir, India. For a dimensionally stable flow analysis using HEC-RAS software to estimate flood levels for a return period of 50 years and above. The length of the river extends from Khanbal to Badshahi Bagh. As for the second researcher, he prepared the study "Samawah Combined Cycle Power Station: A Hydrological Study" by the Consulting Engineering Office.

The objectives of this study were to assess flood risks in the adjacent Euphrates River and to present and analyze groundwater and weather data. In the third part, where the researchers worked in this field, such as [53], to solve navigational problems by increasing the depth of the stream. The last part was concerned with studying the modification of the course of the river, such as [18]. The researcher conducted a study on the Euphrates River with a length of 124.4 km between the Haditha Dam and the city of Hit in western Iraq. They developed a non-dimensional non-static model using HEC-RAS 3.1.3 software. The study aims to analyze the effect of meandering rivers on the following variables

2.4. Sediment simulation of Rivers using HEC-RAS Software

Many researchers have used the HEC-RAS program to calculate the amounts of sedimentation in rivers and to know the extent of their impact on the carrying capacity of the river. The current load is represented by the material that is transported by the water current and it is divided into two movement features, bed load, and suspended load.

The bed load consists of rolling and sliding up to salting of bed material and this movement is restricted near the bed, while the suspended load is considered a mixture of bed material and wash load and transport with the current. Cleaning and removing the sediment into the hydraulic structures is an important aspect of performing regular maintenance where the continuous sedimentation will affect the flow rate through structures, and the removal of the sediment is difficult and expensive unless providing an operating system and successful operation program to prevent the occurrence of sediment. By reviewing 60 papers, it was found that the percentage of researchers who used the HEC-

RAS program to study sediments in the river is 22%. Whereas, Table (1) shows the researchers who used the HEC-RAS model in this field and also shows the study area for each researcher.

Table 1. Researchers simulate river sediment using the HEC-RAS model.

Name	Date	Country	River
1- Haghiabi [14]	2012	Iran	Karun River
2- Khassaf and Ressen[15]	2014	Iraq	Euphrates River
3- Azarang et al. [19]	2015	Iran	Karkeh River
4- Maatooq et al. [20]	2016	Iraq	AL Gharraf River
5- Mohammad et al. [21]	2016	Iraq	Tigris River
6- Omran and Jaber. [22]	2017	Iraq	Al-Hilla River
7- Kayyun and Dagher.[23]	2018	Iraq	Tigris River
8- Ayad Sleibi Mustafa. [24]	2016	Iraq	Euphrates River
9- Gibson, S. Ph.D. [25]	2017	Washington	Puyallup Rivers
10- Alessandra Crosato. [26]	2020	Italy	Tagliamento River
11- Neekita Joshi. [27]	2019	United States	Maumee River
12- Nor Faiza. [28]	2022	Malaysia	Langat River
13- Damte, F. [29]	2021	Ethiopia	Kulfo River

2.5. Flood simulation of Rivers using HEC-RAS Software

The study of flooding in the river stream is very important for Identifying the water levels and inundation areas caused by flooding. Where many researchers have studied the effect of flooding on rivers through the use of the HEC-RAS program by studying 60 research papers, it was found that the percentage of researchers who used the program to study the impact of the flood is 45%. Whereas, Table (2) shows the researchers who used the HEC-RAS model in this field and also shows the study area for each researcher.

Table 2. Researchers who simulate river floods using the HEC-RAS model.

Name	Date	Country	River
1- Al-Kazwini, et al. [18]	2011	Iraq	Euphrates River
2- Al-Thamiry, et al. [30]	2013	Iraq	Euphrates River
3- Consulting Engineering Bureau. [16]	2017	Iraq	Euphrates River
4- Hameed, et al. [31]	2014	Iraq	Al-Kufa River
5- Ahamed, et al. [17]	2016	India	Wadi Jahlum River
6- Logah, et al., [32]	2017	Ghana	Volga River
7- Rumansko, et al. [33]	2018	Romania	Sucevita River
8- Khayun and Dagher. [23]	2018	Iraq	Tigris River
9- Prastica, et al. [34]	2018	Indonesia	Bengawan Solo River
10- Patel, et al. [35]	2018	India	Ambica River
11- El Naqa and Jaber. [36]	2018	Jordan	Wadi Attarat
12- Yakti, et al. [37]	2018	Negeri	Way Ela River
13- Zainalfikry , et al. [38]	2019	Malaysia	Pahang River
14- Zeleňáková, et al. [39]	2019	Slovakia	Slatvinec River
15- Karamouz. [40]	2009	Iran	Sefidrud River
16- Adewale, et. al. [41]	2010	Nigeria	Ogunpa River
17- Timbadiya, et. al. [42]	2011	India	Tapi River
18- Naghshine. [43]	2013	Iran	Maroon River
19- Abbas. [44]	2019	Iraq	Tigris River
20- Vijay, et al. [45]	2007	India	The Yamuna floodplains
21- Alireza, et al. [46]	2014	Iran	The transport channel
22- Mehta , et al. [47]	2014	India	Tapi River
23- Adhikari. [48]	2015	Bhutan	Barsa River
24- Sami, et al. [49]	2016	Algeria	Batna City
25- Padalia, et al. [50]	2017	India	Vishwamitri River
26- Daniel Skublics. [51]	2016	Germany	Danube River
27- S.N. Chan. [52]	2010	China	Pearl River

3.6. Navigation simulation of Rivers using HEC-RAS Software

The researchers tended to solve the problem of navigation in rivers (the decrease in the depth of the waterway) using the HEC-RAS model because this affects navigation and hinders the movement of ships. The percentage of researchers who worked in this field out of 60 researchers was 10%. Table (3) shows the researchers who used the HEC-RAS model in this field and also shows the study area for each researcher.

Table 3. Researchers who simulate river navigation using the HEC-RAS model.

Name	Date	Country	River
1- Pavel Fošumpaur. [53]	2021	Czech/German	Elbe River
2- Gordon Gilga. [54]	2019	German	Drava River
3- H. Havinga. [55]	2006	Netherlands	Waal River
4- Neama. [56]	2021	Egypt	Nile River
5- Calvin T. Creech.[57]	2018	Brazil	Madeira River
6- Talaat ElGamal. [58]	2019	Egypt	Tanta canal

2.7. HEC-RAS for training

Many researchers have carried out large-scale training works on rivers as a result of lateral migration and widening of the channel resulting from a series of large floods .where the percentage of researchers who worked in this field was 23% out of 60 researchers. Table (3) shows the researchers who used the HEC-RAS model in this field and also shows the study area for each researcher.

Table 4. Researchers who simulate river training using the HEC-RAS model.

Name	Date	Country	River
1- WAYNE D. [59]	1992	Australia	Hunter River
2- A. A. Ali. [60]	2012	Iraq	Tigris River
3- SAJAD AHMAD HAMIDI.[61]	2005	Iran	Shahroud river
4- Anna Kidová. [62]	2021	Slovakian	Belá River
5- R. Lammersen. [63]	2002	Germany-Netherlands	River Rhine
6- Baosheng Wu. [64]	2005	China	Lower Yellow River
7- Riyadh Z. Azzubiadi. [65]	2020	Iraq	Tigris River
8- Al-Samuraie. [66]	2004	Iraq	Tigris River
9- NasrAllah. [67]	2008	Iraq	Al- Msharah River
10- Al-Khafaji. [68]	2008	Iraq	Al- Msharah River
11- Bordbar, et al. [69]	2012	Iran	Bashar River
12- Nama. [70]	2015	Iraq	Tigris River
13- Awad. [71]	2015	Iraq	Shatt Al-Rumaithah
14- Arrar. [72]	2018	Iraq	Al-Gharraf River

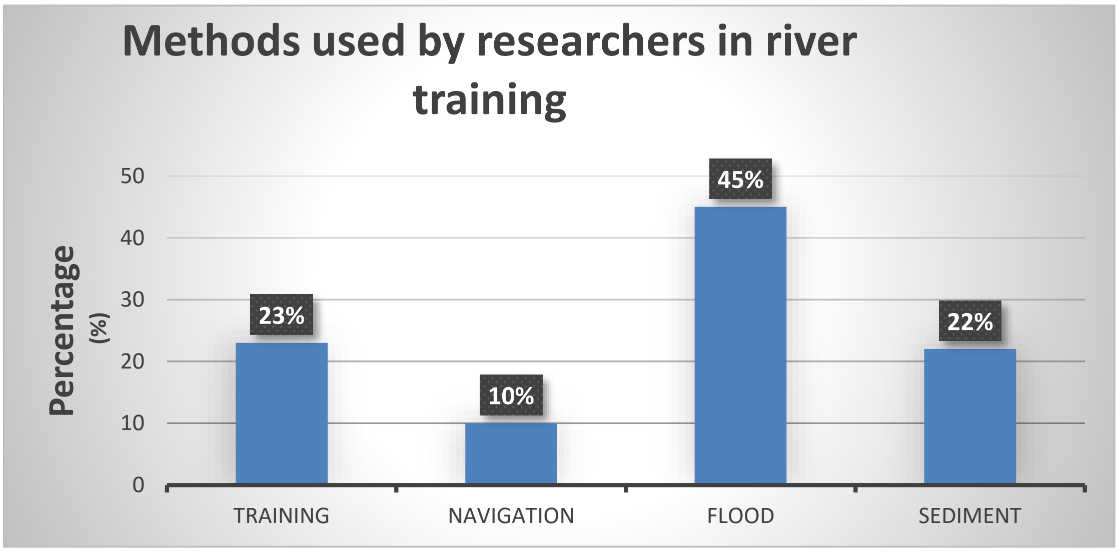

Figure 2. The following figure shows the percentages of the methods used by the researchers in the river training works, using the HEC-RAS model

4. Conclusion

This research aimed to document the historical training work. More than 60 scientific research papers published in international journals on river training of all kinds have been collected, making it easier for the researcher to obtain research that suits his work and field of study. We provide an overview of studies related to riverine training. We have summarized the key insights gained from these studies in an accessible manner for practitioners in river training and river recovery. The methods used in riverine training were divided into 4 sections, according to the riverine training method used by researchers in the HEC-RAS model, as previously explained.

A comparison was made between the number of researchers who used the HEC-RAS model and the MIKE model in the river training process, and it was found that the percentage of researchers who used the HEC-RAS model was 93%. Therefore, using the HEC-RAS model with GIS software is the perfect solution for the river training business.

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Comparison of Unsaturated Hydraulic Conductivity Calculated by Jackson Equation and Van Genuchten Equation for Three Different Soils in Their Gypsum Content and Treated with Polymer and Peatmoss

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Abstract. An experiment was conducted to compare the unsaturated hydraulic conductivity (K) calculated by Jackson equation and van Genuchten equation for soils different in gypsum content and treated with some soil conditioners. Two soils were used, gypsiferous soil (410 gm kg-1gypsium) and clayey soil (435 gm kg-1 clay), were mixed in three levels 0, 50, and 100%. The soils were treated with peat moss 0 and1%, polymer,0,1.and 2% and without addition. Then, were packed into plastic tubes 5 cm diameter and 25 cm in height at bulk density of 1.3 Mg m-3 and were exposed to three wetting / drying cycles. The unsaturated hydraulic conductivity was calculated from (Jackson equation, and van Genuchten equation. the results showed good agreement between K values measu dy using Jackson and van Genuchten equation using RETC program. The relationship between K and θ and percentages of gypsum is a positive and between K and ψ an inverse relationship. The value of K increased from 81.7 cm. day-1 to 137.8 cm. day-1 when the percentage of gypsum was increased from 46 to 410 g kg-1 consecutively for soil in treated with conditioners and within minor tension limits approaching zero. The K values decreased when the soil was treated with peatmoss and polymer, and the most effective treatment in reducing the K values was a mixture of (2% polymer + 1% peatmoss). The K values remained close to zero with medium to high tensions and also with medium to low θ, and it did not increase to an effective degree except when θ approached its upper limits and with low tensions, and its increase was exponential within these ranges.

1.Introduction

Gypsum soil occupies a large area estimated at about 88,000 Km^2 and represents about 20% of the total area of Iraq. It suffers from many problems that limit the nature of its utilization for agricultural purposes related to its physical, chemical and fertility properties, especially when a gypsum content exceeds 10%. It has a negative impact on the properties of soil, including its structure and ability to retain water, which reflected on the growth of agricultural crops, and highlights the importance of expanding the utilization of such lands in order to provide food that appropriate with population expansion. The gypsum content of the soil affects the functions of water transport, including hydraulic conductivity.

Hydraulic conductivity is one of the important physical characteristics of soil in the agricultural and engineering fields, because it is a design criterion in irrigation and drainage projects, in order to determine the quantities of water added to the soil and necessary for the salt leaching process. The hydraulic conductivity in saturated soil (Ks) is the basic parameter for managing soil and water problems related to the environment and agriculture, which it is a physical property that can be defined as the ability of the porous medium to transport water.[6]

Soil Conditioners are organic, industrial or natural chemicals that improve one or more of the properties of soil, and increase its productivity. Improving the structure of the soil or maintaining a good structure is one of the main goals of using soil conditioners for agricultural purposes. Adding conditioners to poorly structure soil increase formation of soil aggregates and their stability and creates suitable conditions for plant growth. Conditioners also added to well-structure soil to protect its structure from the effect of wind and water erosion. Clayey soils (soft textures) are used to mixe with coarse texture soils or gypsiferous soils to adjust the percentage of sand or gypsum, which is reflected in improving their properties for agricultural purposes. Clay acts as a binder for soil particles, thus improving soil structure and aeration, reduces its permeability to water, and contributes in geometric rearrangement of soil pores, which reduces the percentage of large pores. Polymers were used as soil conditioners due to their ability to dissolve in water, and their high molecular weight, which are passive substances that increase soil stability through flocculation of clay. Polymers has a positive impact on preserving water and reducing erosion by increasing the stability of aggregates in the soil. They are able to absorb large amounts of water relative to their weight, retain them and release them when needed. Therefore, it reduce deep seepage and loss of nutrients from the soil, and increase the efficiency of water use and fertilizers. In view of presence of multiple methods for estimating and calculating the hydraulic conductivity, and with what was mentioned above, this study was conducted to compare the hydraulic conductivity calculated by Jackson equation and van Genuchten equation for soils with different gypsum content and treated with some soil conditioners.[11]

2.Materials and Methods

A laboratory experiment was conducted in the College of Agriculture / University of Anbar-Iraq to compare the hydraulic conductivity calculated by Jackson equation and Van Genuchten equation for three different soils in their gypsum content and treated with some Conditioners. Two soils were brought, first soil was (410 gm. kg-1 gypsum) from Anbar University / Ramadi / Anbar Governorate site. While the second soil was (435 gm-1 kg clay) which brought from Al-Nasaf area / Fallujah district / Al-Anbar governorate. Soil samples were taken from the depths of 0-30 cm, air dried, grinded and passed through 2 mm diameter sieve.

Particle size distribution of soil was estimated by the hydrometer method to determine the texture type, which was clayey for the second soil, the texture of the first soil did not determine because the percentage of gypsum was high. The percentage of gypsum was estimated based on the acetone method described in [1], which was 410 and 46 gm kg-1 for the first and second soils, respectively .Bulk density was estimated by core method [2], was 1.02 and 1.29 µg m-3 for the first and second soils respectively. Aggregate stability was estimated by the dry sieving method and according to the weighted mean diameter; it was 0.698 and 0.599 mm for the first and second soils, respectively. Electrical conductivity (EC) and the pH were measured using soil-water extract (1-1) by (EC) meter and PH meter as described in [3]. Siemens where it was (2.42, 3.17 ds.m-1) and (7.83, 7.78) for the first and second soil, respectively. Samples of two soils were mixed in percentages: 100:0, 50:50, and 0:100.

To obtain three new soils with different gypsum and clay content. The three soils resulting from the mixing process were treated with peatmoss at two levels of 0 and 1%, and also with the super absorbent organic polymer (polyacrylamide, polypropeneamide, or polycarbamoyl ethylene), (-CH2CHCONH2) at three levels (0%, 1%, and 2%). The three soils were packed after treating it with Conditioners (without addition, Peatmoss %1, Polymer%1, Polymer%2, Polymer%1 + Peatmoss %1, Polymer +2% Peatmoss1%) in plastic tubes with (diameter of 5 cm and a height of 25 cm) and were closed from the bottom with glass wool. Soil mass was calculated for each tube, depending on the size of the tube for depth of 20 cm, with an bulk density of 1.3 µg.m-1. Soil columns were exposed to three cycles of wetting / drying for about 14 weeks after they were fixed on a table vertically and wetted from the bottom. Saturated hydraulic conductivity was estimated by constant head method as stated in [4]. Columns with an inner diameter of (2.1 cm) and a height of (6 cm) were used, and the columns were wetted from the bottom for 24 hour until saturation. Column with time was estimated, the saturated conductivity was calculated using Darcy's equation [5] as following:-

$$Ks = \frac{VL}{At(h + L)} \qquad (1)$$

As:

Ks= Saturated hydraulic conductivity (cm.min-1). t= Time (min).

V= Volume of water coming down from the column (cm3). h= Height of soil head (cm).

A= Cross-sectional area of the soil column (sm2) L= Long of water head (cm).

Jackson (1972) equation was used to calculate the values of unsaturated hydraulic conductivity, Ki, from the data of the soil moisture characteristic curve and the value of Ks:

$$K_i = K_s\left(\frac{\theta_i}{\theta_s}\right)\sum_{j=i}^{m}[(2j+1-2i)\psi j-2]/\sum_{j=1}^{m}[(2j-1)\psi j-2] \ldots\ldots\ldots\ldots\ldots (2)$$

As:

Ki = Unsaturated hydraulic conductivity (cm. day-1).

θi = Moisture content at any tension (cm3. cm-3).

θs = Values of moisture content at saturation (cm3. cm-3).

j = Denominator index.

ψ= Tension, determined from the moisture characterization curve (cm3. cm-3).

The unsaturated hydraulic conductivity was calculated from the Van Genuchten equation.

$$K(\theta)= K_s \theta_s^{1/2} [1-\theta_n^{1/m})^m]^2 \ldots\ldots\ldots\ldots\ldots\ldots \quad 3$$

As:

n θ= (θr - θ) / (θr - θs), and m = 1 - 1/n

3.Results and Discussion

3.1Saturated water conductivity

Figure (1) shows the effect of soil content of gypsum and soil conditioners on the saturated hydraulic conductivity (Ks) values. As it was found that the values of hydraulic conductivity have a direct relationship with the soil content of gypsum, the value of hydraulic conductivity increased from 3.745 cm. h-1 at a gypsum content of 46 g. kg-1 (S3) to 5.745 cm. h-1 with the increase of gypsum to 410 g. kg-1 (S1) for non-treated soil. The values of the hydraulic conductivity rate decreased when the soil was treated with peatmoss and polymer. It reached its lowest value when the treatment was (polymer 2% + 1% peatmoss), where their values were 2.152 and 2.905 cm. h-1 at gypsum content of 46 and 410 g. kg-1 respectively. While the Ks values ranged for the rest of the treatments between this treatment and the soil that was not treated with conditioners.

Table (1) explains the statistical analysis of the effect of the gypsum content of the soil and the addition of Conditioners (peatmoss and polymer) on the hydraulic conductivity rate. The results shows significant differences between soils according to the gypsum content in the characteristic rate of hydraulic conductivity. The soil S1 (410 g kg-1 gypsum content) exceeded with the highest Ks value of 3.996 cm. h-1 compared to soil S3 (with a gypsum content of 46 g kg-1) with the lowest Ks value of 2.653 cm. h-1, the difference was significant between S1, S2, and S3.

The results of Table (1) also showed that there were significant differences in the Ks values due to the effect of the polymer addition levels. The average Ks decreased from 4.108 cm. h-1 for the zero polymer level (P0) to 2.768 cm. h-1 for the 2% polymer addition level (P2), and the difference was non-significant between P0, P1and P2.

The results showed a non-significant difference for the interaction between the factors S (gypsum content) and P (level of polymer addition). The lowest value of Ks for the interaction between P2 S3 reached (2.235 cm. h-1) and the highest value for P0 S1 amounted to 5.333 (cm. h-1). There was a significant difference for the addition of peatmoss on the hydraulic conductivity, as the value of Ks decreased from 3.525 (cm. h-1) at the B0 level to 3.045 (cm. h-1) at B1. The results showed that there were no significant differences between the interaction between the soil content of gypsum (S) and the addition of peatmoss (B). While the results showed that there were no significant differences between the interactions between the treatment of soils with peatmoss and polymer, as the lowest value of the hydraulic conductivity between P2 B1 reached 2.558 (cm. h-1) and the highest value for P0 B0 amounted to 4.108 (cm. h-1).

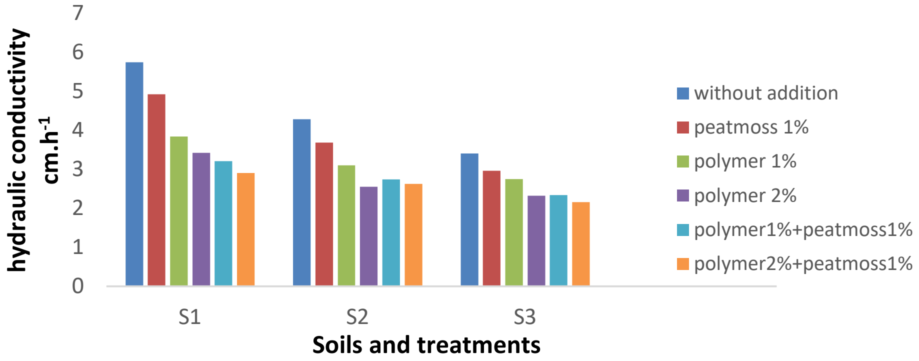


Figure 1. effect of gypsum content and soil conditioners on the saturated hydraulic conductivity (Ks) values

Figures (2), (3) and (4) showed the relationship of hydraulic conductivity and moisture content, and hydraulic conductivity and moisture tension, respectively. As it is clear from Fig. (2) that the relationship between K and θ is a direct relationship, as the values of K increase with the increase in the values of θ for all soils and treatments, while the relationship between K and moisture tension was an inverse relationship Fig. (3), K values decreased with the increase in moisture tension. As shown in Figs. (2, 3, and 4), the K values increase with the increase in the percentage of gypsum and decrease with the addition of conditioners. K value increased from (81.7 cm. day-1 to 137.8 cm. day-1) when the proportion of gypsum was increased from (46 to 410 g kg-1) for the untreated soil (Fig. 2-A) corresponding to (410 g kg-1) for treated soil (with polymer 2% + bitumen 1%). As this treatment is the most effective in decreasing K values compared to the untreated soils and for all levels of gypsum. K values ranged from highest to lowest according to the ratios of gypsum S3<S2<S1. As well as, K values ranged from highest to lowest according to the treatments as follow: (untreated soils) > (peatmoss 1%) > (polymer 1%) > (polymer 2%) < (polymer 1%+ 1% peatmoss) < (polymer 2% + 1% peatmoss). It is also noted from figs. (2 and 3) that the K values were very low and close to zero at θ less than 0.3-0.4 in addition to tension less than 20-80 cm of water. K values did not increase significantly except the great tensions limits, and when the values of θ approached their upper limits and the moisture tension decreased to less than 10 cm of water. The reason for this is due to values of K varied as we mentioned above with the variation of gypsum proportions and with the treatment of soils with conditioners in addition to their association with values of ψ and θ.

The increase of K with the increase in the percentage of gypsum may be related to the speed of gypsum's absorption of water and its solubility in it. In addition, the increase in the wettability of the soil, which leads to the rapid progression of the wetting front (6). The increase in gypsum is also associated with an increase in the proportion of large pores in the soil, which increase the cross-sectional area of the water carrier, thus achieving an increase in the Ki values. Besides that, the increase in the specific surface area of the soil resulting from the increase in the percentage of clay and the increase in the percentage of small pores, that are associated with a decrease in the proportion of gypsum increases the ability of the soil to hold water and reduces the rates of water progression, which are reflected in the decrease in the K values by decreasing the proportions of gypsum, [7]. Likewise, K values decrease when treat soils with peatmoss and polymer. This is due to the organic materials are hydrophobic, as they reduce the speed of soil wetting with water and increase the soil's water-holding forces, and may reduce the cross-sectional area that carries water, in addition to coat the particles and aggregates, which reduces the ability of the soil to absorb water. Soil conditioners may improve one or more characteristic of the soil and increase its stability and ability to transfer water, which is reflected in the values of the two water functions K [8] and [9]. The main mechanism affecting the decrease of K(θ) with the addition of conditioners. Unsaturated hydraulic conductivity is affected by the volumetric distribution of the pores and that the increase in the percentage of clay that has swelling characteristic causes obstruction in the movement of water and increases aggregates stability, which leads to decrease K(θ) values.

Table 1 .Statistical analysis for the effect of gypsum content in soils and add the peatmoss and polymer and the

Interaction between gypsum and polymer	**S1**	**S2**	**S3**		**Polymer mean**	
P0	5.333	3.986	3.183		4.108	
P1	3.524	2.921	2.542		2.976	
P2	3.130	3.091	2.235		2.768	
Gypsum mean	3.996	3.333	2.653			
			SxP 0.280	P 0.125	S 0.161	LSD

Interaction between gypsum and peatmoss	S1	S2	S3	Peatmoss mean
B0	4.314	3.646	2.823	3.523
B1	3.678	3.019	2.483	3.045
Gypsum mean	3.996	3.333	2.653	
		SxB N/S		LSD

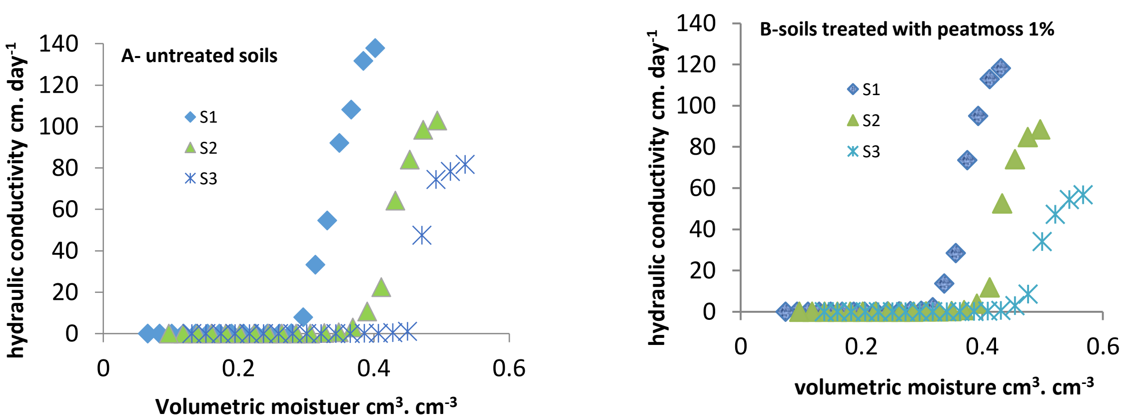
Interaction between polymer and peatmoss	P0	P1	P2	Peatmoss mean
B0	4.399	3.193	2.977	3.523
B1	3.818	2.758	2.558	3.045
Polymer mean	4.108	2.976	2.768	
	N.S	P x B : LSD		

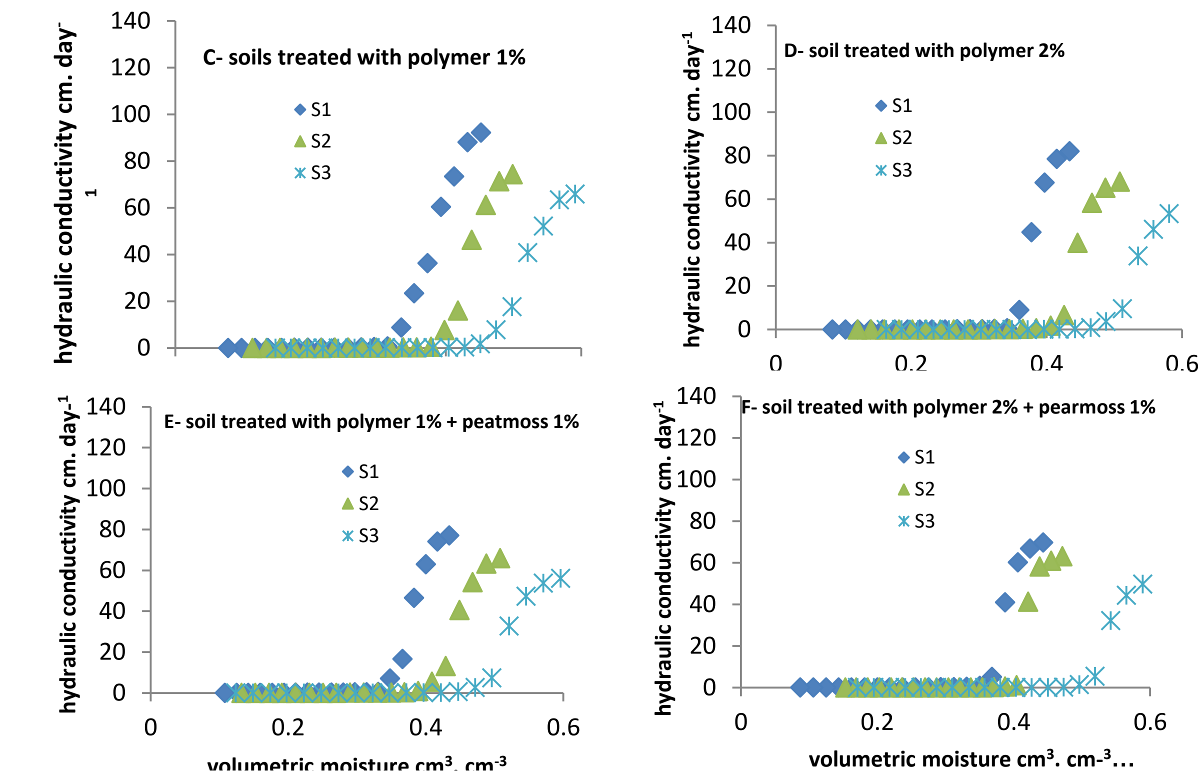
interaction between them in hydraulic conductivity rate

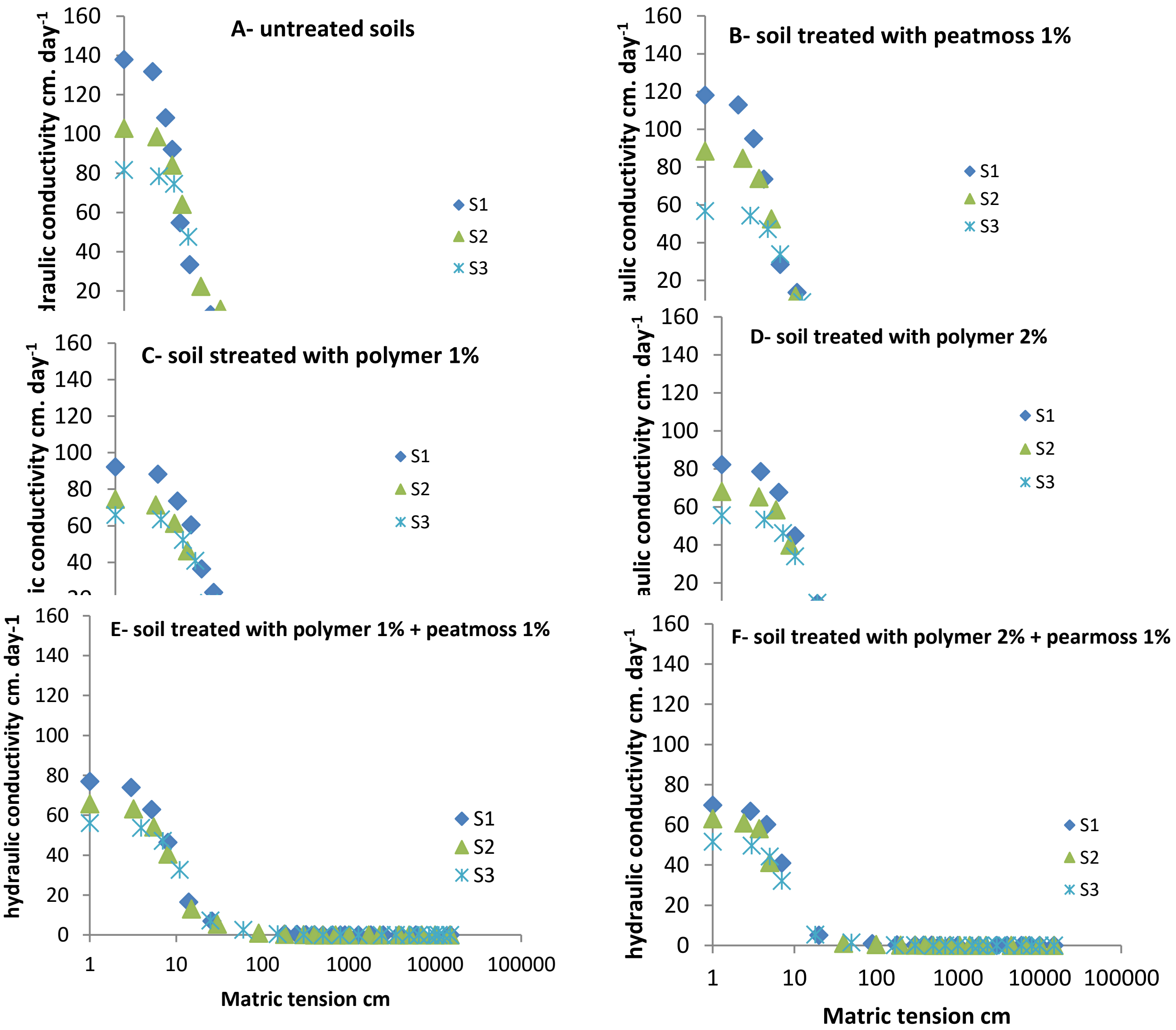
S:Soil **P: Polymer** **B: Peatmoss**

The addition of the polymer also caused a decrease in the unsaturated hydraulic conductivity because the polyacrylamide contributed in redistribution of the soil pores, and increased the percentage of small pores and decreased the percentage of large pores. The reason may be attributed to the destruction of soil pores as a result of the swelling of the SAP when it absorbs water in the soil during repeated wetting / drying cycles, which leads to a decrease in water infiltration into the soil. On the other hand, the sticky of SAP itself becomes greater, which leads to an increase in resistance against water movement downward. These results agree with the findings of [10] and [11].

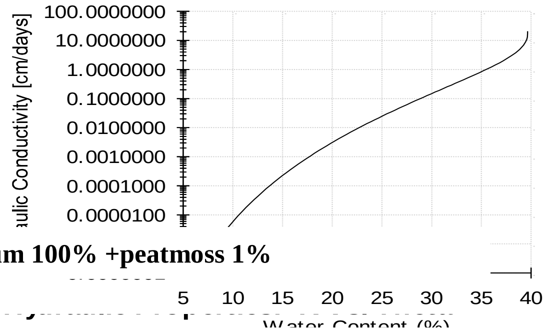
Figure (5) shows a comparison of the values of hydraulic conductivity measured by the Jakson equation with the K values measured by van Genuchten equation. The relationship was a linear relationship represented by a quadratic equation with a coefficient ($R2$ = 0.962) of hydraulic conductivity measured with two equations for gypsum soils without addition, and with ($R2$ = 0.952) for clay soils treated with polymer 2% + bitumen 1%. The R2 values showed good agreement between the K values measured from Jakson equation with van Genuchten equation for all levels of gypsum and the addition of Conditioner, which shows the possibility of adopting the van Genuchten equation in predicting hydraulic conductivity, although its virtual constants give estimated results and are not to be exact.



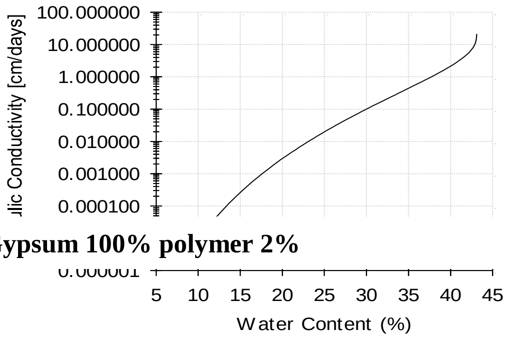

C- soils treated with polymer 1%
D- soil treated with polymer 2%
E- soil treated with polymer 1% + peatmoss 1%
F- soil treated with polymer 2% + pearmoss 1%
S1
S2
S3
hydraulic conductivity cm. day-1
volumetric moisture cm³. cm-³


A- untreated soils
B- soil treated with peatmoss 1%
C- soil streated with polymer 1%
D- soil treated with polymer 2%
E- soil treated with polymer 1% + peatmoss 1%
F- soil treated with polymer 2% + pearmoss 1%
S1
S2
S3
hydraulic conductivity cm. day-1
Matric tension cm

Gypsum 100% without addition

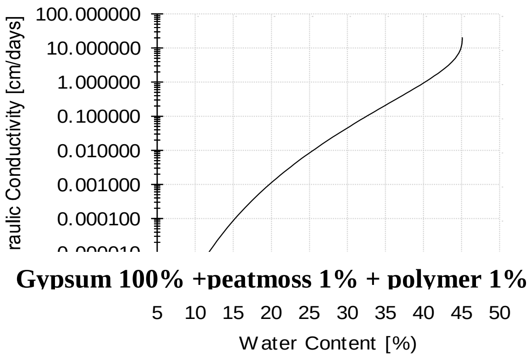


Gypsum 100% +peatmoss 1%



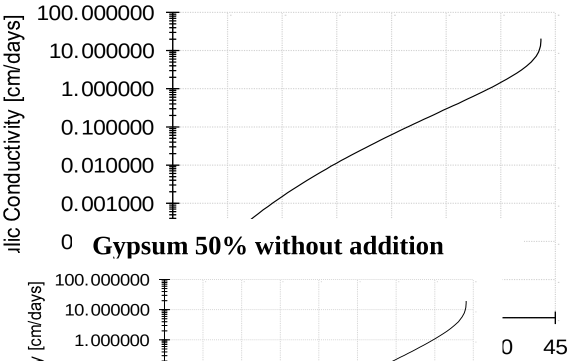
Gypsum 100% +peatmoss 1%

Gypsum 100% polymer 2%

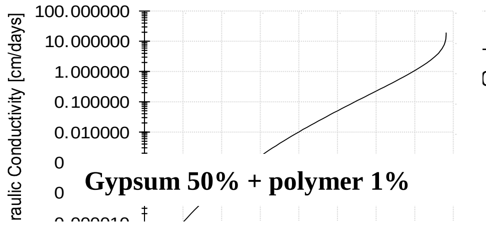


Gypsum 100% +peatmoss 1% + polymer 1%

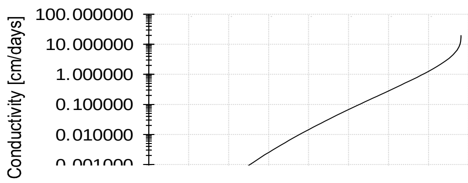
Gypsum 100% +peatmoss 1% + polymer 2%



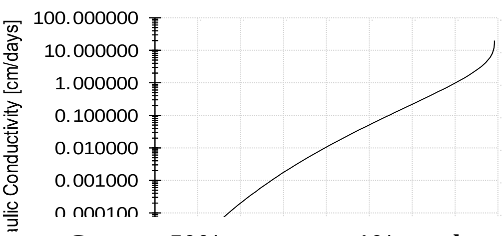
Gypsum 50% without addition



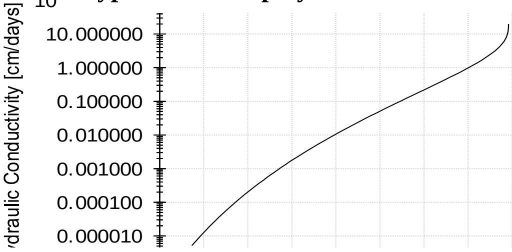
Gypsum 50% +peatmoss 1%



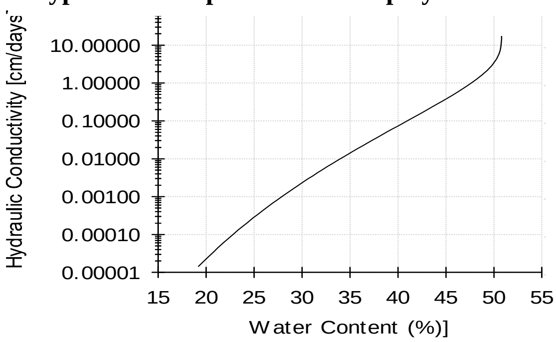
Gypsum 50% + polymer 1%



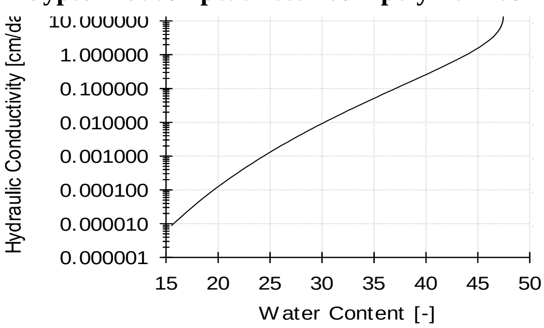
Gypsum 50% + polymer 2%



Gypsum 50% +peatmoss 1% + polymer 1%



Gypsum 50% +peatmoss 1% + polymer 2%



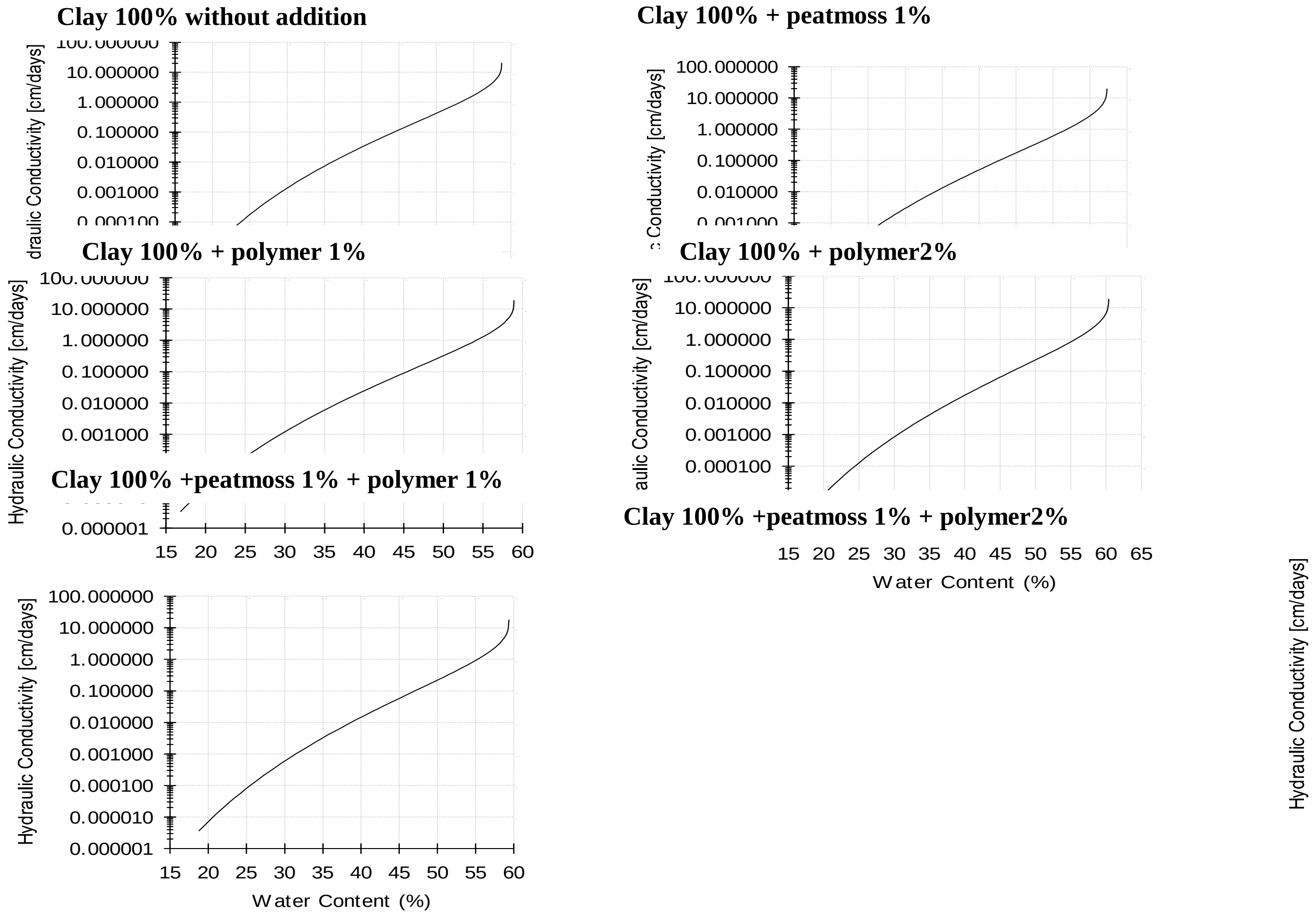


Figure 4. hydraulic conductivity calculated from the Van Genuchten equation for soils treatments

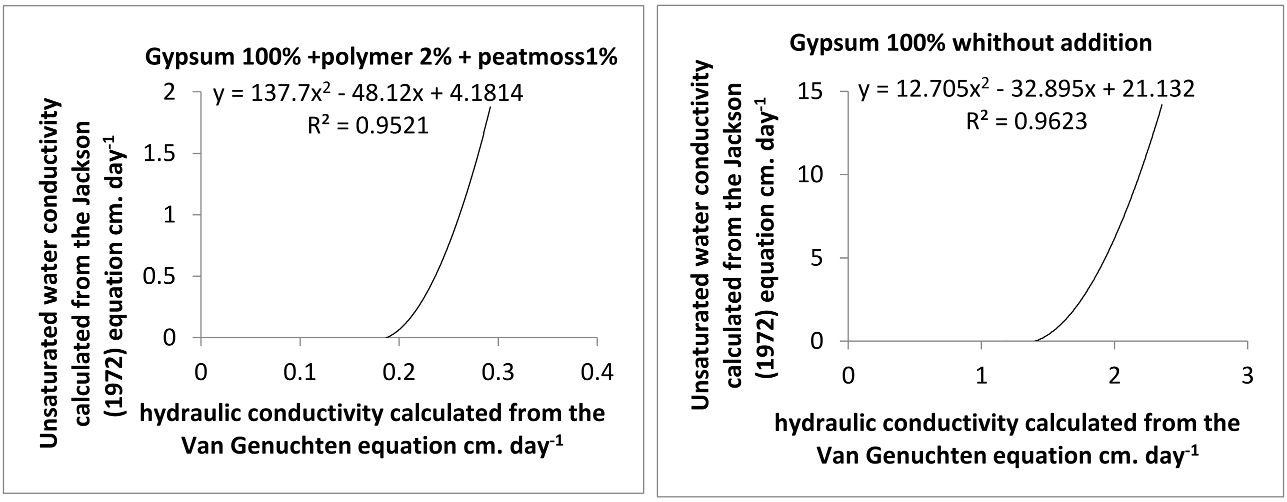


Figure 5 .comparison of the values of hydraulic conductivity measured by the Jakson equation with the K values measured by van Genuchten equation

4.Conclusion

High match was obtained between unsaturated hydraulic conductivity calculated by the Jackson equation and from RETC program in gypsiferious soils. There is a positive relationship between K values with gypsium content in soils.

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Response of Anatomical Characteristics of Nile Flower Eichhornia Crassipes to Environmental Changes and their Impact on Tigris Water Quality

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Abstract. The current study was conducted on the Tigris River in the distance between Qayyarah district of Nineveh province and Baiji district of Salahuddin province by five stations (Al-Gayyarah, Jisr Al-Shirgat, Asdeira, Al-Zuwia and Almsahag). Anatomical Characteristics of Nile flower Eichhornia crassipes were studied. Some qualitative properties of river water were studied. The results indicated that there were significant differences between the study stations in all anatomical characteristics of the plant, Significant differences were found in the different study stations in all the characteristics of the upper and lower skin of the leaves of the Nile flower plants, it is the dimensions of stomata and its index and the average dimensions of the cells of the upper and lower skin. For the stems of the Nile flower plants, anatomical characteristics showed significant differences with different study stations. Al- Mosahak station achieved the highest stomatal dimensions of 15 and 13 µm for length and width respectively. Al-Gayyarah station excelled in the highest averages of the stomata index and average length × width of normal cells with values of 14 and 32 × 15 µm respectively. The highest mean of the physical characteristics of the river water was 1407 mg / L of total dissolved solids at the Al-Zuwia station in December, 8.4 for pH at Al-Gayyarah and Jisr Al-Shirgat stations during January, and 1.4 mg / L for BOD5 in Al-Gayyarah station during March, 2.3 mg / L for total hardness at Asdira station in February, 1.02 mg / L of nitrate at Almsahag station in December, 1.231 mg / L for sulfate at Al-Gayyarah station in January, 2.38 mg / L for sodium at Al-Zauwia station in December, and 1.2 mg / L for potassium at Almsahag station in March.

1. Introduction

The plants flower from the Nile aquatic weed growth is harmful environmental disaster is difficult to get rid of them easily have spread from the original home in the Amazon Basin in Brazil to different countries with the appropriate environment for the presence and breeding such as duty tropics and subtropics, including Iraq,.Was introduced this plant to some countries in the beginning that the plant Accessories Water fast growth in water bodies and on the banks of rivers, where to grow and form hopper vegetative beautiful scene and gives the flowers nice also, but later turned to plant water Ghazi cause significant damage in the collapsed number of countries and spend Currently these countries a lot of money to combat and reduce its spread and minimize the harm. (Wikipedia 2018; Tayeh et al. 2007; Gannon, 2014)

The Nile flower plant has actually invaded the pure water systems in more than 50 countries in five continents. It is almost spread in all the southwest Asian parts like Egypt, Iraq and most Arab countries; also the USA southeast, middle and west Africa and middle America (Gomez Balandra and Martinez Jimenez, 2007). It is spread in the equatorial and semi-equatorial water surfaces where the nutrients levels are almost high because of superficial flow of agriculture, erasing forests and the insufficient processing of sewage waters (Villamagna, 2009).

Plant structure consists of root system under water surface and shoot system that floats over the water surface. It is an aquatic plant with rhizobia short floating stems or extended stems as extensions (Al-Hialy and Shihab, 2014). The plant height reaches (50 – 100cm) and could be more with the raised plant density and available nutrients (Jones,2009). It's noticed that the optimal temperature for its growth is 28 – 30oC (Center and Dray, 2010). This plant grows as a dense mass that floats over the water surface, and it obtains all the nutrients from water column. Sometimes, the plant conducts the bottom via its long fibrous roots which feature with abundance, being netted, very long, have a dark purple or bluish black color due to the presence of purple anthocyanin stain and have nods at their tips (Al-Hialy and Shihab, 2014). More than 50% of the huge mass the Nile flower Eichhornia crassipes plant forms extend fibrous roots with roots that varies between 15-30cm in length to give feather shape to roots, roots also contain solved stains like anthocyanin that protects roots of herbivorous animals (Sculthorps, 1985).

Plant leaves are skinny, thick and glossy with orbicular or ovate shape. Blade diameter varies between 10 – 20cm and raise over water via a huge and swell stem that's light and spherical with parallel venation and stem is spongy and swelled in its early stages to form leaves, helping plant to float over the water surface and then this swelling goes. In case of Nile flower E. crassipes, rhizobia extensions with diameter 3 – 6cm and 30cm length having so many nodes are formed, each node gives leaves upward and roots downward. Lateral buds could form extensions that grow at 60 degree from the rhizobium. (Agyemang, 2002).

Impacts of Nile flower is directly bound to its density or coverage size. It's obvious that its density at development would be affected with ambient conditions like, temperature, salinity, available nutrients, water flow and wild animals. Water meshes could directly influence the solvent oxygen, nutrients concentration, heavy minerals and contaminators concentration and water transparency (Tiwari and et al., 2007). The species Eichhornia crassipes is one of the species that spread in many of our Iraqi waters, and the fact that the Nile flower is considered one of the polluted plants because it is poisonous on the one hand and because it absorbs huge amounts of Iraqi water, was the reason for our selection and study of it from the morphological and anatomical point of view.

Study was done on particular spots of Tigris River, beginning from Al- Gayyara District in Nineveh Province until Baiji District in Salahuldin Province as shown in table (1). Study included five stations which are, the first- Al- Gayyara District, the second- Al- Shirgat Bridge, the third- Sdeira Village, the fourth- Al- Zuwia District and the fifth- Al- Msahag District. The study lasted six months since December, 2018 to March, 2019. Tests were made in the labs of Biology Department- Sciences College- Tikrit University.

Figure 1. Study Stations Locations (Using Google Maps)

2.1.Collecting Water Samples.

This operation has started in the morning, one time monthly as average, beginning from December, 2018 to March. 2019. Polyethylene bottles of 2.25L capacity had been used for in vivo chemical and physical tests, considering to wash all the bottles with sample water, thrice before taking them. Two (Winkler), 250ml, transparent and dark bottle has been used in each station to estimate solved oxygen and oxygen bio-requirement. Mentioned tests were lately done in higher studies lab in Biology Lab / College of Sciences / Tikrit University.

2.2.Collecting Plant Samples

plant sample for Nile flower Eicchinoria crassipes were gathered from each station in many field picnics during the study period, Put in nylon bags, marked and transported to lab for investigation and imbedding in 70% ethyl alcohol until ready for the anatomic tests.

Species of genus Eicchinoria have been diagnosed counting on books, patrols and plant flora to confirm the morphological properties. It's found that this genus includes nine species, the most important is Eicchornia crassipes which is most spread and important species in our Iraqi seas. So; we focused in this research on this species only morphologically, anatomically, chemically and environmentally.

Prepare section from leaves, stems and roots of fresh plants, gathered for study stations on Tigris River as follows,

1. Part to prepare is put on a glass slide where the studied smear is put downward with removing the other parts with a sharp lancet via razing, gently and carefully to save the required part. During the scattering, some hot water drops were added from time to time to maintain sketch flexibility.
2. Prepared part is to be transported using fine forceps to hot water for cleaning from other tissue residues.
3. After that, it's turned over and put on a glass slide for coloring with sufranin stain at 1% concentration, resolved in 70% alcohol with washing with 70% alcohol.
4. Section is then transported to a clean slide with putting glycerin drop, then covered with cover slide when ready to investigate.
5. After that, slides are put in a slide folder and placed in fridge at 4oC until studied.

Classification key of scientist (Bor, 1970) when diagnosing the genus. Compound microscope of (Altay) and (Motic) brand had been used to study and investigate the plant parts, tissues and cells under 36.151=41µm, then specimens were pictured with a digital camera branded Canon. Some morphological and anatomic traits were studied as the following, first, qualitative and quantitative traits of upper and lower epidermises of leaves that are, stomata length and width in upper and lower surfaces (micrometer), stomata index on upper and lower surfaces and it's been calculated with the following equation,

$$\text{Stomata Index} = \frac{\text{Stomata Number}}{\text{Stomata Number + Normal Epidermal Cell Number}}$$

Also, average length and width of normal cells of upper and lower surfaces (micrometer), and stomata frequency on upper and lower surfaces (stomata/cm2), is definitely, stomata number in area unit. Also, stomata percentage between upper and lower surfaces (%), sponge tissue thickness (micrometer) and average lengths and widths of sponge cell (micrometer).

Secondly, qualitative and quantitative dissecting traits of stem epidermises which are, stomata length and width (micrometer), stomata index, average length X average width of normal cells (micrometer) nature of radial and transversal walls and stem stomata frequency (stomata/cm2).

Estimating

2.3.Total dissolved solids TD .
Total dissolved solids TDS, were estimated in water samples basing on the method mentioned in (APHA, 1999), where the filtered volume of 50ml of water samples was evaporated and then dried in electrical oven under 105oC according to TDS concentration by the following equation, and results were expressed by mg/L unit,

$$\text{Total Dissolved Solids mg/L} = \frac{(A-B) \times 1000}{\text{Sample Volume ml}}$$

Where, A= dish weight with the remaining, B = empty dish weight.
Estimating Acid Function pH, the pH meter apparatus was used to measure the hydrogen potential after being titrated with regular solutions at the beginning of each measure.

2.4.Oxygen Biological Requirement BOD5.
The oxygen bio-requirement was measured according to the method used to estimate dissolved oxygen (DO5), and the difference with the primary dissolved oxygen DO0 has represented the value of BOD5 mg/L (APHA, 1998).

2,5. Total Hardness TH.
model of (APHA,1998), has been followed to estimate total hardness, taking a size of (5 - 10)ml of sample water, then diluted by completing the size with distil water to 50ml, then titrated with (Na2EDTA) standard solution with the presence of suitable amount of Erichrom Black-T reagent powder. Total hardness is calculated with the following equation,

$$\text{Total Hardness} = \frac{V_{Na2EDTA} \times N_{Na2EDTA} \times 1000 \times \text{M.W. as } CaCO_3}{V_{sample}}$$

Nitrate Ion NO3, to estimate nitrate we can use the chromo tropic acid method. Color intensity is measured using photometer apparatus on 430nm wavelength in order to estimate the nitrate concentration (APHA, 2012).
Estimating Sulfate SO4 concentration, it's been used the sulfate concentration method in river waters with absorbability (spectrophotometer) with turbidity method, adding barium chloride as mentioned in (APHA, 2003). Absorbability was measured with 470nm wavelength, according to sulfate concentration in unit mg/L.
Estimating Sodium Na and Potassium K, each sodium and potassium were estimated using flame photometer of brand PFP 7, manufactured in JENWAY Corporation, readings then have been compared with standard curve of each element to determine concentrations, expressed by mg/L (APHA, 2012).
Statistical Analysis, after gathering data, they've been arranged and tabled using Microsoft Office Excel program, then variance analysis was made to them, then comparison was made for average factors (stations and months) and their interactions, using Duncan Multiple Range method at likelihood level $P \leq 0.05$ using the statistical analysis system (SAS), the ninth version 2009.

3. Results and Discussion
3.1. Anatomic Traits of Nile Flower Eichornia crassipes Plant Leaves
It's clear, through the current study that the leaves of species E. crassipes were of type (Amphistomatic Leaf); so, stomata exist on both upper and lower leaf surfaces, but stomata number and frequency in lower leaf are greater in lower surface than the upper. This why they adapt to environmental circumstances, and because the upper surface is more exposed to light and heat,

compared to leaf lower surface, and the stomata type was of paratetracytic type, it means there is four assistant cells to surround the guard cells.

Study showed a clear variance among average stomata dimensions in the five stations to study according to averages test results using Duncan multiple range method; so, it's discovered that the longest stomata in lower surface was in both stations of Al- Shirgat Bridge and Sdeira 2, 3 which reached 16 micrometer and the shortest stomata was in Al- Zuwia that reached 12 micrometer, while the widest stomata in the lower surface was in Nile flower plant, existing in Al- Msahag, to reach 14 micrometer, while the narrowest stomata was spotted in Al- Gayyara plants as 9 micrometer as in table (1).

For the upper surface stomata, they varied in the five study stations. The longest stomata was in Al- Shirgat Bridge plants that reached 16 micrometer. While Sdeira and Al- Zuwia plants have recorded the shortest stomata as 12 micrometer value. While for leaves width in Nile flower plants leaves, Al- Msahag plants have made the highest mean value as 15 micrometer, while the least values in width for leaf upper surface was in Al- Gayyara station that reached 9 micrometer.

While for stomata index on the lower surface, the greatest one was in Al- Gayyara that reached 20, while the least index was in Sdeira as 14 as shown in table (1). Stomata index on the upper surface was also variant in Nile flower plants within the five stations. It's noticed that the highest stomata index on the upper surface was in Al- Gayyara and Al- Zuwia that reached 18, while the least index of upper surface stomata was in Sdeira station as 12, while the lower surface stomata have made the highest mean value of this trait, compared with lower surface stomata. This variance is a result of ambient conditions and factors related to waters nature and consistence of salts and intense light.

While for normal dermal cells, variance in dimensions also present in study stations, where it is found that average length X average width of normal cells in lower surface was high in Sdeira plants, that value reached 11X32 micrometer in a significant difference from other stations average values, while the least average value of cell length X width was in Al- Msahag, that reached 25 X 12 micrometer as in table (1).

While for the normal cells on the upper surface of Nile flower plant leaves, they also have significant variance within the five stations of study. It's noticed that the highest average leaf length X width in Al- Msahag, that was 10 X 29 micrometer. It's also noticed that cell dimensions were greater in length and width in the upper surface than they're in lower surface of Nile flower plant in all the five stations in table (1). It could be attributed to cell differentiation in upper surface at development, compared to cells in the lower surface. It could return to other environmental and genetic factors.

Table 1. Traits of Upper and Lower Epidermises of Nile Flower Eichhornia crassipes (Micrometer)

Stations Traits		Al- Gayyara	Al- Shirgat	Sdeira	Al- Zuwiya	Al-Msahag
Stomata in lower surface	Average length	c13	a16	a16	d12	b14
	Average width	e9	b13	c11	d10	a14
Stomata index on the lower surface		a20	c18	e14	b19	d15
Stomata in upper surface	Average length	b15	a16	d12	b12	c13
	Average width	e9	b14	c12	d11	a15
Stomata index on the upper surface		a18	b15	d12	a18	c13
Average length X Average width	Lower surface	b 10 X 30	d 9 X 28	a 11X32	c 10X26	b 12X25
For normal epidermal cells	Upper surface	b 12 XX 32	a 15 X 30	c 13X28	d 10X34	e 10X29

Values followed by the same letter doesn't significantly differ from each other

The current study results agree with what obtained by (Tellez and et al., 2008 and Wilson and et al., 2005) who referred to the difference of Nile flower plant growth from environment to other and so morphological traits differ as they're more influenced with ambient environment. It also agrees with(Center and Dray ,2010), that Nile flower plant quickly responds and changes with urgent environmental changes and heavily influences the environmental system. When temperature and radiation decrease in winter, photosynthesis might decrease and, in turn, growing cells decrease and thus it reflects on the dry weight and this agrees with (Reddy, 1984). So, it's found that plant growth rate is very low in winter by 0.36 g dry matter/m2/day; while in summer, its growth rate 46 g dry matter/m2/day.

The current results agree with the anatomic study made by(Al-Karawi ,2012), who found that leave epidermis thickness varies between 5 – 20 micrometer and number of vascular bundles varies between 3 – 8 rows, he also mentioned that normal epidermal stomata and cells varies between studied genus upper and lower epidermises by size and dimensions; so, the cell number of lower epidermis is less than it is in the upper, while the stomata number in the upper epidermis is less than them in the lower as a type of adaptation with ambient conditions. While for cell shapes, they were polygonal and also a cell sides number varies between 5 – 8 sides and almost eight unequal in length sides like in the lower epidermis, while for the upper epidermis, they varied between 5 – 6 ribs and almost six unequal in length sides. The regular shape of cells dimensions decreases, in addition to size, when they surround the stomata., while for the quantitative properties of upper and lower epidermises; so, cell length in the upper epidermis has varied between 2.5 – 4.25 micrometer and width has varied between 2.25 – 5 micrometer.

Al-Waga'a and Sultan (2015), mentioned that wax percentage on leaves is very limited as an aquatic plant doesn't require wax because it's a plant adaptation in hot and dry environments, and stomata number was great, and for the continuity of photosynthesis processes, plant reduces tissues temperature via transpiration despite the plant ability to grow in equatorial environment with high temperature, beside the excessive speed in growth and mechanical adaptation to spread. In addition, leaves have a lower respiration rate than what presents in land plants, and body organs death is limited, compared to land or amphibious plants because they are aquatic plants.

One reason for plant growth rate to decrease, is being at the stage of forming new vegetative organs like leaves, branches and extensions, as well as the decreased temperatures especially at night. It maybe because of reproduction and horizontal growth more than vertical growth. So,(Didham and et al. 2005) and Wilson and et al. (2005) to the forming and increase of leaves number when temperature and suitable nutrients avail, but their number differs according to plant growth nature. So, in the months that forming new leaves decreases, plant tends to form new branches and extensions.

3.2 Nile Flower Eichhinoria crassipes Stems Anatomic Traits.

It's shown in table (2), the average anatomic traits (quantitative and qualitative) of stems epidermis in Nile flower plant, and from which it's clear the presence of significant differences among the average traits of stomata dimensions and index and average length X width of normal cells within the study stations according to test results via Duncan multiple range model, so in traits of stomata dimensions, we find that Nile flower stems in Al- Msahag have made the highest averages to reach 13 and 15 micrometer for length and width, successively. In addition to stems stomata length in Al- Shirgat Bridge plants that reached 15 micrometer too, while the least averages have reached 11 micrometer 11 micrometer for length in Al- Ziuwia station and 10 micrometer for width in Al- Gayyara.

While for stomata index trait in Nile flower plant stems, they ranged between 6 – 14 at Al- Zuwia and Al- Gayyara stations successively, with significant differences among all the average values for length range X width for normal cells of Nile flower plant stem epidermis. It's found that the highest mean value of these cells dimensions multiplication result was at Al- Gayyara station that recorded dimensions as 32X15 micrometer, while Al- Shirgat Bridge station has recorded the least dimensions of normal epidermis cells as 21X10 micrometer.

While for the nature of diametric and transverse walls of stem epidermis cells, it's clear that they're all thick walled for Nile flower plants in study stations. They were straight in Al- Gayyara and Al- Msahag stations, sloppy in Al- Shirgat Bridge plants and curvy in Sdeira and Al- Zuwiya stations.

Table (2), Anatomic, Quantitative and Qualitative Traits of Stem Epidermis in Nile Flower Eichhinoria crassipes (Micrometer)

Stations Traits		Al- Gayyara	Al- Shirgat	Sdeira	Al- Zuwia	Al-Msahag
Stomata Dimensions	Length	b14	a16	a16	d12	b14
	Width	d10	b13	c11	d10	a14
Stomata index		a14	c18	e14	b19	d15
Normal Cells			a16	d12	b12	c13
Average length Average width		a15X32	b14	c12	d11	a15
Diametric and Transverse Walls Nature		Thick and straight	Thick and sloppy	Thick and cuvy	Thick and cuvy	Thick and straight

Values followed by the same letter doesn't significantly differ from each other

States the average values of stomata frequency in leaves and stems of Nile flower plants with the study stations in Table(3), where it's noticed significant differences among the average values of studied traits according to comparison studies among the average values according to Duncan multiple range model. So, the plants of Sdeira station have significantly dominated with the highest mean values of stomata frequency of upper and lower leaf surfaces which reached 20 and 24 stomata / cm2 successively. While Al- Msahag plants have recorded the lowest mean values as 12 and 16 stomata / cm2 for upper and lower leaf surfaces for ratio between successively. In addition that this station plants have recorded the least average ratio between upper and lower surface frequencies as 75%, while the greatest average value of upper and lower surface ratio was in Al- Gayyara station as 68%. While for stem stomata frequency, average values have ranged between 6 and 12cm2 in Al- Gayyara and Al- Zuwia stations plants successively. it's also found that stems stomata frequency is less than it is in leaves because leaves is responsible for gas exchange, respiration and photosynthesis.

From the previous studies, Al-Garraway (2012) suggested that the cross sections of leaves of genus Eichhornia crassipes are featured with epidermis that consist of a uni-rowed layer with rectangular shape, followed with a layer of parenchymal tissue which is built of two layers, and the common is three rows of sided cells that surround interspaces, after which, the first vascular bundles layer exist that usually has a smaller diameter than the vascular bundles close to center, the number of bundled rows has ranged between3 – 8 rows and it came similar to our current study on stems, these bundles consist of bundle sheath, which varies in its cell number in bundle rows; so, it's formed of 7-12 cells in the first row, to 9-16 cells in rows close to center. Bundle sheath is surrounded with xylem and phloem, where xylem tissue consists of xylem fibers which are sided and wall thickened, also straws and vessels which have large diameter, especially in vascular bundles close to center, vascular bundles lengths in first

Table 3. Stomata Frequency in Stems and Leaves of Nile Flower Plant Eichhornia crassipes (stomata/cm2)

Stations Traits		Al- Gayyara	Al- Shirgat	Sdeira	Al- Zuwiya	Al-Msahhag
Leaf Stomata Frequency	Lower surface	C22	D21	A24	B23	E16
	Upper surface	B19	D16	A20	C18	E12
	Percentage between upper and lower surfaces %	A86	D76	B83	C78	E75
Stem Stomata Frequency		C6	B11	C9	A12	D8

Values followed by the same letter doesn't significantly differ from each other

Row have varied between 50-100 micrometer, while they varied in both the second and third row between 100-200 micrometer, the widths of bundles in the first row was between 70-100 micrometer, while the other rows have become close in dimensions with the first row, but their average value was a little greater, and aerobic spaces shape varies between triangular to poly-sided to give leaf stalks a flexible or spongy nature and it's attributed to the plant aquatic nature, which is similar to our current study on stems, while the epidermis has a little thickness walls due to plants presence in a water nature and its need to a thin surface to help rapid evaporation and water loss.

3.3. Qualitative Characters of Tigris River Water

Total Dissolved Solids TDS, it's noticed that solids levels shown in table (4) for river water samples within the study stations and months and their interaction that the highest average values have reached 1021, 1075 and 1407 mg/L in Al- Zuwia average values, December and their interaction successively. While the water samples in Al- Gayyara average values and May and Sdeira during may to achieve the least TDS average values that reached 927, 795 and 790 mg/L for each one successively, with significant differences according to averages test results with Duncan multiple range methods. It's also clear that dissolved solids levels in study stations has reached 996 mg/L during January in Al-Gayyara station and 1008, 1011, 1407 and 1000 mg/L during December in the other stations, successively. While the least values have reached 797, 793, 790, 803, and 793 mg/L during May, for the five stations successively.

Table (4), Total Dissolved Solids TDS Levels (mg/L) in Water Samples within Study Stations and Months

Months / Stations	December	January	February	March	April	May	Stations Average Values
Al- Gayyara	r948	f996	i990	o963	w870	y797	e927
Al- Shirgat Bridge	c1008	h994	k981	p955	t919	z793	c942
Sdeira	b1011	g995	j985	u907	v893	a790	d930
Al- Zuwia	a1407	e998	g995	i974	q950	x803	a1021
Al- Msahag	d1000	f996	n964	m968	s933	z793	b942
Months Average Value	a1075	b996	c983	d953	e913	f795	

Values followed by the same letter doesn't significantly differ from each other
Repeated letter is less significant than the individual due to mean values exceeding letters circuit

3.4 Acid function pH

For acid function levels, it is noticed in table (5) the presence of significant differences among their average values in river water samples within study stations, months their interactions according to Duncan test, it's obvious that they ranged between 7.673 and 7.84 in average value of the two stations, Al- Zuwia and Sdeira successively, while they ranged between 7.45 and 8.34 during both April and January, successively, and for study stations and months, where the acid function levels have varied between 7.3 within Al- Gayyara samples during February and 8.4 within Al- Gayyara and Al- Shirgat Bridge samples and 8.3 during January too in Sdeira, Al- Zuwia and Al- Msahag stations, while it reached the lowest values 7.3 during February in Al- Gayyara station and 7.36, 7.61 and 7.4 during April in stations of Al- Shirgat Bridge, Sdeira and Al- Msahag successively and 7.4 in May in Al-Zuwia station.

Al-Omar (2010) mentioned that acid function values range in pure waters naturally and generally between (6.5-8.5), and the waters where the acid function exceed these limits are considered contaminated. The decrease of acid function values could be attributed to the slowed water streaming velocity due to the presence of obstacles in river canal like accumulated wastes and residues flowed with water stream that raise the organic load because of the role of biotic factors (Watson and et al., 1989). Also (Hammer and Viessman, 1985) suggested that the raised acid function values would negatively affect the activity of Nile flower plant.

Table (5), Acid Function pH Levels in Water Samples within Study Stations and Months

Months / Stations	December	January	February	March	April	May	Stations Average Value
Al- Gayyara	e7.741	a8.4	q7.3	h7.7	m7.46	j7.6	d7.7
Al- Shirgat Bridge	h7.7	a8.4	h7.7	c7.8	p7.36	c7.8	b7.793
Sdeira	f7.737	b8.3	d7.79		i7.61	c7.8	a7.84
Al- Zuwia	j7.6	b8.3	k7.52	c7.8	n7.42	o7.4	e7.673
Al- Msahag	c7.8	b8.3	g7.72	j7.6	o7.4	i7.5	c7.72
Stations Average Value	c7.716	a8.34	e7.606	b7.74	f7.45	d7.62	

Values followed with the same letter doesn't significantly differ from each other with stations average values, months and interaction

3.5. Biologic Oxygen Requirement BOD.

for average concentration of BOD, we notice in table (6) the dominance of average vision and its interaction with December an making the highest average values that reached 1.133 and 1.104 mg/L successively, while March had made the highest value among the study months as 1.3 mg/L with significant differences according to Duncan multiple range test, while the least value has reached 0.978, 0.66 and 0.42 mg/L in average values of Al- Shirgat Bridge in December and Al- Msahaq in December, successively. It's also noted the highest BOD values in stations has reached 1.4 mg/L during March in Al- Gayyara station and during January in Al- Zuwia station, 1.3 mg/L in January and February in Al- Shirgat bridge and asdeira stations, 1.2 mg/L in the months January, march and April in Al- Msahag stations, while the least values have reached 0.58, 0.6, 0.9 and 0.42 mg/L in Al- Gayyara, Al- Shirgat bridge, Al- Zuwia and Al- Msahag station successively and 0.75 mg/L during February in asdeira station. Time and place difference in BOD concentrations could be because of the direct effect of Nile flower plant in the studied water environment.(AL-Hourani,2019) suggested that the decreased concentration of BOD could be a result of absorption and adsorption processes which changes the taste of the water and makes it semell unpleasant ,thus polluting the environment.

Table (6), BOD Levels (mg/L) in Water Samples within the Study Stations and Months

Months / Stations	December	January	February	March	April	May	Stations Average Value
Al- Gayyara	o0.58	c1.2	h1	a1.4	k0.85	f1.05	c1.013
Al- Shirgat Bridge	n0.6	b1.3	k0.85	b1.3	I0.8	g1.02	e0.978
Sdeira	i0.8	b1.3	m0.74	b1.3	h1	h1	b1.025
Al- Zuwia	j0.9	a1.4	d1.15	B1.3	eE1.1	i0.95	a1.133
Al- Msahag	p0.42	c1.2	k0.85	C1.2	c1.2	f1.05	d0.987
Moths Average Value	f0.66	b1.28	e0.92	a1.3	d0.99	c1.014	

Values followed with the same letter doesn't significantly differ from each other with station average values, months and interactions

3.6.Total hardness (TH)

Total hardness is a numerical expression of the water content of minerals, primarily calcium, magnesium and other Alkali mineral ions, which is one of the main properties that differ according to the quality of water around the world (Cech. 2003). It is shown from the total hardness levels in table (7) for river water samples within the rates of study stations and months and their interactions, that the highest Hardship levels reached1.15, 1.9 and 2.3 mg/L in the rates of Al-Zawia, February, and Asdira during the month of February, respectively. Whereas the water samples supervised in Almsahag rates and the month of May in achieving the lowest averages for total hardness, which amounted to 0.983 and 0.38 mg/L each of them, respectively, with significant differences according to the results of the averages test using Dunkin's multi-ranges method. For the interactions, the averages were the lowest TH rates were 0.3 mg/L in water samples for Jisr al-Shirqat stations during May, Asdira during April, and Al-Zawia during March and May and Almsahag during the month of April, respectively. It is also noticed that the highest levels of TH within the stations reached 0.2 mg/L during December at the Gayyarah station. Whereas they were 1.8, 2.3, and 2.2 mg/L during February at Jisr Al-Shirgat, Asdira, and Al-Zawia stations, and 1.9 mg/L during January at Almsahag station, while the lowest values were 0.4, 0.3, and 0.3 mg/L during May. At Al-Gayyara, Jisr Al-Shargat and Al-Zawia stations, respectively, in addition to the month of March at Al-Zawia station, and 0.3 mg/L during the month of April at my station Asdira and Almsahag.

Table (7), Total hardness levels (mg/L) in water samples within the stations and months of study.

Months stations	December	January	February	March	April	May	station average
AlGayyarah	2 c	1.5 g	1.5 g	6.0 l	0.5m	4.0 n	1.083b
Jisr Al-Shirgat	4.1 h	3.1 i	8.1 e	7.0 k	4.0 n	3.0 o	0. 983d
Asdira	1.1 j	7.1 f	3.2 a	4.0 n	3.0 o	0.5m	1.05c
Al-Zawia	7.1 f	8.1 e	2.2 b	3.0 o	6.0 l	3.0 o	1.15a
Almsahag	1.1 j	9.1 d	7.1 f	5.0 m	3.0 o	4.0 n	0. 983.e
rate of months	46.c1	64.b1	9.1 a	5.0 d	42.e o	38.0 f	

The values followed by the same letter are not significantly different from each other within the averages of stations, months and interaction.

3.7. Nitrate ion NO3

For the average nitrate concentration shown in table (8), it is noticed that there are significant differences among the averages of each the stations, months of the study, and their interactions according to the results of the averages test by Dunkin's multi-ranges method, as they reached the highest concentrations 0.917, 0.996, and 1.02 mg/L in river water samples at survey rates of December, Almsahag, and their interactions, respectively. lowest nitrate concentrations 0.9003, 0.612, and 0.601 mg/L in the water samples of Asdira, Msahag during May.

Apparently, the highest levels of nitrates within the study stations were 0.995, 1.006 and 1.02 mg/L during December at stations Al-Gayyarah, Al- Zawia, and Al-Msahag, respectively, and 0.991, 0.978 mg/L during January at Jisr Al-Shirgat and Asdira stations. respectively, while reaching the lowest values of 0.613, 0.615, 0.607, 0.624 and 0.601 mg/L during the month of May for the five stations, respectively. This is due to the increase in its concentrations in the studied water samples Organic endurance, While the decrease in nitrate concentrations may be attributed to its consumption by floating plants and algae in the study area,(AL-Zamili.2007)(AL-Hamdani.2010). In an experiment for (Rommens et al. 2003) to test the ability of the Nile flower to absorb nitrates NO3, they found that the average plant uptake of the Nile flower reached1.13 mg of nitrates per kilogram of Nile flower (wet weight) every hour, and they mentioned that the coastal sites ,where the Nile flower is grown, in Chivero lake in Zimbabwe, has much lower nitrate content than control sites or coastal sites that are not contains Nile flower.

Table (8), nitrate levels of NO3 in water samples within the study stations and months (mg/L).

Months / Stations	December	January	February	March	April	May	station average
AlGayyarah	995. 0 d	0.965 o	0 .974 k	0 .975 j	0 . 969n	0 . 613 y	915.b 0
Jisr Al-Shirgat	0. 986g	0.991 f	0 .927v	0.976 i	0 . 97 m	0.615x	0.911c
Asdira	0.971i	0 . 978h	0.947r	0.969 n	0 . 93u	0.607 z	0.9003 e
Al-Zawia	1.006c	0.963p	0.947 r	0.947 r	0 . 95q	0.624 w	0.906d
Almsahag	1.02 a	0.993 e	0 .942s	1.008b	0 .936t	0 .601a	0.917a
rate of months	0.996a	0.978 b	e 0.947	0.975c	0. 951d	f 0.612	

The values followed by the same letter are not significantly different from each other within the averages of stations, months, and interaction.

3.8. sulfates SO4

.it is noticed from the table (9) that there are significant differences among their averages in river water samples in months of the study and their interactions according to the results of the Duncan's test, as they ranged between 0.817 and 0.876 mg/L in the rates of the two stations, Asdira and Gayyarah, respectively, whereas it ranged between 0.509 and 1.018 mg/L during the months of May and January, respectively. For the interactions between study stations and months of study, sulfate levels ranged between 0.492 in Asdira samples during May and 1.231 in Gayyarah samples during January. It also turns out that the highest levels of sulphate within the stations reached 1.231, 0.959, 0.916, 0.978, and 1.007 mg/L during the month of January in the study stations, respectively, while the lowest values were 0.504, 0.526, 0.492, 0.51, and 0.513 mg/L during the month of May for the five stations, sequentially.

In this regard, the results of(Muyodi et al. 2004) study reported that the sulfur concentration is very high in the sediments under the mass of the Nile flower plant at the shore of the lake, but in the sediments in the middle of the lake is few, and they attributed this by the fact that the Nile flower plant contains Lactate substrate that Lactate-Utilizing SRB bacteria benefit from.

Table (9), sulfate SO4 levels (mg/L) in water samples within the study stations and months

Months / Stations	December	January	February	March	April	May	station average
AlGayyarah	r 0.866	a 1.231	o 0.872	h 0.893	i 0.891	x 0.504	a 0.876
Jisr Al-Shirgat	q 0.869	d 0.959	n 0.875	e 0.917	p 0.87	u 0.526	c 0.836
Asdira	p 0.87	f 0.916	m 0.882	l 0.883	s 0.861	y 0.492	e 0.817
Al-Zawia	t 0.833	c 0.978	k 0.886	j0.87	o 0.872	w 0.51	d 0.828
Almsahag	s 0.861	b 1.007	g 0.914	h 0.893	r 0.866	v 0.513	b 0.842
rate of months	e 0.86	a 1.018	c 0.886	b 0.895	d 0.872	0.509	

The values followed by the same letter are not significantly different from each other within the averages of stations, months and interaction.

3.9. Sodium element Na.

For the average sodium concentration shown table (10) sodium levels in the river water within the five study stations and their six months and their interactions, and from them it turns out that the rates of the stations ranged between1.483 and 1.733 mg/L at Gayyarah and Ai-Zawia stations, respectively.

As for the average of months, the sodium values ranged between1.166 and 2.062 mg/L during January and March, respectively. The averages for the interactions of study stations and months ranged between1.09 and 2.38 mg/L at the Jisr Al-Shirgat stations within a month of January and Zawia during the month of December, respectively. It also turns out that the highest levels of sodium were within the stations2, 2.01, 2.07, 2.1, and 2.13 mg/L during the month of March in the five study stations, respectively, while the lowest values were 1.2, 1.09, 1.13, 1.2, and 1.21 mg/L during January for the five stations respectively..

The variation in sodium levels in different stations may be attributed to the differences in the nature of the land through which the river course passes. (Jafarian and Tamasebi .2006) indicates that the high concentration of sodium ion in water that the geological basis is. is the main influencer on the water chemistry in those areas.

Table (10), Na levels (mg/L) in water samples within the study stations and months.

Months stations	December	January	February	March	April	May	station average
AlGayyarah	1.39 r	1.2 w	1.22w	2f	1.33t	1.76i	1.483e
Jisr Al-Shirgat	1.54o	1.09y	1.42q	2.01 e	1.45p	1.67 j	1 .53d
Asdira	1.62i	1.13x	1.42q	2.07 d	1.55n	1.77h	1.593 c
Al-Zawia	2.38a	1.2w	1.34s	2 .1c	1.61m	1.77h	1.733 a
Almsahag	1.66k	1.21v	1.33t	2.13b	1.77h	1.79g	1.648 b
rate of months	1.718c	1.166f	1.346e	2.062a	1.542d	1.752b	

The values followed by the same letter are not significantly different from each other within the averages of stations, months and interaction.

4. Conclusion

We conclude from the foregoing that there are significant differences in the anatomical characteristics of the leaves and stems of the Nile flower plants in different study stations, as well as the presence of significant effects of the Nile flower plants on the qualitative characteristics of the river water. Thus, we recommend the use of the plant in wastewater and polluted water treatment programs and the possibility of reducing heavy metals in some types of water.

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Morphological of the Euphrates River between Al-Qaim and Hit City using Modern Technology

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Abstract. The study aims to illustrate the River characteristics, river morphology and river processes in the study area Landscape. The river and morphological variables used in the study were derived from the satellite imageries available, digital elevation models, and relevant maps. River morphology is used to describe the shapes of river channels and how they change in shape and direction over time. River channel morphology is an indicator of a number of environmental processes and conditions. The river channel is the product of many geographical and geomorphological components that are determined by many factors, which are independent variables of the landscape (Geology, Climate, And Man) and reflect their influence in shaping the variables dependent on the landscape and the channel (sediment supply, stream discharge, and vegetation). Based on the aforementioned variables, the landscapes of the Euphrates River profile between the cities of Al-Qaim and Hit were chosen, which affect the formation and development of the channel. Where it leads to creating the shape of the planform and the active river area. The topography of the study area is characterized as a plateau crossed by the Euphrates River. It was affected by tectonic activity and this was reflected in the shape planform and geomorphic characteristics.The length of the river distance for the studied profile is 348 km, and it was divided into four reaches.It appeared that the index of this distance is characterized by sinuosity, as it reached 1.4, now the meanders are present in the second and fourth reach, while braiding prevailed in the first reach. The emergence of human settlements and increased until the present time, represented by the construction of a group of dams on its basin. It led to the occurrence of a series of hydrological and geomorphological changes, which necessitates the restoration of this basin and finding ways to ensure the stability and well-being of the inhabitants of its basin.

1. Introduction

The study of river banks is one of the favorite sites for human settlement due to the security, stability and well-being it provides, as well as its spatial importance in areas where drought prevails.

"River morphology" refer to the field of science dealing with changes of river planform and cross-section shape due to sedimentation and erosion processes. In this field the dynamics of flow and sediment transport are principal elements. Practically all rivers are subject to morphological processes. believe that research on river morphology must comprise a well-tuned balance of four components, field surveys, laboratory experiments, mathematical modelling and theoretical analyses [1].

2. Materials and Methods

2.1. Theoretical framework of the variables of the river section

The research problem focuses on the morphology of the river and its relationship to human use, as the river is in a state of anomaly in this region. What is the nature of the variables affecting the shape of the stream in the study area?

The research aims to know the nature of the relationship between river morphology and human use, by knowing the shape of the river in each section and then its impact on the type of use.

River geomorphology means the study of the shape and function of the nature of the course or river. It requires not only an understanding of the shape of the channel, but also the effective role of the geomorphological processes that are concerned with a set of variables related to the morphology of the river channel, which is a function of a number of processes and environmental conditions.

Major factors control the formation and development of the landscape of the river basin or any section of it with the geological, climatic and human conditions, which are considered as independent variables, while the variables of this landscape such as the supply of the basin with sediments, the drainage of the stream, the vegetation cover and the characteristics of the channel are considered as the dependent variables. The channel then responds to these variables, as in (Figure 1). Sediment supply, stream discharge, and vegetation are determined by the frequency, volume, and caliber of material received by the channel [2].

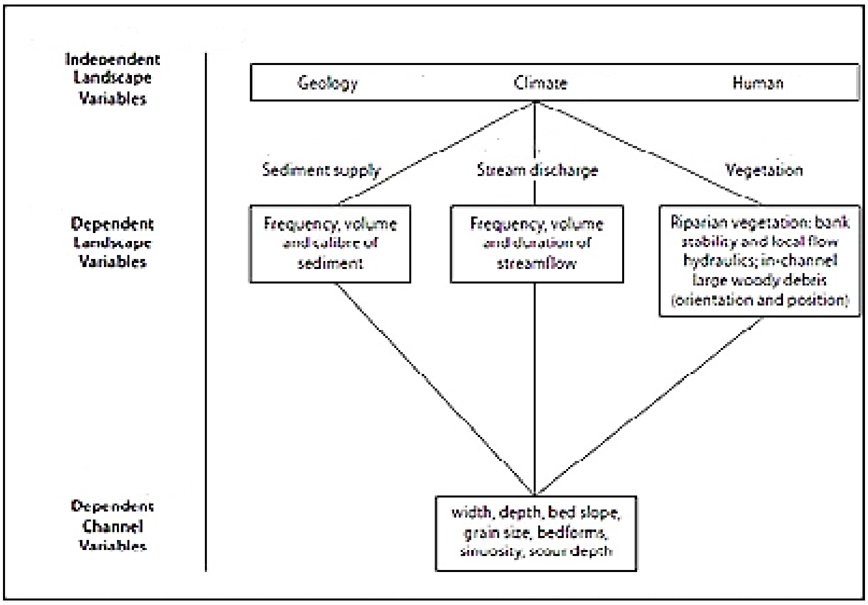


Figure 1. The independent and dependent variables of the river section

Based on what was mentioned above, the river section of the Euphrates River was chosen, starting from the Al-Qaim n-Iraqi border to the city of Hit, i.e. before entering the sedimentary plain region (Figure 2) That is, between the coordinates of the $N33^{0},20^{-},0^{=}$- $34^{0},42^{-}, 0^{=}$ and E

$40^{0},50^{-},40^{=}-42^{0},49^{-},50^{=}$ .The reason is due to the diversity in its land appearance and what it reflects in terms of the variables related to the appearance and the pattern of the canals and their impact on the distribution of the population and land uses. Therefore, this section has been divided into four river reaches in order to clarify the variables that are formed and developed by their influence.

The completion of the research requires working on several programs in order to reach the desired goals, which can be summarized as follows,

a- **(Arc GIS 10.8)** program, in the process of producing maps from satellite images the year (2017) and

extracting information from them by providing databases for them.

b- **Global Mapper 11 program**, it was used to derive contour lines, cross sections, gradients, and to

identify the third dimension.

c- **Google Earth program**, It was used to identify the locations of cities and places.

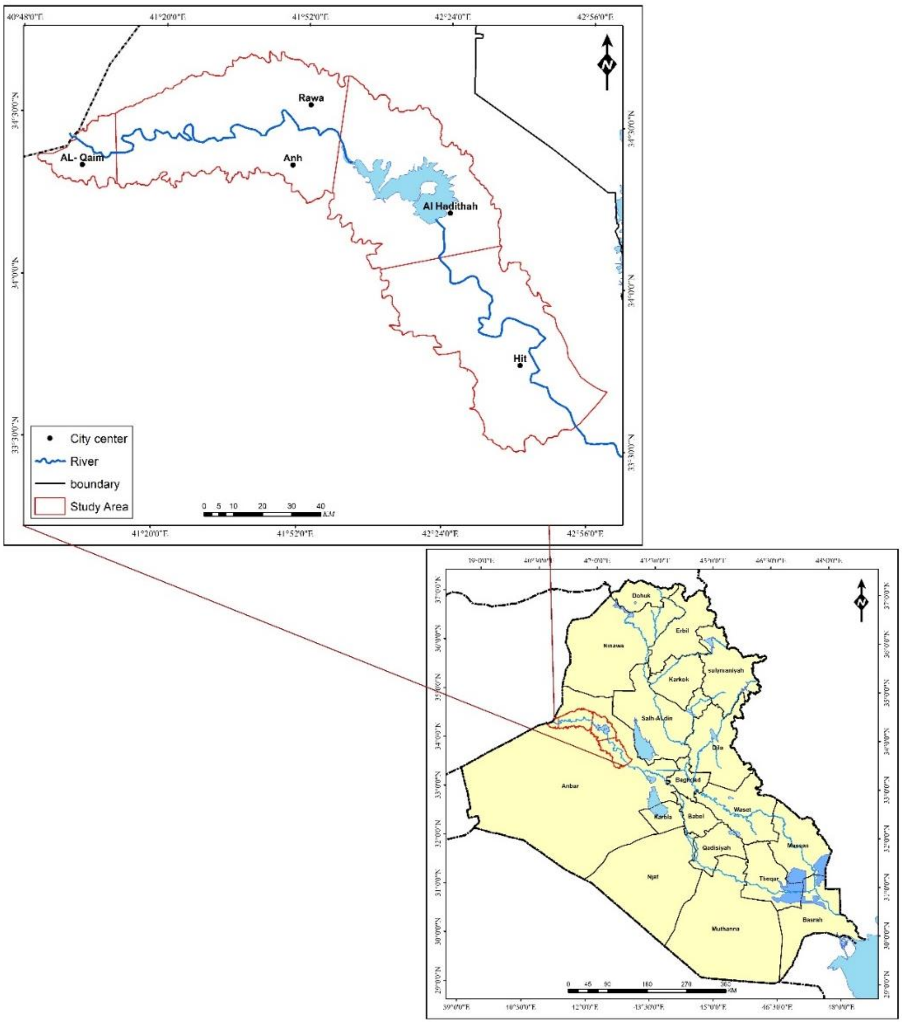


Figure 2. The location of the study area

The Euphrates is the longest river in Southwest Asia. Its length is 2786 km, and its area is about 440,000 km 2. Its basin is shared by 5 countries (Iraq 47%, Turkey 28%, Al-Qaim 22%, Saudi Arabia 2.97%, Jordan 0.03%), where the first three countries are the main riparian.
The Euphrates River originates from the mountains of the eastern part of Turkey in the Armenian highlands near the city of Erzurum and Lake Van at an altitude of 3000 meters (above sea level) (Figure 3). The main tributaries that make up the river are the Kara-Su and Murat-Su, and they meet north of the city of Keban to form the Euphrates River. After that, the river extends for about 430 km to enter Al-Qaim near Jarabulus, at an altitude of 325 meters at sea level. The tributaries of Al-Sajur, Al-Balikh, and Al-Khabur join the Euphrates River in Al-Qaim [3]. After crossing the Al-Qaim n-Iraqi border, the Euphrates River heads southeast to cross the border and enter the city of Husaybah, 3 km from the border, to reach the city of Rawa. After that, the river heads towards the southeast until it reaches the city of Haditha, and this time it travels a distance of (80 km) to reach the city of Hit, after its course had penetrated the northeastern edge of the western plateau, to be a deep narrow stream surrounded by high banks. The width of the river ranges between Husaybah and Hit between (300-350m) with a depth of (5.5m) and a flow rate of (10cm/s) [4].

2.2. Independent landscape variables

These variables are factors controlling channel morphology to those imposed on the river basin and include geology, climate, and humans.

2.2.1 Geological setting

The Euphrates River enters Iraqi territory from Al-Qaim where it forms the point of contact between two tectonic zones, the Jazira and the Western Desert. As the river runs parallel to the Anah anticline in a west-east direction, and it is the only fold along the river inside Iraqi territory and continues to the town of Haditha. There it flows entirely within the Jazira zone to the west of the city of Ramadi. And although the largest part of the Euphrates River basin lies within the stable platform, there are still many indications of tectonic activation(Neotectonic)in the profile [5].

The study which indicates that the stable platform, in which the study area is located, is divided into two zones, Al-Rutba-Al-Jazeera and Al-Salman , separated by the Abu Jir Fault [6]. What concerns us in this area is the area of Al-Rutba - Al-Jazeera because of the river's influence on it. This structural pattern is characterized by regional uplift and depressions caused by orogenic movements that occurred in the Mesozoic and Triassic era. The Horsts was formed in the form of anticlinal folds, and the Grabens valley in the form of syncline folds.

The study which concluded that the left side of the Euphrates River is affected by tectonic activation due to the influence of the tyrat anticlinal fold. It applied all geomorphological indicators of tectonic activation [7]. It turned out that there is a variation from weak to high activity. Its effect was reflected in the formation of cliffs surrounding the Euphrates River from the left side with an arc that starts from the Al-Qaim n border to the city of Hit.(Figure 3).

The Euphrates formation of the is exposed when a river enters the Iraqi territory from Al-Qaim to the ancient town of Anah, as it consists of limestone, dolomite and marl in the lower Miocene age. After which it is exposed, Anah formation is formed of hard limestone. And near the town of Alus, between the cities of Haditha and Hit on the left side of the river, a hole FATHA formation is exposed. It consists of periodic rocks of green marl, reddish-brown clay stone, limestone, gypsum, and age to the Miocene . And near the town of HIt, about 70 km west of Ramadi, the river flows entirely within the Fatah Formation. Between the town of Hit and the city of Ramadi, on the right side of the river, the Nafa'il Formation are exposed, as it consists of alternating green marl and limestone, The age of formation is the Middle Miocene [8].

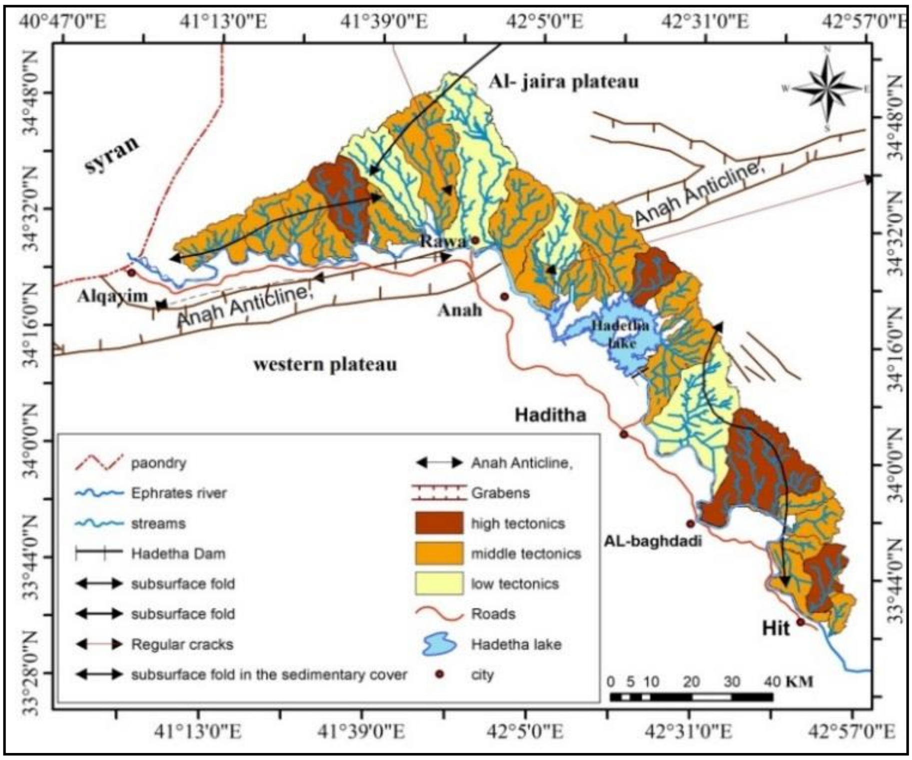


Figure 3. Results of application of geomorphological indicators of tectonic activation

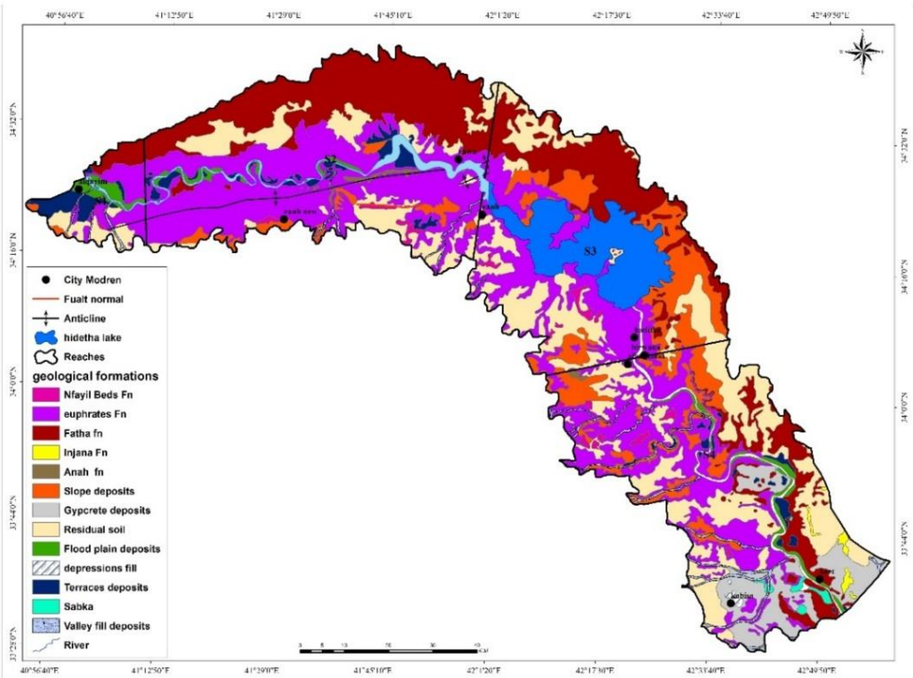


Figure 4. geology of the study area [9]

2.2.2 The climatic situation

The Euphrates River crosses several climatic regions, starting in Turkey until its confluence with the Tigris River in southern Iraq at Qurna. The average annual precipitation in its basin ranges between approximately 1000 mm in Turkey in the north to 150 mm in Al-Qaim and only 75 mm in southern Iraq. Climate charts (Figure 5) for selected stations clearly illustrate this shift from a cooler Mediterranean climate characterized by hot, dry summers and cold, wet winters. Precipitation prevails in the autumn, winter, and spring, with a mixture of rain and snow in winter. Its effect decreases inland and to the south [10].

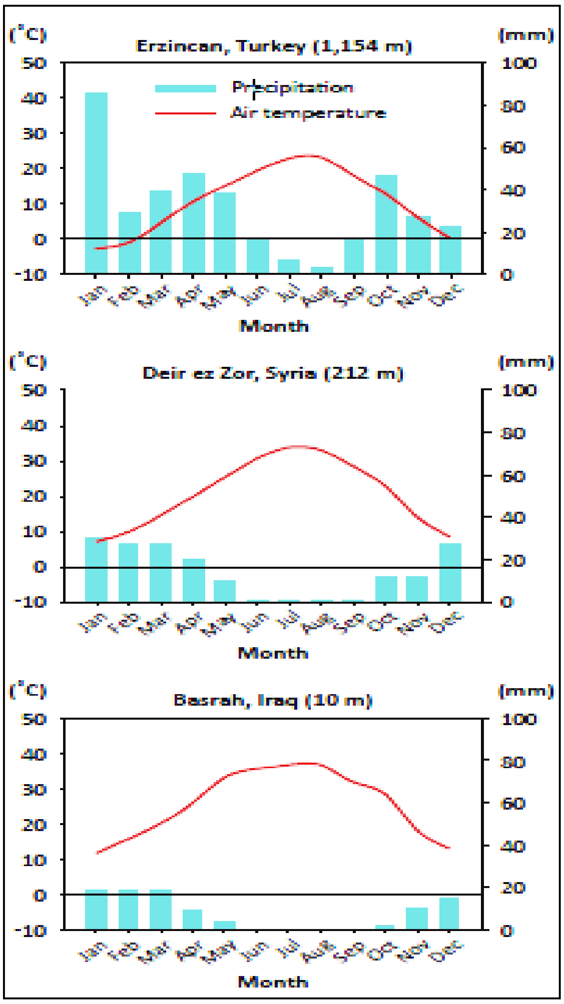


Figure 5. Shows climate charts for selected stations

And to the increasingly hot and dry climate with the progress of the river towards southern Iraq, which has a desert climate, hot dry, continental in the summer, and cold, wet in the winter. The average temperature in the Iraqi western desert is 50 degrees Celsius between the end of May and the end of August and may drop to less than 10 degrees Celsius between January and February. Most of the rain falls between mid-January to the end of March.

There are two main paths of cyclones that affect the climate of the Iraqi western desert, and they are the main cause of precipitation between January and the end of March, and they are The depressions of the Mediterranean Sea cross west into Iraq. This depression track is responsible for precipitation over the northern parts of Iraq. The path of the second depression, called the Sudan Depression, begins in southern Sudan and passes east to affect southern and central Iraq, and sometimes these two depressions affect Iraq at the same time [11]

2.2.3 The human role

The study area witnessed a population attraction since ancient times due to the population migrations from the Arabian Peninsula as a result of the drought there about 15 thousand years ago. It built settlements from the stone ages, i.e. 3000 years BC, until the Islamic period in 1700 AD, when it amounted to 126 settlements. It extended from the Al-Qaim n border to the archaeological site of Akarkov, south of the city of Ramadi, including 57 settlements in the study area, which were concentrated on the cliffs and terraces of the Euphrates River [12].

The study area currently occupies five districts (Hit, Haditha, Ana, Rawa, and Al-Qaim), with a population of (455,000) people, for the year 2019. The majority of its human settlements are concentrated on the river's edges and terraces [13]. These facts appear clearly when Look at the form as follows,

-Green areas stand out on both sides of the river, which represent intensive agriculture, taking advantage of the floodplains and river terraces.

- A close series of human settlements appear along the river along the convex sides of the river in the form of a conglomerate pattern, which increases in size according to the widening of the bend.
- A group of dams were built on the Euphrates River, whether in Turkey, Al-Qaim and Iraq. The Haditha dam, which is located at the front of the city of Haditha, is 7 km away, with an initial storage capacity of 8.28 billion cubic meters. Construction work began in 1978 and ended in 1986.

It may reflect effects on the morphology of the river, which is represented by sedimentation before the dam and erosion after the dam. In addition to other pedological, climatic and hydrological effects [14].

2.3. Variables of landscape of the river profile

Both runoff and sediment supplies (also called driving variables) fluctuate over time, which means that continuous modification occurs through erosion, rework and sediment deposition, as they drive these processes [15].

2.3.1 river discharges,

The discharges of the Euphrates River fluctuate over time in response to the precipitation inputs in its basin. Its discharge ranged from 30.26 billion m^3 (for the average period between 1933-1972) to 23.59 billion m^3. (1973-1989 average). In recent years, it decreased to about 16.90 billion m^3 (1990-2014 average), or a decrease of 44.1%. (Figure 6)[16].

The maximum and minimum discharges recorded in the city of Hit were 7460 m^3/s on 13/5/1969, and 55 m^3/s on 5/9/1973, respectively. In view of the analyzes of the flow records, they show a continuous decrease in the flow over time (Figure 7). This negative trend is attributed to the construction of the Southeastern Anatolia Project (GAP) dams as well as climate change and drought. It should be noted, however, that the construction of dams increases water losses as a result of evaporation from reservoirs [17].

The discharges of the Euphrates River vary according to the snowfall in the upper basin and the precipitation in it. The rise in levels and the occurrence of floods in the wet seasons begins from November and continues until the end of March. Due to the increases in nutrients due to heavy rains and torrential rains. In the same wet seasons, floods occur as a result of melting snow in the months of April and May in the upper reaches of the river basin. At the end of May, the river levels begin to decline gradually until the end of September.

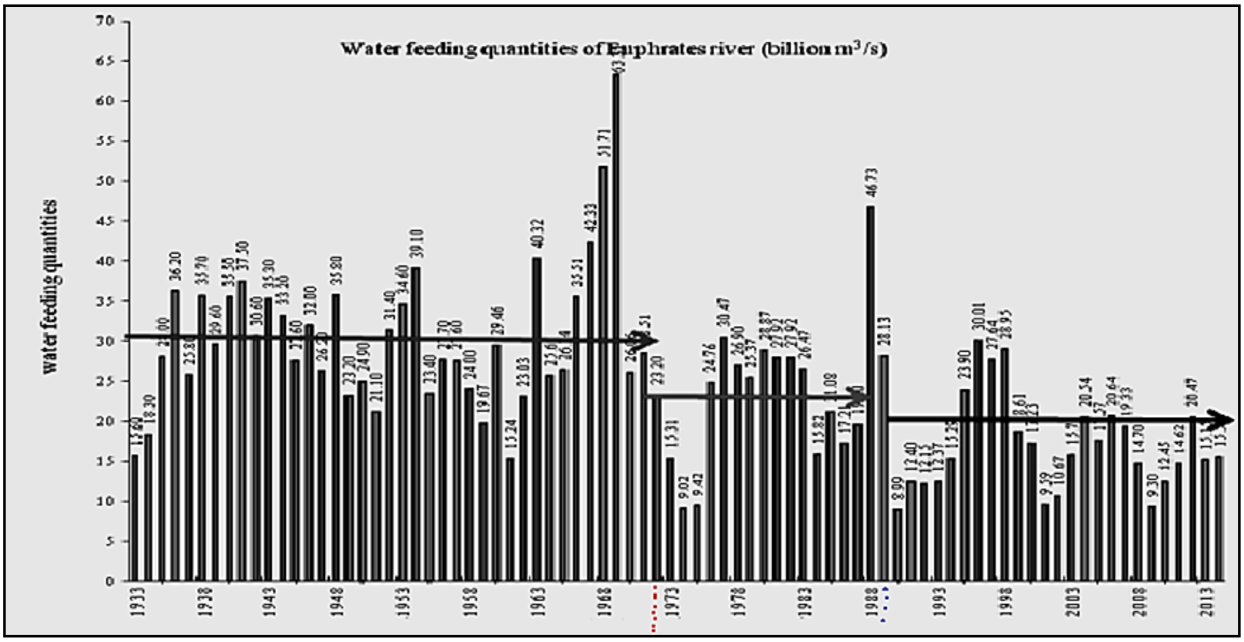


Figure 6. Discharge of the Euphrates River with water at the Al-Qaim n-Iraqi border. The red line represents the Discharge rate for the period 1933-1972 of 30.26 billion m^3. The blue line represents an average of 23.59 billion m^3 for the period 1973-1989. The black line represents 16.90 billion cm^3

The Euphrates River witnessed for the period between 1898-1988 a number of floods amounting to 9 floods, which had a clear negative impact south of the city of Hit, especially the flood of 1967, whose level reached 50.51 m [18].As for the flood of 2018, whose revenue amounted to 13.16 m^3 Compared to its annual rate of 9.56 m^3 Ministry of Water Resources [19], it was under control. As the surplus of the discharge was stored in the dams of Al-Qaim and the Haditha dam in Iraq, because the years before this year were dry years(Figure 8).

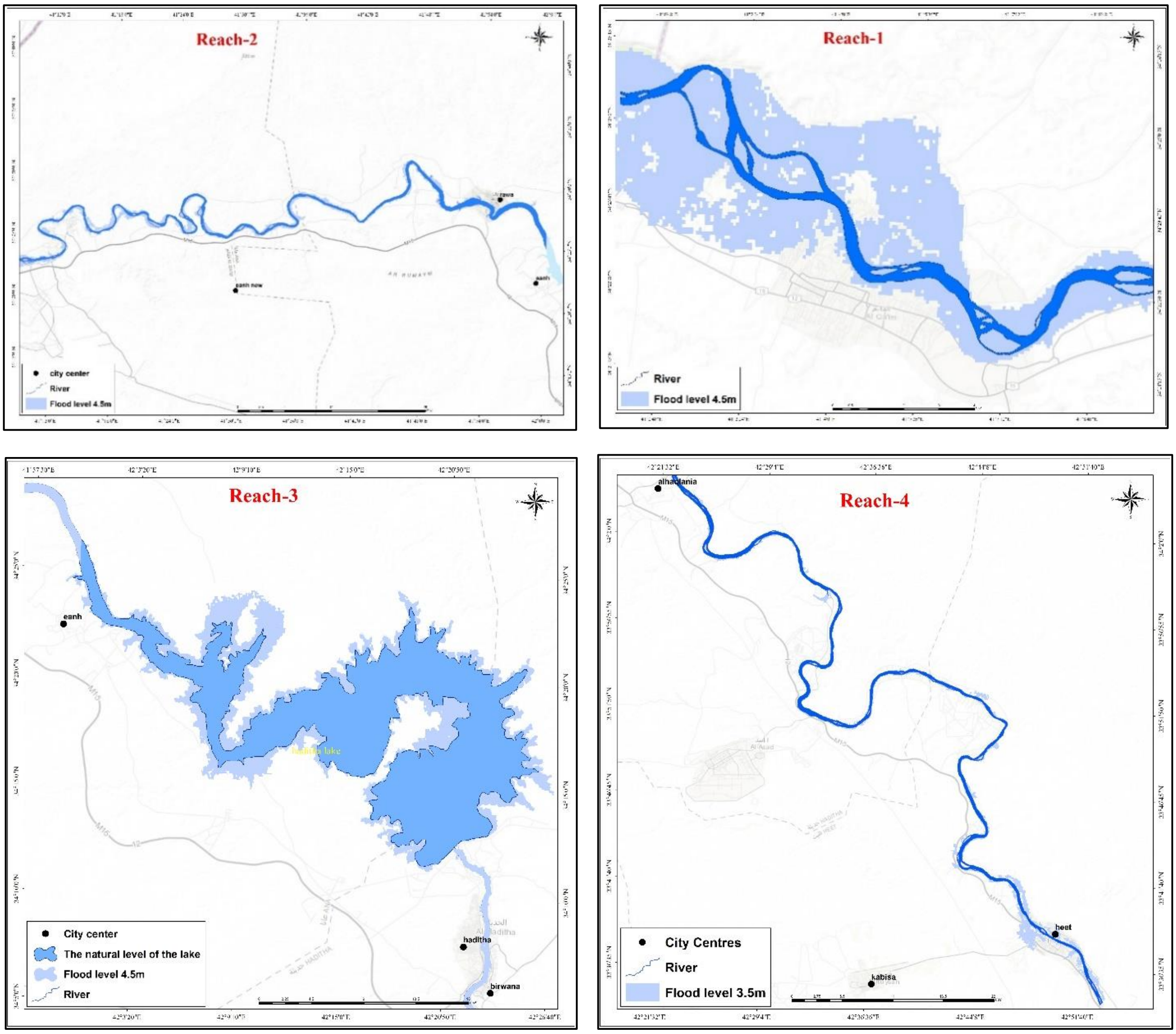


Figure 8. Flood events 2018 in study area

Source, The researchers worked in contact with the people of the region to identify the extent of the flood level and use a program GIS and global mapper11and Dem.

2.3.2 Sediment supply

The sediment load on the Euphrates is generally low in sedimentary joints due to the strong organization of drainage and the many dams built on it in Turkey, Al-Qaim and Iraq. The maximum sediment load, 25% of the annual load, occurs in March during the flood season. The sediment is composed of silt (more than 60%) with the remainder composed of clay and sand. As the maximum suspended load of sediments was measured 10^7 * 2.1 tons / year in 1970, and the minimum suspended load was 10^6 * 1.9 tons / year in 1985 [20]. In addition to the sediments deposited by the river over time, such as terrace sediments and floodplains, what was deposited by the floods of the valleys that flow into the river and others.

2.3.3 Vegetation

Desert vegetation prevails in the western plateau (the northern Badia), which is crossed by the Euphrates River. Its plant environment is classified as an intermediate state between short grass pastures or dry steppe and true deserts, as the average annual precipitation is mostly more (i.e. more than 100 mm) than what is customary for deserts (i.e. more than 100 mm). Annual plants, Ephemerals of all kinds, and perennial shrubs, such as Artemisia herba alba, Haloxylon salicornicum, and others, are common there [21].

It is spread on the banks of the Euphrates River and its islands (the island is locally called Hawija), trees, shrubs, and natural plants. It is distinguished by its density and diversity, such as poplar, willow, licorice, allies, linden, and others.

2.4. Analysis of channel dependent variables

Based on the above-mentioned independent and dependent variables of the landscape of the Euphrates River profile, which affect its formation and development. Because the river system is a dynamic equilibrium system, it may lead to reaches variation in the rate of sediment transport through the channel and the rate of deposition on floodplains, banks, bars. River morphology can also be affected by human interaction, which is the way the river responds to a novel factor in how the river changes course.

This paragraph includes an analysis of the reaches components of the Euphrates River profile from the Al-Qaim n-Iraqi border to the city of Hit, and then what the components of these reaches reflect on the formation of the planforme of the river profile.

3. Results and Discussion

3.1. Analysis of selected reaches components

The section of the Euphrates River between the cities of Al-Qaim and Hit has been divided into four river reaches according to the differences in the shape of the channeles and its components, as follows,

3.1.1. The first reach, Al-Qaim region

This reach extends from the Al-Qaim n-Iraqi border, at a distance of 20 km. The river channel is characterized as unconfined and multi-threaded sinuosity and braided.. On its sides, geological formations (Euphrates, Nfayil, and Al-Fatha), sediments, and river water predominate, constituting a ratio of 0/045.2, 0/052.8, and 2.1% of the components of the river profile (figure and table). The height of the reach area ranges between 160-220 meters above sea level, and its slope rate is 0.5%. The left side (Al-Jazeera region) was affected by the asymmetrical anticline fold [22]. A its effect was reflected by the presence of steep edges, with a height of 30 m from the floodplain. As for the right side (the western plateau region), it starts from 190 m to 200 m, and between them are terraces, the floodplain and the river channel. And above this height, the features of the western plateau region appear. The width of the channel was measured in several places, and it averaged 200 m. It is interspersed with point bars that are mostly connected to the banks of the channel. Mid bar are spread in the middle of the channel in the form of longitudinal bars, numbering 11, diagonal bars, number 2, and islands bars, number 6. There are also many dry valleys in this reach, but three of them flow into the right side of the channel. Its effect appears when its flashing floods occur, which puts pressure on the balance of the channel and adds its sediments at its mouths.

Changes in sediment storage patterns within the channel in bars and islands are also an early indicator of future channel problems[23]. Non-vegetated bars show accumulations of sediment usually above the low water level that often develop on the sides of the channel, although such accumulations may also form in the middle of the channel.

3.1.2. The second reach from the end of the city of Al-Qaim to the city of Rawa

This reach starts in a direction from southwest to northeast at a distance of 120 km to the city of Rawa. The aforementioned studies indicate that there are tens of different tectonic evidences in the stable platform area, indicating that it is tectonically unstable. By making various cross-sections for the different locations of this river reach, it is clear that the Anah fold is not the only one in affecting the river channel, but there is an influence of both the anticlines(tayrat and Euphrates folds) located on the left side of the river[24].

The channel becomes confined, single threaded, sinuosity ,meandering , and its slopes range from 0.45-0.65 $^0/_0$ at a rate of 0.52 $^0/_0$. Ten places were measured for the width of the channel, and it was found that its width averaged 300 m .There are 73 islands varying in shape and size, interspersed with point bars that are mostly connected to the banks of the channel. Bars are spread in the middle of the channel in the form of longitudinal bars, numbering 51, and islands number 9, and oxbow lake that is extinct and has narrow floodplains. There are also many dry valleys in this link on both sides. Its effect appears when its flashing floods occur, which puts pressure on the balance of the channel and adds signs at its mouths

3.1.3. The third reach from the city of Rawa - Haqlaniya

This reach starts in a direction from the southeast, and after the Haditha Dam, it turns towards the south, at a distance of 92 km, in the Haqlaniya area. Its average height is 120 m and its slope is 1.01. This change in direction is due to the fact that plunge of anticline Ana ends at the floor of the dam lake.

After the city of Rawa, to a distance of 10 km to the south, and the average width of the channel is 738 m. The effect of the extension of the lake water levels begins, and the thickness of the sediments increases. However, the edges appear clearly as we head north, and the width of the river confined between the two edges of the channel increases at an average of 738 m. Its effect was reflected in the lack of floodplains and bars.

The estimated distance of the river after the dam to the end of the reach is 15 km, and the average elevation of the area is 128 m above sea level. Hence the role of the dam in controlling the flow of water according to regulating the needs for the various land uses , controlling floods and generating electric power.

A longitudinal earthen dam was also constructed on the banks of the right side of the river to mitigate releases in excess of storage needs during floods. This control changes the state of the natural balance of the river (erosion and sedimentation processes) and the planform its variables. The average channel width is 344 m. The channel here is characterized by being confined and single-threaded, leaving a narrow floodplain, and the presence of pools and riffles, and the presence of bars connected to the banks of the channel, longitudinal bars, and islands estimated at 13.

3.1.4. The fourth reach from Haqlaniya to the city of Hit

The length of this river reach is 136 km, it is heading southeast, with an average height of 76.2 m and a slope of 0.46 %, the sinuosity function is 1.36, and the average channel width is 294 m. These variables indicate that the river begins to decline towards the region of the sedimentary plain to the south, compared to the connections located before it, although the tectonic activity is still continuing, but to a lesser extent, and the emergence of the lithological role represented by the approaching of the formation of the Fatha and Injana with less solid rocks than the formation of the Euphrates from the banks of the channel, especially the part south of the reach.

The channel of this reach is characterized as single-threaded, as there are many meanders and river terraces, and a group of dry valleys flow into it to build deltas. Its banks are connected by point bars, in addition to the bars in the middle of the channel (longitudinal, transverse, diagonal, and islands), as some of them will unite with the bank soon, and pools and riffles prevail when building bends. A dense network of plant roots can increase erosion resistance. As a result, the channels with vegetation banks are narrower than those that are not covered with vegetation under similar formational flows. Longitudinal bars also extend in the direction of flow.

It is formed in the center of the channel, and the channel is usually relatively wide. The growth of the bar is caused by the accumulation of fine materials. It becomes a spire downstream. Whereas, point bars are a feature of most curved channels and are formed within them as a result of secondary flow patterns associated with curvature of the channels. These bars are extended in the direction of flow, with a sharp outer face. There are also diagonal bars in the middle of the channel connected to the banks and extending indirectly through the silt channels and mixed basins. riffles diagonal bars are often associated.

3.2. plan form (plan view)

Through the analysis of the morphological processes the reaches of the Euphrates River profile, it becomes clear that there are identical processes mentioned by (drat'ev et a1982). Which reflects its impact on the construction and development of the planform studied profile of the Euphrates River, as in the figure (Figure 9), as this figure includes a group of processes that form the planform, which are.

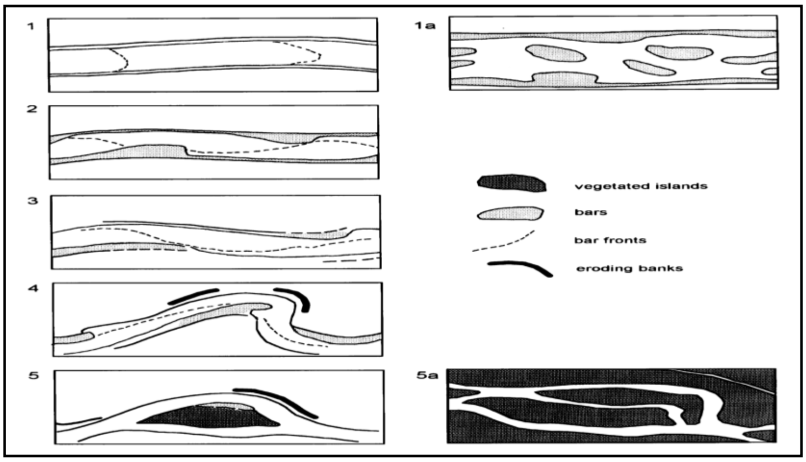


Figure 9. Classification of channel processes by Kondrat'ev *et al*. (1982)

1.Transverse bar process – downstream movement of transverse bars separated from each other by four to eight channel widths.

2.Alternate bar process – asymmetrical movement of alternate side bars.

3.Limited meandering – downstream shifting of undeveloped, loosely sinuous meanders along a narrow valley.

4.Free meandering – meanders rising through all stages from a slightly curved channel to omega forms without any limit of horizontal migration.

5.Incomplete meandering – neck cut-off occurs before a meander reaches the maximum curvature .

1a. Channel multibranching – corresponds to 'classic' braiding.

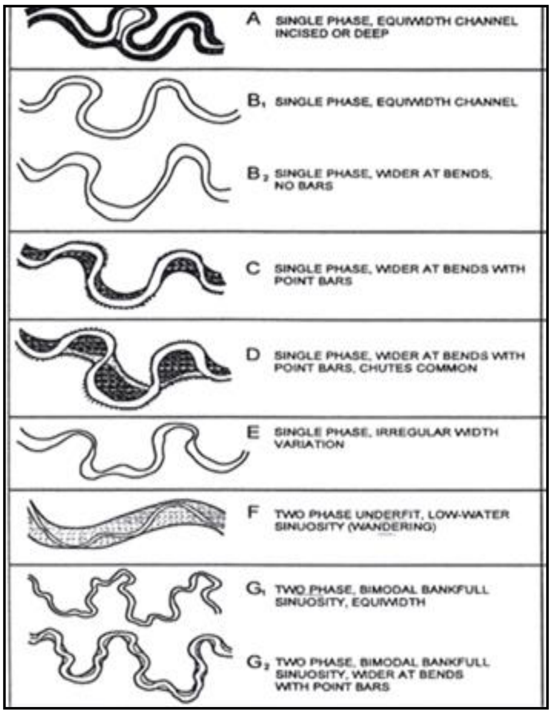
5a. Floodplain multibranching – corresponds to anastomosing or anabranching [25]

When looking at the view of Google Earth for the year 2022, it is noted that there is a difference in the dominance of these processes depending on the variation in the local conditions for each reach (width of the valley floor, slope, lithology). process 5 prevailed in reach 1 before the construction of dams in Al-Qaim . While processes 2, 3, and 4 are , commonly found in reach 2. In reach 3 before the embankment, process 3 may occur because steep ridges dominate the canal, but processes 1, 3, and 4 occur after the embankment. Processes 1, 2, 3, and 4 also predominate in reach 4.

The river plan form is categorized into straight, sinuosity and braided. One of the parameters often used in analyzing a river's plan form is the sinuosity, usually defined as the ratio of the length of the talweg or the length of the middle of the channel to the length along the valley. The definition can be used for one or more channels., In the case of multiple channels, the length of the middle of the channel can be taken for the widest channel in each extension of the channel belt [26]. If the results of the measurements are from 1.1-1.5, then the channel is straight and sinuosity) and more becomes meandering.

The degree sinuosity has been identified from the (Figure 10) [27]and the characteristics of meanders from the (Figure 11) [28]. When referring to (Table 1) and (Figure 12), it is noted that there are 18 measurement points, a pattern of sinuosity degrees has been recorded, of which, 5 are located between (1.06-1.25) and 7 are more than 1.26, and are not found below 1. There is also one braided pattern and 3 meanders. 2 straight.

As for the meanders, Brice took the criterion of the extent of lateral morphological activity in classifying the meanders into seven types. Thus, the bank line ratio that declines due to bend migration from species A to F, And when referring to the visuals Google Earth, and the type of meanders in the study area was identified. Type C and B 2 exist, as indicated in (Table 1).



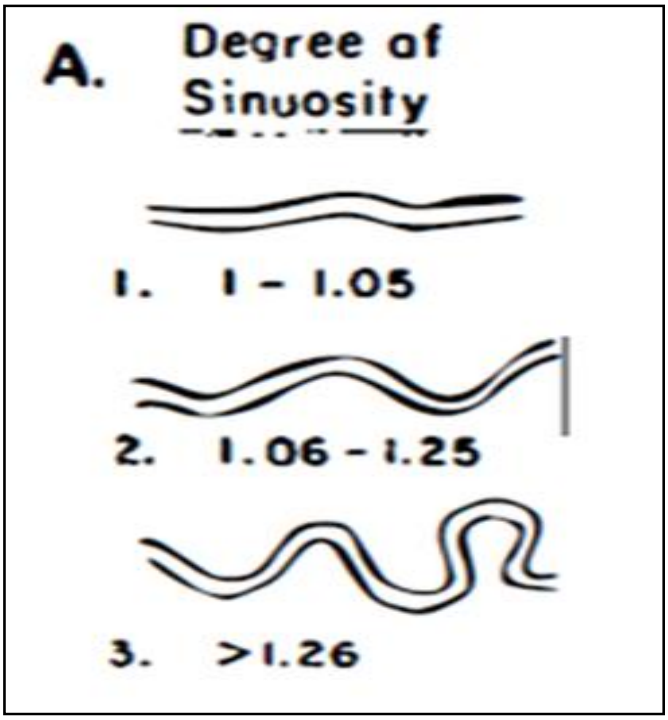


Figure 10. Brice classification for meandering rivers Figure 11. Types Degree sinuosity. (From Brice *et al.*,1978)

Table 1. Basic data to identify the planform of the studied profile

Reach	Description	sinuosity indicator	straight length/ km	river distance /km	elevation /m	slope%	distance classes /km
1	braided	1.30	15.4	20	158.9	0.5	0-20
2	meandering	1.76	11.34	20	159.4	0.46	20.1 -40
	meandering	1.59	12.6	20	160.7	0.53	40.1 -60
	meandering	3.08	6.5	20	160.9	0.51	60.1 -80
	sinuous	1.40	14.3	20	159.4	0.45	80.1 -100
	sinuous	1.20	16.7	20	142.5	0.65	100.1 -120
	sinuous	1.18	16.9	20	142.5	0.55	120.1 -140
3	sinuous	1.32	15.1	20	115.3	0.42	140.1 -160
	straight	1.06	18.8	20	110	0.56	160.1 -180
	sinuous	1.36	14.7	20	115.3	0.28	180.1 -200
	straight	1.09	11	12	112.9	0.47	200.1 -212
	sinuous	1.16	17.2	20	109.3	0.56	212.1 -232
4	sinuous	1.44	13.9	20	69.5	0.5	232.1 -252
	sinuous	1.42	14.1	20	71.9	0.5	252.1 -272
	sinuous	1.35	14.8	20	69.1	0.5	272.1 -292
	meandering	1.55	12.9	20	71.5	0.55	292.1 -312
	sinuous	1.42	14.1	20	70.2	0.6	312.1 -332
	sinuous	1.21	13.2	16	71.9	0.49	332.1-348
	sinuous	1.4	246.14	348	115.1	0.50	average / sum.

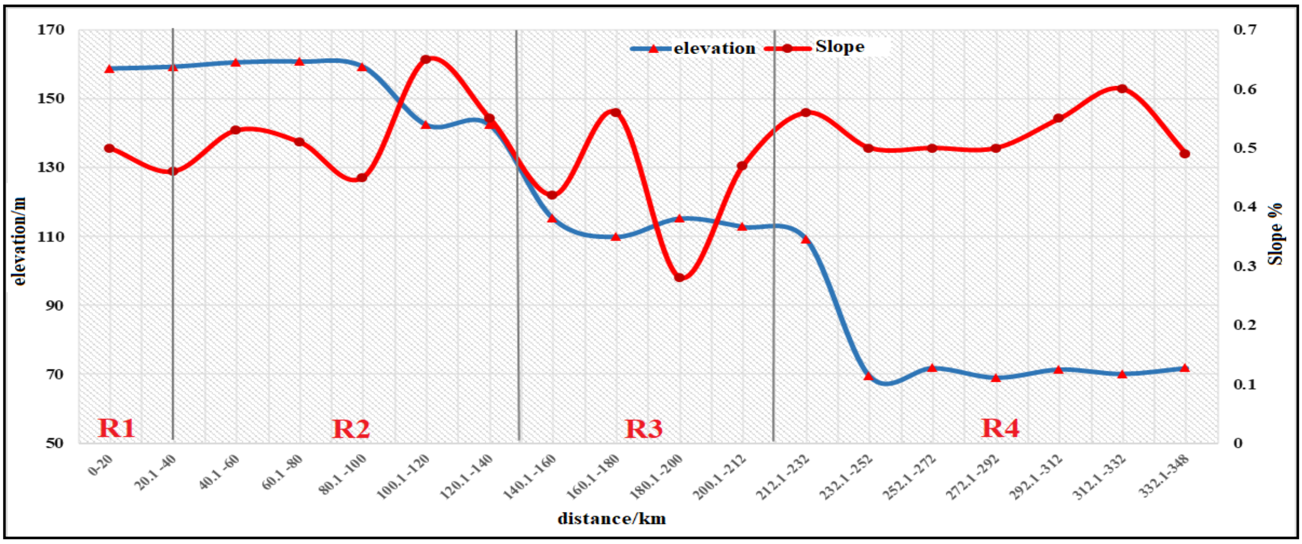


Figure 12. The relationship between elevation and slope(red line.slope and,red river)

In order to simplify the above analysis, the set of common channel patterns can be grouped into five basic patterns (Figure 13). This figure is more important because it is based on cause-and-effect relationships and shows the differences that can be expected when the type of sediment load, flow velocity, and stream power differ. It should also depend not only on channel pattern but also on variables that affect channel shape, especially if the classification provides information about channel stability.

Table 2 Classification of stable alluvial channels (after Schumm 1977)

Type of channel	Bed load (% of total load)	Type of River	
		Single channel	Multiple channel
Suspended load	<3	Suspended-load channel. Width-depth ratio <10; sinuosity >2.0; gradient relatively gentle.	Anastomosing system
Mixed load	3-11	Mixed-load channel. Width-depth ratio >10, <40; sinuosity <2.0, >1.3; gradient moderate. Can be braided.	Delta distributaries Alluvial plain distributaries
Bed load	>11	Bed-load channel. Width-depth ratio >40; sinuosity, <1.3; gradient relatively steep. Can be braided.	Alluvial fan distributaries

As shown in Figure 13, when the channel pattern changes from 1 to 5, other morphological aspects of the channel also change, That is, for a given discharge, the gradient ratio, width, and depth all increase. In addition, peak discharge, sediment volume, and sediment load are likely to increase from pattern 1 to pattern 5. With such geomorphological and hydrological changes, hydraulic variations can be expected, and flow velocity, traction force and stream power also increase from Pattern 1 to 5. Therefore, the stability of a gradient stream decreases from pattern 1 to Pattern 5, with Patterns 4 and 5 being the least stable. A brief discussion of the five basic styles is given below [29],

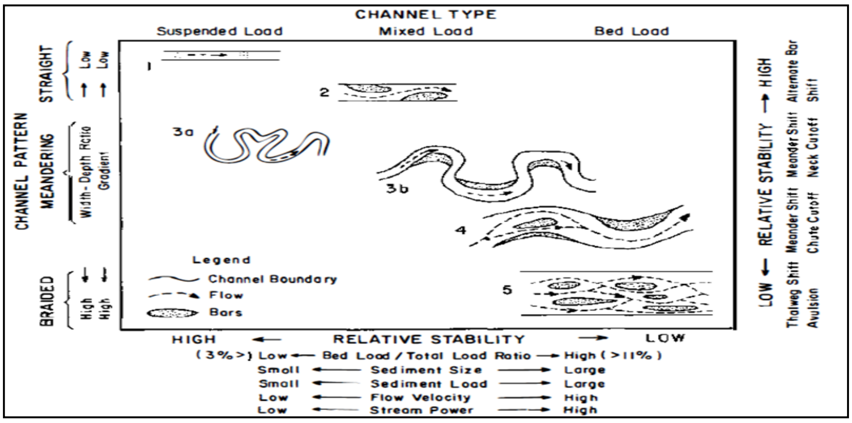


Figure 13. Channel classification based on pattern and type of sediment load, showing types of channels, their relative stability, and some associated variables. (After Schumm 1981)

PATTERN 1 , The channel of the suspended load is straight and sparsely spaced with a relatively uniform width. It carries very little sand and gravel load, has low gradients, and the channel is relatively narrow and deep (The channel width-to-depth ratio is low). The banks are relatively stable due to their high content of silty clay. It is found in some parts of reach 34 (i.e. before the dam).

PATTERN 2 ,The mixed-load straight channel has a sinuous thalweg (Figure 3). It is relatively stable and carries a small load of coarse sediment, which may move through the channel as alternate bars (Figure 4b). As these bars shift through the channel, banks are alternately exposed and protected by the alternate bars. Hence, at any one location the thalweg will shift with time. This means that the apparent deposition or fill at one side of the channel will be replaced by scour as an alternate bar migrates downstream Also, at any time, one side of the channel may be filling while the other is scouring. It is found in some parts of reaches 2 and 4

PATTERN 3 This pattern is represented by two channel patterns, which are only two of a continuum of meandering patterns (Figure 2B). Pattern 3a shows a suspended-load channel that is very sinuous. It carries a small amount of coarse sediment. The channel width is roughly equal and the banks are stable, but meanders will tend to cut off at their necks (Figure 4c).

Pattern 3b shows a less stable type of meandering stream. Mixed-load channels with high bed loads and banks containing low-cohesion sediment will be less stable than the suspended-load channels. The sediment load is large, and coarse sediment is a significant part of the total load. The channel is wider at bends, and point bars are large. Meander growth and shift (Figure 4e) and neck and chute cutoffs are also characteristic (Figure 4c). The channel, therefore, is relatively unstable, but the location of the cutoffs and the pattern of meander shift can be predicted. The shifting of the banks and thalweg follows a more or less regular pattern. Pattern 3b prevails in reach 2 and 4

PATTERN 4 This pattern represents a meander-braided transition (Figure 3). Sediment loads are large, and sand, gravel, and cobbles are a significant fraction of the sediment load. The channel width is variable but is relatively large compared with the depth (high width-depth ratio), and the gradient is steep. Chute cutoffs, thalweg and meander shift, and bank erosion are all typical of this pattern (Figures 4d,e). In addition to these problems, which are also characteristic of pattern 3, the development of bars and islands may modify flow alignments and change the location of bank erosion. It is found in reach 1 and the beginning of reach 2 only.

PATTERN 5 This bed-load channel is a typical bar-braided stream (Figure 3). The bars and thalweg shift within the unstable channel, and the sediment load and size are large. Braided streams are frequently located on alluvial plains and alluvial fans. Their steep gradients reflect a large bed load. Bank sediments are easily eroded, gravel bars and islands form and migrate through the channel, and avulsion (Figure 4f) may be common.

The other type of braided stream is the island-braided stream. This is a much more stable channel, and it would appear to the left of pattern 5 on (Figure 13). Island formation, erosion, and shift occur in these channels, but at a much slower rate than in a bar-braided channel. here is no pattern 5 in the study area.

3.3. Geomorphological evaluation of the studied river profile

This evaluation begins to reveal the natural qualifications and the determinants that need restoration and restoration of the studied section. In this regard, the ground units will be revealed and their functions highlighted, which reflect their significant impact on the distribution of human settlements and land uses. This profile consists of the following landforms units (Table 3) and (Figure 14),

3.1. Highland Unit

This unit is located at the top of the valley’s edges overlooking the river. It consists of types of sedimentary rocks (calcareous, gypsum, marl, sandy and clay) belonging to the geological formations mentioned earlier, . Morphoclimatic processes (weathering and movement of materials of all kinds) were affected, and resulted in rock fragments and solutions transported to the river by morphodynamic processes (river load and wind sediments). The valleys also bring sediments and remnants of organic matter through their torrential floods that flow into the river. It also includes colluvium sediments and residual soils.

This unit is repellent to the population because it is characterized by drought and severe temperatures in the summer seasons. However, it is suitable as pasture, especially in the wet seasons of the year (Figure14) and (Table 3).

Table 3. land forms units for the study area

Sum.km²	R4	R3	R2	R1	landforms units
474.5	161.5	18.7	214.8	79.5	The floodplain
191.5	43.0	0.0	81.9	66.6	River terraces
266.8	37.8	172.5	50.0	6.5	River
7404.8	2494.6	2239.2	2438.1	232.9	Highland Unit
8337.6	2736.9	2430.4	2784.8	385.5	Sum.km²

3.2. The floodplain Unit

A floodplain or lower land is an area of land adjacent to a channel of a river extending from the banks to the base of the surrounding valley walls, which is subject to flooding during periods of high drainage. Soils usually consist of clay, silt, sand and gravel that are deposited during floods.

Because regular floods in a floodplain can deposit nutrients and water, floodplains often have high soil fertility, intensive agricultural development, and urban areas concentrated near or over the floodplains to take advantage of the rich soil and fresh water. However, the threat of floods led to increased efforts to control it.

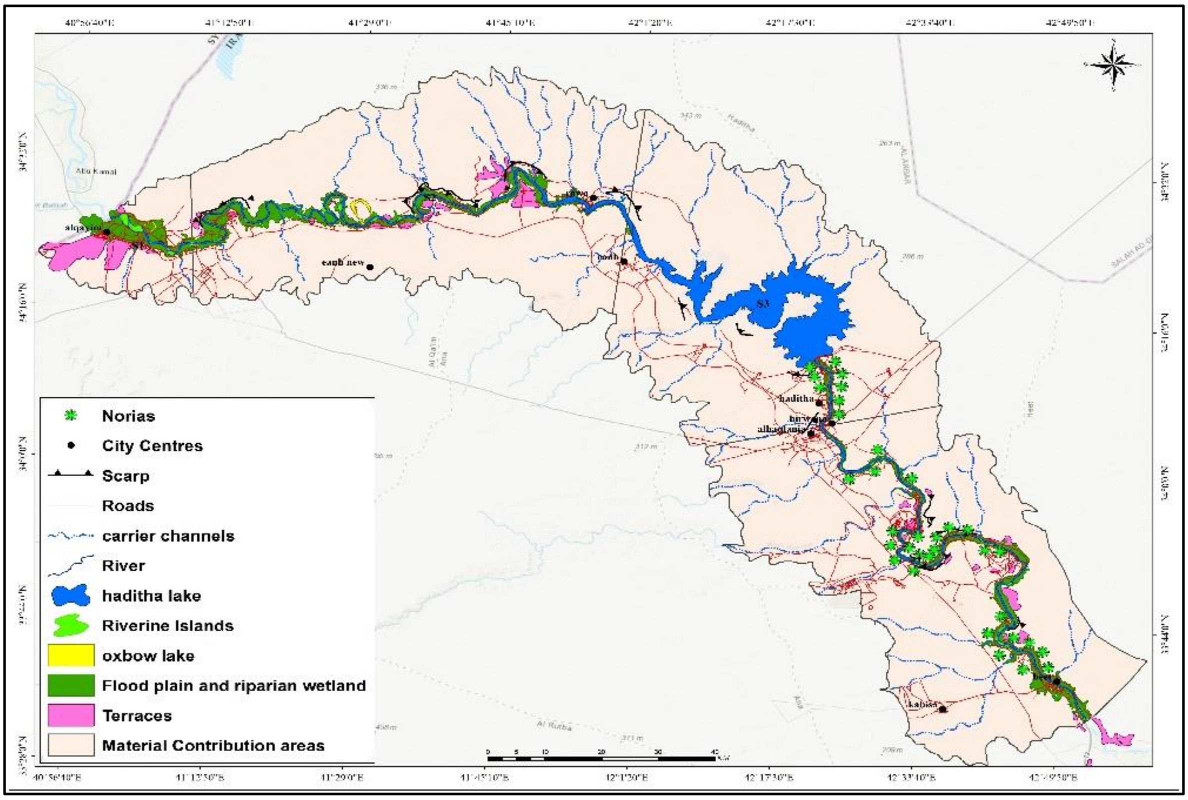


Figure 14. of the components of the landscape of the Euphrates River profile

Most floodplains are formed by deposition within bends of rivers and flowing over banks. As the river meanders, the flowing water erodes the riverbank on the outside of the meander, while sediment is simultaneously deposited in a point bar inside the meander. This is described as lateral accretion, as deposition builds up the point bar laterally in the river channel.

Floodplains support diverse and productive ecosystems. They are characterized by great diversity in space and time, which in turn results in some of the most species-rich ecosystems around. From an ecological perspective, the most characteristic aspect of a floodplain is the flood pulse associated with annual floods, thus a floodplain ecosystem is defined as a part of a river valley that is regularly flooded and drained. Flooding material brings nutrient-rich crumbs and releases nutrients from dry soil as it submerges. Decaying terrestrial plants submerged in flood waters increases the supply of nutrients. The area near the flooded banks of the river provides an ideal environment for many aquatic species[30].

The floodplains include the Riparian Wetlands. They are generally low-sloping lands with flooded or moist soils that support wetland plant species. Soil inundation as a result of either stream and river water levels or as a result of rising groundwater levels, or both.It also includes the Meander Belt areas. It is the area within which the channel will shift or "bend" over time and represents the most active part of the active river region.

3.3. River terrace

A terrace is a roughly flat area that is limited by sloping surfaces on the upslope and downslope sides. River terraces are the remains of old valley floors that are left sitting on valley sides after river downcutting. River terraces slope downstream but not necessarily at the same grade as the active floodplain. Paired terraces form where the vertical downcutting by the river is faster than the lateral migration of the river channel (Figure 9.9a). Unpaired terraces form where the channel shifts laterally faster than it cuts down, so terraces are formed by being cut in turn on each side of the valley [31].The study [32], indicated that the climatic fluctuations that occurred in Iraq and the Arabian Peninsula during the Tertiary Period had a major role in the sedimentation processes that led to the formation of the highest terraces in the study area. Also during the Pleistocene ice Period, Iraq was exposed to “fluvial’ periods” of increased precipitation as the rivers discharge increased, which led to a change in the sedimentation system and erosion in the Euphrates and its tributaries. The end result of these climatic fluctuations is a specific staircase of the river terraces. Changes in the location of the main river flow of the Euphrates led to the occurrence of unpaired river terraces where the river erodes on the outside of the meander bends.

It is clear by looking at (Table 3 and Figure 14) that the floodplain and river terraces are among the best places for human settlement since ancient times until now. Due to its natural qualifications and suitability that are very important in ensuring a guaranteed income to live in, in addition to the extreme climatic factor prevailing in the study area. Among the means of adaptation of the population to these conditions is the spread of waterwheels, especially south of Haditha Dam Lake, in the riverine places where there are bars in the middle of the river and with slight slope river edges that facilitated the process of transporting water to arable lands for investment. However, this technology began to decline due to the increasing use of modern means of transporting water. The reasons mentioned above have led to the concentration of human settlements in the form of a linear pattern along the river, and some of them have developed into district centers such as the cities of Hit, Haditha, and Al-Qaim, because their locations were associated with floodplains and river terraces.

On the other hand, there are determinants that act as pressures (stressors) to modify the level of geomorphic change by emphasizing the balance between the flow and supply of sediments, including climate change, land uses, land cover change, and hydraulic controls. As these pressures lead to the destabilization of the watercourses, which forces them to get out of their natural balance and lead to short-term fluctuations or regular long-term modifications in the morphology of the stream. Since the rivers respond to the pressures and advance to a new state of equilibrium, the stream undergoes a natural change through degradation processes , widening , aggradation, and modification of planimetric dimensions.

4. Conclusion

The topography of the study area is characterized as a plateau crossed by the Euphrates River. It was affected by tectonic activity and this was reflected in the shape planform and geomorphic characteristics.

The length of the river distance for the studied profile is 348 km, and it was divided into four reaches.It appeared that the index of this distance is characterized by sinuosity, as it reached 1.4, now the meanders are present in the second and fourth reach, while braiding prevailed in the first reach. Human settlements are concentrated in the form of a linear pattern along the river, and some of them have developed into district centers such as the cities of Hit, Haditha, and Al-Qaim, because their locations were associated with floodplains and river terraces. It is clear by looking at (Table 3 and Figure 14) that the floodplain and river terraces are among the best places for human settlement since ancient times until now. Due to its natural qualifications and suitability, it is very important to ensure a guaranteed income for the population.

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Hydrochemical Study of Artesian wells in Babylon Governorate - Middle of Iraq

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Abstract.This study tended to evaluate the quality of groundwater of three artesian wells (free ground water) distributed randomly in the province of Babylon in order to knowledge a better using of this water, Three water samples were chosen from each well to achieve this purpose, Groundwater samples were analyzed in the laboratory of the department of applied geology in terms of the following variables: total dissolved substances (TDS), electrical conductivity (EC), positive cations and negative ions, and the heavy elements, The results showed that the water of the artesian wells 1, and 3 have extreme salinity, whit high Electrical Conductivity ranging from 3200 to 8800 µS/cm, In addition, they are characterized by exceeding the critical limits for the percentage of magnesium and show more extent of the sodium element through a high percentage of soluble sodium (SSP%)and they were characterized by exceeding the permissible values for chloride ions, And also, the analysis result of heavy elements shows wells 1 and 3 have slight copper contamination and high cadmium contamination, so that my causing damage in plant growth, While the analysis results of water of well 1 confirm to be valid for the irrigation of sensitive plants, Our recommendation is good management of water resources is essential for preserving the region's soil and surface water and reducing underground pollution,

1.Introduction

Hydrogeological studies are considered important work in areas suffering from climate change and dry, in which where groundwater is the main source of water for various purposes of life, especially for drinking and agriculture, Meanwhile, the overuse of groundwater leads to an increase in soil salinity and the deterioration of groundwater quality [1, 2], Therefore, many researchers have studied the hydrochemical properties of different types of water (surface and ground) in several regions of Iraq, Although many researchers have investigated both surface and underground water in different locations in Iraq, but still there is a lack of studies on underground water types in Hillah-Iraq due to increased water demand in this area for agricultural use, So, in this study, the hydrochemical properties of artesian wells have been investigated, as a kind of free groundwater resource, to show their suitability for the irrigation of plants and other uses, Since the studied area is an agricultural region and the population need irrigation water, it was necessary to show the suitability of well water in those areas and to know its physical and chemical properties for the purpose of agriculture and know the types of crops that can be grow with this type of water, The variation of the sedimentary structure along the southern section of the southern section of the Al-Masab Al-Aam Canal extending from Nasiriyah-Basra obtained relationship between sulfate concentration and mineral saturation coefficient tends to increase with the solubility of most minerals [3], The significant decrease in hydraulic indicators of permeability and specific capacity values is found in the groundwater the Dammam aquifer in the west of Iraq [4], In addition, through the observation of the measuring well (W/7) the ground water level of the flowing well in the study area has significantly decreased and declined [4], Groundwater quality was studded in selected areas in southern Babylon/Iraq Governorate, These wells have been found to have high percentages of sulfates, which are harmful when the water is used for multiple purposes, and high percentages of chlorides and other substances, indicating that the water is unsuitable for agricultural use [5], Map to identify groundwater areas at risk in the Upper Al-Sanaf swamp sub-basin in Maysan in southern Iraq was produced [6], The groundwater risk map depends on applying the equation that exemplifies the combination of the vulnerability map with the land use and cover map using Geographic Information Systems, It has been found that the risk map by areas goes from 117 to 218 (low, medium, high and very high) [6], The spatial distribution of precipitation in Iraq was studied, and Characteristics of each region have been found to stand out separately, including detailed aspects relating to groundwater recharge, groundwater flow quality, hydraulic characteristics of groundwater aquifers, problems facing the groundwater sector and the development of recommendations, in terms of optimal investment and development of groundwater resources in each region [7], The groundwater quality of wells near the Iraqi city of Hillah to assess its viability as water for agricultural irrigation was investigated, According to the water quality index, many wells have poor water quality, which severely restricts irrigation needs and necessitates relatively high permeability soils and salt-resistant plants [8], The groundwater quality for agricultural use focused on cation and anion concentrations and their distribution in the Zubair region of Basra city, southern Iraq was studied and evaluated, The groundwater has been discovered to have no Mg-harmful, great SAR and Na%, and acceptable pH values, but is inappropriate for TDS and EC due to excessive salinity, which is represented by Ca and Cl [9], Whatever, the main aim of this study is to evaluate the groundwater of some artesian wells distributed randomly in Babylon city to assess its validity for different purposes use,

The study area is situated within the sedimentary plain of the unstable Shelf region, It is occupied a middle part of the Mesopotamian foredeep basin that according to the tectonic division of Iraq, The floodplain sediments covered all ground surface of the study area [10], Babylon Governorate is located in the center of Iraq, about 100 km away from Baghdad, Its area is 5119 km^2, which constitutes 2% of the total area of Iraq, It is dominated by a desert climate, which is characterized by a low amount of rainfall, ranging from 50 to 200 mm annually, and a high temperature in summer that may reach 50 centigrade degrees, The Euphrates River andl Shatt al-Hillah are considered the main rivers for irrigation of the study area, so the governorate depends primarily on agricultural activity [11], Three artesian wells were selected randomly distributed on the Babylon Governorate to achieve this research as shown in Fig, 1,

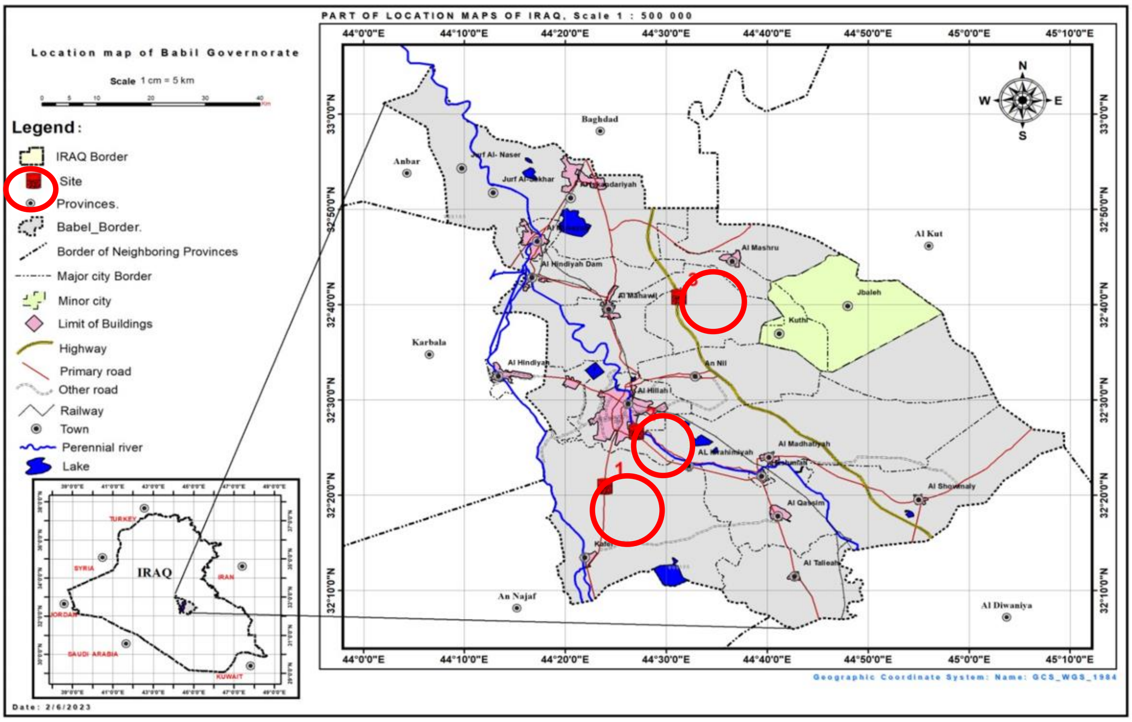


Figure 1, A geological map of the Babylon Governorate area

2. Materials and methods

Three groundwater samples were taken in November 2022 from three artesian wells distributed randomly to cover the study area, The borehole location coordinates were determined using a GPS device, The depths of drilled artesian wells are between 10 and 16 meters, as illustrated in Table-1,

Samples were collected in acid-washed 500 mL polyethylene bottles and were taken immediately to a laboratory for analysis, The sample was immediately taken to the laboratory for analysis, Samples were analyzed by Flame Atomic Absorption (Thermo Scientific iCE3000 series) at Babylon Agriculture Directorate / Water and Soil Laboratory, The methods used for pH, EC, soluble actions and anions depict in Table- 2,

Table 1. Locations and coordinates of the artesian wells and collected groundwater samples

Well No.	Total depth(m)	Sample No.	Artesian wells location	Coordinates of artesian wells	
				Latitude (N)	Longitude (E)
1	10	1	Shrine of the Prophet Ayoub, adjacent to the Hilla-Najaf road.	32°20'55.17"	44°23'56.22"
2	12	2	Shrine of the Prophet of Ayoub, in the Al-Ma'amirah area.	32°20'55.17"	44°23'56.22"
3	16	3	The Imam district of the Al-Mahaweel area.	32°40'46.60"	44°31'14.89"

T

pH , EC	pH-Ec meter model (multi350i)	in the field
Na^+, K^+	The flame photometry method	Babylon Agriculture Directorate / Water and Soil Laboratory
Ca^{+2}, Mg^{+2}	Titration with EDTA (EthyleneDiamineTetra Acid) ASTM, 1989	
Cl^-	Titration with AgNO3 (Abawi 1990)	
$CO3^=$, HCO^{-3}	Titration with HCl + methyl red indicator	
$PO4^{-3}$, NO^{-3}	UV-visble spectrophotometer (Abawi 1990)	
$SO4^=$	Gravimetric method with ignition of residue(Abawi 1990)	
Pb, Cu, Zn , Cd	Atomic-absorption spectrometer (APHA 3030A)	

:ion rate
s (1954)

'05):

$$SSP\% = (Na)\,x100/\,(Mg + Ca + Na + k) \ldots\ldots\ldots\ldots,\ (2)$$

meq/L all ion concentrations are expressed,

Residual sodium carbonate (RSC) is calculated using the following equation (Ragunath, 1987):

$$RSC = (HCO3 + CO3) - (Mg + Ca)\ldots\ldots\ldots\ldots,\ (3)$$

meq/L all ion concentrations are given,

(RSBC) Residual sodium bicarbonate was defined by Gupta and Gupta (1987) and calculated using the following equation,

$$RSBC = (HCO3 - Ca) \ldots\ldots\ldots,, \ldots\ldots\ldots\ldots\ldots \quad (4)$$

The ion concentration is expressed in meq/L,

Magnesium hazard (MH) in irrigation water was proposed by Szabolcs and Darab (1964) as follows:

$$MH = 100x\,[Mg/\,(Mg + Ca)]\ldots\ldots\ldots\ldots\ldots \quad (5)$$

meq/L All ion concentrations are expressed,

(KR) The Kelly Ratio is calculated using the following equation (Kelley *et al*, 1963):

$$KR = Na/Ca + Mg \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

meq/L All ion concentrations are expressed,

The Doneen (1964) and Ragunath (1987)-described Permeability Index (PI), which is determined using the following equation:

$$PI = [([Na^+]+[HCO^{-3}]1/2)]x100/\,(Mg^{2+}+Ca^{2+}+Na^+) \ldots\ldots (7)$$

The concentrations of all ions are expressed in meq/L, Water hardness can calculate from of Ca^{2+} and Mg^{2+} concentration, (Todd & Mays, 2004) using the following equation:

$$T,H = 4,111\ Ca + 2,798\ Mg \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots,,\ldots,(8)$$

The concentrations of all ions are expressed in ppm

3. Results and Discussion

3.1. Soluble Anion and Cation

The relative abundance of various geochemical processes in the subsurface hydrogeological system influences the availability of dissolved ions in groundwater systems, Processes involving the interaction of water and rock, such as mineral weathering and cation exchange, can be followed by cation concentrations and anion ratios [13], The most prominent cation is sodium (Na^+), whereas the least dominant is potassium (k^+), the high concentrations for (Na^+) in well 3 and low concentrations in well (2), While the concentration of potassium was the lowest concentration in of cations , as it was the lowest concentrations in well (2), which amounted to (0,34 meq/L), and the highest concentrations in well (1, 3), as displayed at Table 3 and Fig, 2 – C l8and D, The chloride ion concentration in groundwater in the study area is between (2-29) meq/L (Table 3 and Figure 2-E), Depending on the classification Hagen 1987 [28], the abundance of chlorides in a high percentage leads to the toxicity of sensitive crops, According to the results shown in Table 3, all wells have a high negative effect on sensitive crops, except for well 1, which has a small effect,

The primary source of carbonate and bicarbonate ions in groundwater is carbonate rocks (limestone and dolomite of a lower Fares Formation), The study area's groundwater had HCO_3 content of (3,2 to 4,8) meq/L, (Table 3 and Figure 2-G), The high levels of HCO3 have resulted from the breakdown of the carbonate rocks by CO2 in the soil region which is the main cause of increasing the HCO3 ion concentrations in groundwater,

Sulfate concentrations (SO_4^{-2}) range (2,5-7,8) meq/L, The concentrations Ca^{+2} precipitates with SO_4^{-2} to form gypsum, the concentration SO_4^{-2} concentration is still high compared with other ions and with locations worldwide, [27],

The results showed that there was a slight increase in the concentrations of magnesium in the water of the wells, which are considered low concentrations of this element in well 1(10,5) meq/L and in well 2 (13,5) meq /L , while in well 3 highly concentrated reached to (53,5)meq/L, (Table 3 and Figure 2-B), The salt water contains magnesium ions that lead to an improvement in soil structure and water movement [29],

Calcium found in groundwater is due to its various sources, the most important of which are carbonate rocks represented by limestone, dolomite, and sulfates such as gypsum, An increase in the concentration of calcium in the water leads to a change in the taste of the water and reduces its ability to dissolve soap and increases its hardness, The results showed that calcium concentrations ranged between (3,5-9,5) meq/L (Table 3 and Figure 2-A),

Table 3. Physical and chemical properties for water samples

Sample No.	pH	Ec µS/cm	TDS ppm	Cations (meq/L)				Anions (meq/L)				Minor anions (mg/l)	
				Ca	Mg	Na	K	Cl	SO_4	Co_3	HCo_3	No_3	P
1	8	7900	5451	3.5	10.5	23.9	1	16.5	5.96	0	4.8	9.8	0.26
2	8.2	3200	2208	6	13.5	17	0.34	2	2.5	0	3.2	8.4	0.26
3	7.6	8800	6072	9.5	53.5	26.2	1	29	7.8	0	4	11.9	0.3

Table 4, FAO-UN Guidelines for Irrigation Water Quality Parameters

Potential irrigation problem	Parameters	Degree of restriction on use		
		none	Slight to moderate	Severe
Salinity	Electrical conductivity ds/m	<0.7	0.7-3.0	>3.0
	Total dissolved solids	<450	450-2000	>2000
Infiltration based on SAR and EC	SAR			
	0-3 Electrical conductivity (ds/m)	>0.7	0.7-0.2	<0.2
	3-6	>1.2	1.2-0.3	<0.3
	6-12	>1.9	1.9-0.5	<0.5
Toxicity	Sodium (Na) meq/l	<3	3-9	>9
	Chloride (Cl) meq/l	<4	4-10	>10
Miscellaneous Effects	Bicarbonate(HCO_3) meq/l	<1.5	1.5-8.5	>8.5
	Potassium (K) meq/l		0-2	
	pH		6.5-8.4	

3.2. Total Dissolved Solids (TDS) and Electric Conductivity (EC)

Total Dissolved Solids (TDS) is a measure of overall content All inorganic and organic matter contained in molecular form in a liquid, Total Dissolved Solids is usually only discussed for freshwater systems, since salinity includes some of the ions that make up the TDS definition, The main application of TDS is to study the water quality of streams, rivers and lakes, and although TDS is not usually considered a major pollutant (for example, it is not considered to be associated with health effects), it is used as an indicator for the aesthetic properties of drinking water , and as a comprehensive indicator of the presence of multiple chemical pollutants, [16], TDS is calculated in milligrams per letter (mg/l) or parts per million (ppm), and TDS for irrigation water ranges from 0 – 2000 ppm (for irrigation classified, if TDS < 450 mg/l and is preferred for irrigation and TDS > (450–2000) mg/l is little to moderate and TDS > 2000 mg/l is unsuitable for agricultural using [15], [14], The TDS values shown in Table (3) range from a maximum value of 2208 ppm to a minimum value of 6072 ppm (Table 3 and Fig,3 – Z),

The conductivity meter (EC meter) measures the conductivity in solution in the range of (3200 to 8800) µS/cm as shown in (Table 3 and Figure 3 - Y), It is commonly used in hydroponics, aquaculture, and freshwater systems to monitor the levels of nutrients, salinity or pollutants in the water, It is closely related to TDS due to the effect of ion solute concentration, EC is calculated in µS/cm, [14], Tables 5, 6, and 7 show the EC water quality classifications for USRS, RC, and TC, respectively, According to the USRS classification the water is very saline water and according to the Russian classification it belongs to group (C) which means that the water is acceptable as long as it has been washed and the soil drained, While the well water under study belongs to group D (very intense water) when classified according to the Taylor classification,

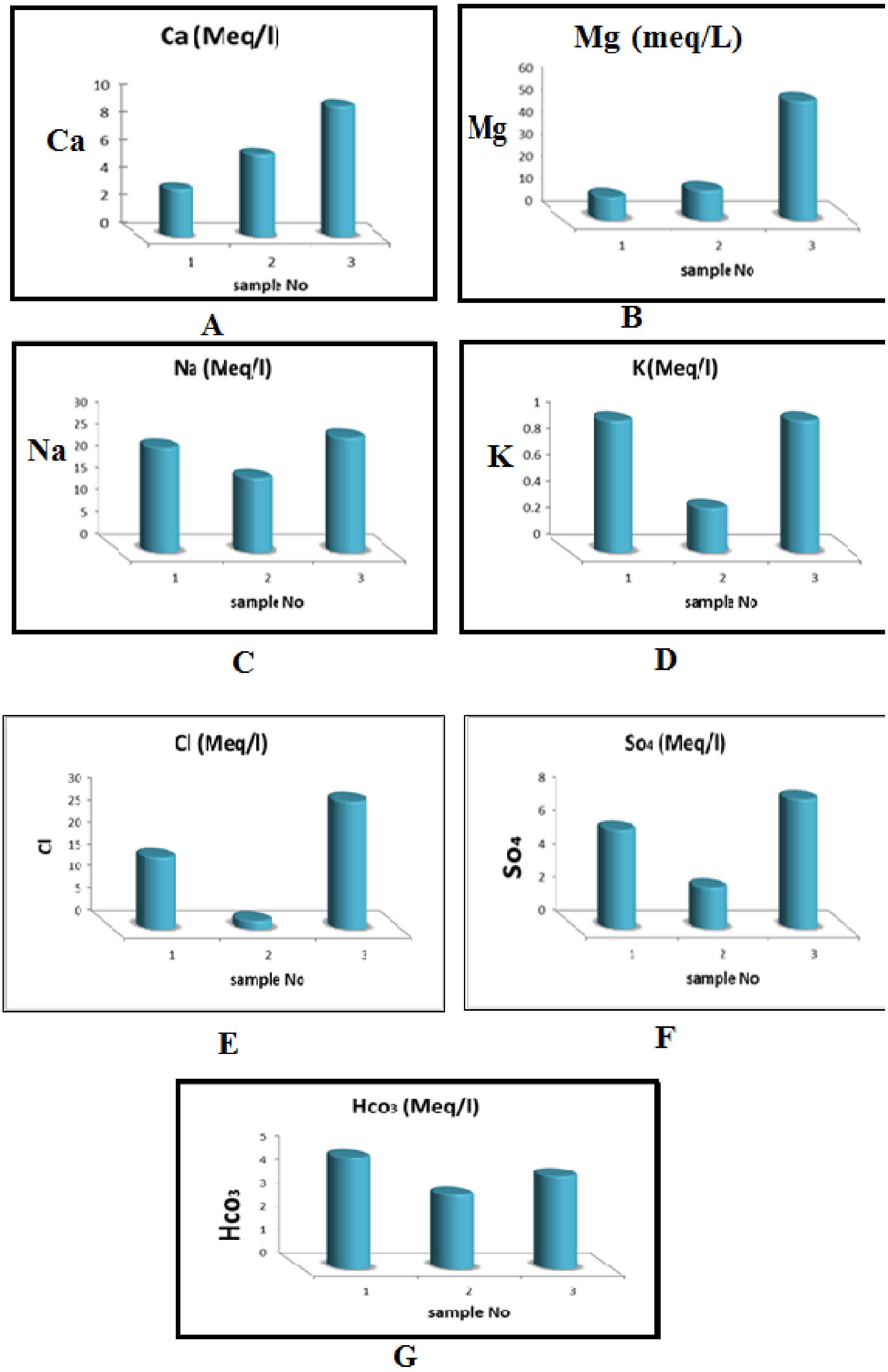
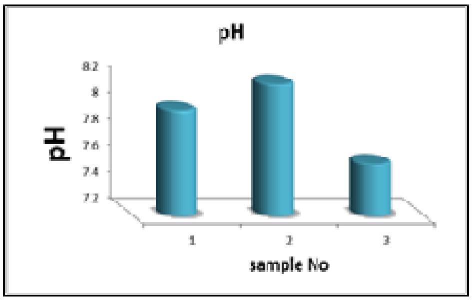
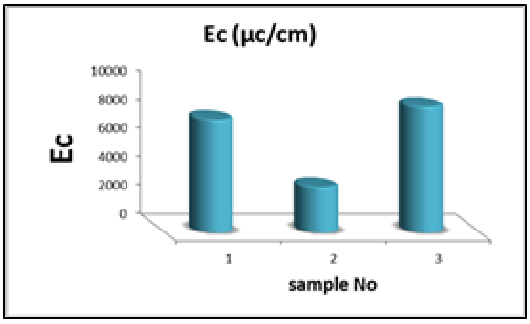


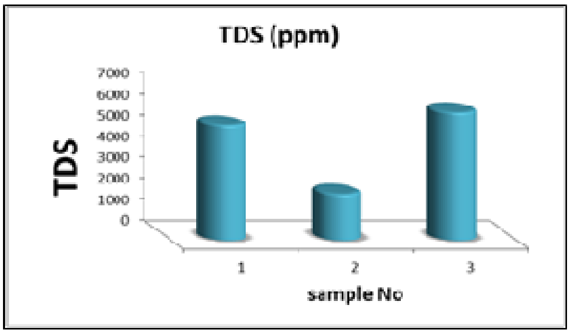
Figure 2, Histogram of the chemical components of the water sample; (A) Ca, (B) Mg, (C) Na, (D) Cl, (F) SO4 and (G) HCO3



X



Y



Z

Figure 3, The histograms of the physical properties of the water samples (X) pH, (Y) Ec, (Z) TDS

Table 5. The American Classification USRS of water salinity

No.	EC value µm/cm	Classification
1	$100 < EC \leq 250$	Very low salinity water
2	$250 < EC \leq 750$	Medium salinity water
3	$750 < EC \leq 2250$	High salinity water
4	$2250 < EC$	Very High salinity water

Table 6. The water salinity classification according to the Russian Classification

No.	EC value µm/cm	Group	Classification
1	$200 < EC \leq 100$	A	Good water quality
2	$1000 < EC \leq 200$	B	Acceptable water and has little effect on sensitive plant
3	$2000 < EC \leq 7000$	C	Acceptable water provided that there is washing and drainage soil

3.3. Hydrogen ion concentration (pH)

In general, the pH of the water is not a problem in and of itself; however, it is a sign of other issues like sodium and carbonate, The acidity or basicity of water is indicated by its pH, The growth of plants, the performance of irrigation equipment, and the efficacy of pesticides can all be affected by the acidity (or alkalinity) of water supply, Bicarbonates (typically at a pH of 8 or higher) and carbonates (typically at a pH of 9 or higher) may be present in high concentrations in alkaline water, As a result, it affects plant growth by causing the soil to release calcium and magnesium, Some trace elements, like copper and zinc, will be also less available to plants in this situation, The pH of irrigation water should typically be between 6,5 and 8,5 [16], The pH values of all groundwater samples in the study area were within the acceptable range for irrigation of 7,6 to 8,2 (Table 3 and Fig, 3-X),

3.4. Sodium adsorption ratio (SAR)

According to the American Salinity Laboratory [30], the sodium adsorption ratio (SAR) represents the relative activity of the exchange reaction between sodium ions and soil, It is a good indicator to measure the suitability of water for irrigation issues, Water is classified into four main categories based on SAR, In this study, SAR values ranged from 4,66 to 9,05 meq/L (Table 8), and all groundwater samples collected were of low class according to the American Salinity Laboratory [30], which can be us to irrigate all types of soils,

Table 7 . The Taylor Classifications of water salinity

No.	EC value at 25 0C µm/cm	Group	Classification
1	**EC ≤ 750**	**A**	**Low**
2	**750 < EC ≤ 1500**	**B**	**Medium**
3	**1500 < EC ≤ 3000**	**C**	**Intense**
4	**3000 < EC**	**D**	**Very Intense**

Table 8. Some of the parameters that were used to evaluate the quality of irrigation water in groundwater samples from the area under study

Well No.	Sample No.	T.H PPM	SAR (Meq/L)	MH %	SSP %	RSC (Meq/L)	RSBC (Meq/L)	KR	PI %
1	1	623.53	9.05	75	61.43	-9.2	1.3	1.70	68.83
2	2	946.59	5.44	69.2	46.14	-16.3	-2.8	0.87	51.45
3	3	1973.03	4.66	85.4	29.04	59-	-5.5	0.41	31.61

Table 9. The water classification according to the SAR American Classification

No.	SAR value	Water Classification	Specifications
1	0 < SAR ≤ 10	Low sodium water	It can be used to irrigate the majority of the soil, but there are some dangerous sodium levels.
2	10 < SAR ≤ 18	Medium sodium water	It can be used in rough soil with high permeability and poses a sodium risk in soft soils with few washing conditions.
3	18 < SAR ≤ 26	High sodium water	may pose a sodium risk, necessitating specialized soil management
4	26 < SAR	Very High sodium water	Typically, it is not suitable for irrigation.

4.5. The soluble sodium percentage (SSP%)

Table 10 illustrates the groundwater suitability for irrigation based on the sodium percentage and specific conductance [18], When the SSP% is more than 60% water, it creates sodium accumulation, which will result in a collapse of the soil's physical properties [17, 18], The sodium percentage In the studied wells between 29,04% and 61,43% (Table 8) , where the water of the first well is considered doubtful, while the water of the second well was Permissible, and the water of third well classification as a good water,

Table 10. According to Wilcox (1955), the soluble sodium percentage (SSP%) classification of the groundwater samples in the study area.

No.	SSP of water (%)	Water type
1	0-20	Excellent
2	20-40	Good
3	40-60	Permissible
4	60-80	Doubtful
5	>80	Unsafe

4.6. The residual sodium carbonates (RSC)

The bicarbonate content in the water refers to the residual of sodium carbonate (RSC) value in the water, When there is a lot of bicarbonate in the water, the pH of the water goes up, The precipitation of calcium and magnesium as a result of an increase in the water's RSC value can also raise the content sodium in the soil that is irrigated with this water, In addition, Plant toxicity and mineral nutrition are impacted by irrigation waters of a high bicarbonate ion concentration [19], The chemical analysis displayed that all groundwater samples examined in the study area fall into the RSC's good class based on this classification, The RSC was less than 1,25 meq/L as in Tables 8 and 11, ranging from -9,2 to -59 meq/L,

Table 11. The groundwater samples in the study area were categorized by Eaton using residual sodium carbonate (RSC).

No.	RSC (meq/L)	Class
1	< 1.25	Good
2	1.25 - 2.5	Doubtful
2	> 2.5	Unsuitable

4.7. The residual sodium bicarbonates (RSBC)

The residual sodium bicarbonates (RSBC) are defined as the total concentration of Inion HCO_3^{-1}, and Cation Ca^{+2} (all ions are expressed as equivalents per liter), Waters with RSBC of less than 5 meq/L are suitable for agricultural use, Groundwater samples in the study area had RSBC ranging from -5,5 to -1,3 meq/L, which were within the acceptable range as in Table-8 [20],

4.8. The magnesium hazard (MH)

A magnesium hazard (MH) parameter is more effective in evaluating irrigation water [21], Groundwater with a magnesium ratio greater than 50 is considered harmful and unfit for irrigation, as in Table-12 [21], so the soils become more alkaline and crop yields would suffer, The study area's magnesium ratio values range from 69 to 85,4 as in Table-8,

Table 12, Categorize of the magnesium hazard for groundwater samples [21]

No,	Water type	Magnesium hazard (%)
1	Suitable for Irrigation	< 50
2	Unsuitable for Irrigation	> 50

4.9. The Kelly's Ratio (KR)

Kelley's ratio could easily be used to figure out the sodium issue in irrigation water, Groundwater with Kelley's ratio greater than one is generally considered unfit for irrigation [22], The groundwater samples in the study area have Kelley's ratios ranging from 0,41 to 1,7, as displayed in Table-8, Wells 2 and 3 have values that are less than one, indicating that they are suitable for irrigation, Whereas, the well 1 has ratio greater than one, which makes them inappropriate for irrigation, as in Table-13,

Table 13. Kelley's Index (KR) classification 1963

No.	**Kelley's Index (KR)**	**Water type**
1	**< 1**	Suitable
2	**>1**	Unsuitable

4.10. The permeability index (PI)

Long-term irrigation water use has an impact on the soil's permeability due to the soil's Na^{+}, Ca^{+2}, Mg^{+2}, and HCO^{-3} content [23], The permeability index (PI) based on the required ion concentrations in meq/L to determine whether water is suitable for irrigation [25], Table 8 shows that the groundwater samples in the study area have PI values ranging from 31,61 percent to 68,83 percent, According to standard index [26], all of the studied water wells with a PI value between 25% and 75% representing class 2 are suitable for irrigation, as shown in Table-14,

Table 14. The permeability index (PI) was used to group the groundwater samples in the area under study [26].

No.	**Permeability Index (PI %)**	**Water type**
1	< 25	Unsuitable
2	25-75	Good
3	>75	Excellent

The total hardness of groundwater is calculated on the basis of the presence of binary ions of the mineral components, especially calcium, and magnesium, which are abundant in this water, Classification of TH included soft 0–60 mg/L, moderately hard 60–120 mg/L, hard 120–180 mg/L, and very hard > 180 mg/L [27], Analysis results show all examined samples in the study area are very hard in total hardness,

4.12. Graphical interpretation of USSL diagram

The water classification diagram for purposes of irrigation [28] was used to classify the groundwater of the study area, as manifested in Fig 4, All samples of water were of high levels of salinity and electrical conductivity, located in the regions C4-S2, and C4-S3 respectively, as shown in Fig 4,

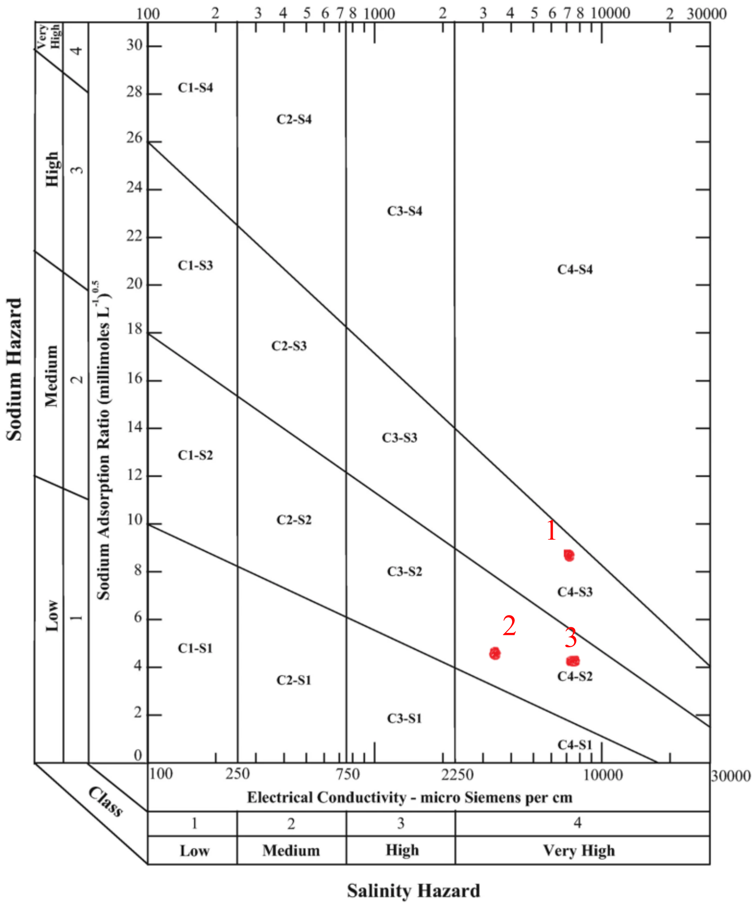


Figure-4. Diagram of classification of groundwater for irrigation use based on salinity and SAR [28]. The red circle posted on the diagram represents well water samples

4.13. Heavy Metals

The heavy elements that can be present in groundwater are Cadmium (Cd), Copper (Cu), Lead (Pb), and Zinc (Zn), These metals Due to their toxic effects even at low concentrations are a major concern, The chemical analysis results of some heavy ion concentrations (mg/L) in groundwater samples in the study area were displayed in Table-15, Copper concentrations in drinking water must not exceed 1,5 mg/L [29], Whereas, the concentration of Cu in wells 1 and 2 appeared below the permissible limit of 0,2 mg/L, so it could be used for irrigation [15], Meanwhile, well, No, 3 had a concentration of more than 0,20 mg/L as in Table 15, The results show that there was no contamination in zinc or lead, but there was high pollution in cadmium in all wells, with samples ranging from 0,11 to 0,97 mg/l as shown in Table 15, There are a number of reasons for this, including the leaching of cadmium from chemical fertilizers and corrosion in the inner lining of the pipes [30],

Table 15. Analysis results of groundwater samples in the study area for heavy metals, and comparison with irrigation water based on [15] [24].

Well No.	Sample No.	Cu (mg/l)	Pb (mg/l)	Zn (mg/l)	Cd (mg/l)
1	1	0.239	*N.D	0.034	0.118
2	2	0.261	N.D	0.036	0.779
3	3	0.330	N.D	0.036	0.971
FAO. 1985*		0.2	5	2	0.01

* N.D = not detected
* using for irrigation according to (FAO. 1985)

4. Conclusion

All artesian wells water studied can be considered unsuitable for irrigating sensitive crops due to its extreme salinity those have EC ranging from 3200 to 8800 µS/cm, in addition; the well's water was characterized by exceeding the critical limits for the percentage of magnesium, which means causing damage to plant growth, Depending on the SSP% parameter, which shows the extent of the sodium element's effect on plants, it was found that the water of wells 1, 2 is not suitable, while the water of well 3 is suitable for irrigation, The water of wells 1, 3 was characterized by exceeding the permissible values for chloride ions, which means that there is caused damage to plant growth, Bicarbonate did not appear to have a clear effect in the water samples examined for all wells, There is slight copper contamination and high cadmium contamination, Our recommendation is good management of water resources is essential for preserving the region's soil and surface water and reducing underground pollution,

We present a grateful thanks to the Department of Applied Geology at the University of Babylon for its continuous support and permitting for us to use the advanced chemical and soil laboratories, We would like to thank the Directors of Agriculture in Babylon for helping with fieldwork and providing scientific reports for the study area,

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Hydrogeochemical Evaluation of Surface and Groundwater in Haditha Area, Al-Anbar Governorate, Western Iraq

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Abstract. This research deals with the study of the hydrochemical characteristics of surface water and groundwater to assess the quality of water and its suitability for different uses in the Haditha region. Thirty –Two samples were collected in July 2022,6 samples were taken from the Euphrates River and 17 samples from wells were analyzed. In this study, main cations (Ca2+, Mg2+, Na+, and K+) and anions (Cl-, SO4, HCO3),Total dissolved Solids(TDS), pH, Electrical conductivity(EC), and Temperature(T) were studied. The results show that the water types are mainly earth-alkaline water with an increased portion of alkalis with prevailing SO4 and Cl according to Piper and Stiff diagram. The results of the water quality index (WQI) show that surface water are suitable for drinking while the groundwater is not suitable except for W1, W13, W15, W16 and W17. The classification of water for irrigation purposes according to the Sodium Adsorption Ratio and Residual sodium carbonate showed that the ground and surface water in this region is excellent and good quality according to Permeability Index. Irrigation water quality based on sodium ion percentage indicates that all samples belong to the permissible category for groundwater except for W1, W11, and W16, while Surface water is good quality for irrigation. Finally, the absence of management and low discharge, are the primary reasons for the continuous deterioration of water quality.

1.Introduction

Water is one of the most important resources that cannot be dispensed with it at all and life on this planet is impossible without water [1]. Recently, climate changes affected Iraq's rivers which suffered from a severe water shortage, as evidenced by the lack of rain and high temperatures. The study of the Euphrates River's waters and the wells in the Haditha area is necessary as it is a basic water source for various uses such as human consumption and agricultural use. The quality of Water quality and its suitability for drinking were examined by determining its quality index.

The World Health Organization [2] standard for drinking purposes had been considered for the calculation of WQI. There are many researchers studied this area. Al-Paruany [3] conducted a study on the hydrochemical conditions of the region, describing the isotopes and hydrochemical of surface water, groundwater, and springs. Al-Sudani [4] conducted a study on the groundwater quality and Hydrogeochemistry in the Northeast part of Anbar Governorate in which he confirmed that the groundwater in the studied area is not suitable for human drinking. Al-Sumaidai and Al-Kubaisi [5] conducted a study on the groundwater levels and Hydrochemical characteristics, the extent of the geologic water-bearing layers, and the groundwater's suitability for multiple purposes. This research aims to study the Hydrogeochemical characteristics of the ground and surface water to specify the water type, evaluate its quality for the study area and indicate its suitability for different purposes by comparing it with the Iraqi and global specifications.

2. Materials and Methods

2.1 Location and Geological setting

Haditha city is situated on the Euphrates River in the western part of Al-Anbar, about 240 km North-West of Baghdad (Fig. 1). The geographic coordinates of the study area are between the longitudes 42° 14′ 30″- 42° 31′ 00″ E and the latitudes 33° 59′ 00″ - 34° 15′ 30″ N with an area of 766 Km2. The Euphrates river divided the study area into two parts, the eastern bank of the Euphrates river represented by sub-districts of Barwana, and the western bank represented by Sub-districts of Haditha. The metrological data were recorded at Haditha station during 1990-2020 [6]. The total yearly rainfall was 121.5 mm, and evaporation of 2855 mm, with a monthly average temperature of 21.8 °C, relative humidity was 46.7 %, and wind speed of 2.8 m/s. The climate in the research region is classified as arid. The stratigraphic sequence which characterized the study area is represented by geological formations explained from oldest to the youngest are Anah Formation (upper Oligocene), Euphrates Formation (Lower Miocene), Fatha Formation (Middle Miocene), and Quaternary deposits [7] (Fig.2).The Euphrates Formation represents the upper groundwater aquifer in the regions, which represents the discharge regions of groundwater [8].

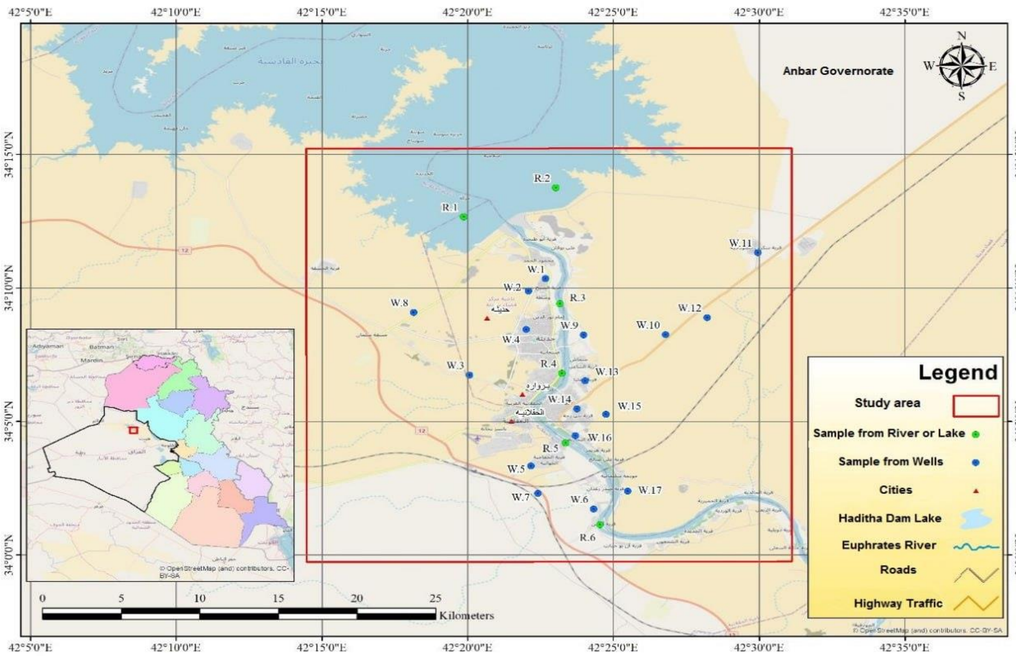

Figure 1. location map of the study area

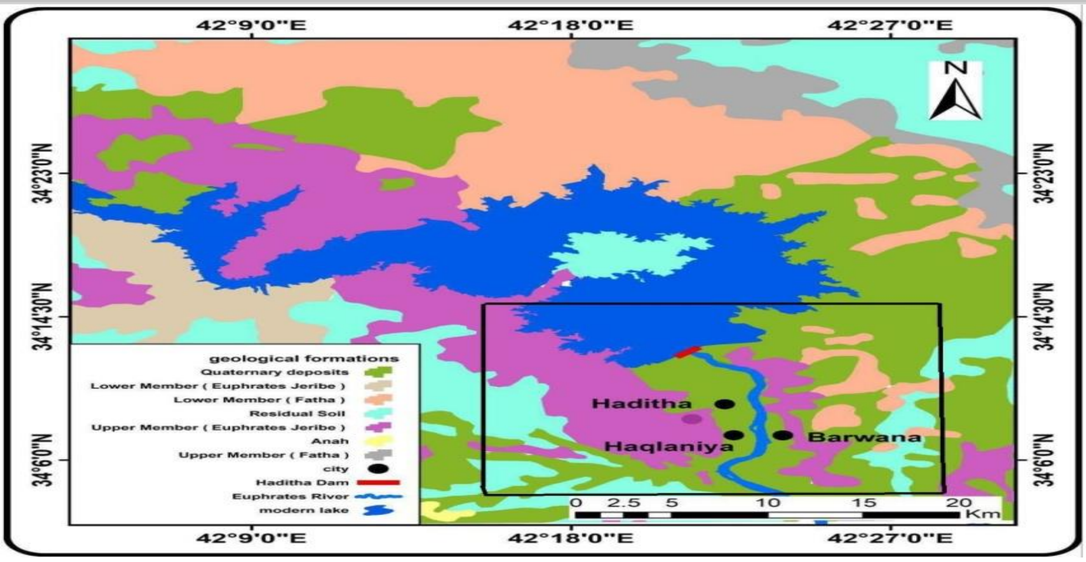

Figure 2. Geological map of the study area [9]

2.2 Sampling

Sampling was carried out in July 2022. Twenty-three samples from surface water (Haditha Dam Lake and Euphrates River) and groundwater (wells) were selected for hydrochemical analysis, plastic bottles of one-liter capacity were used, in which samples are kept after rinsing them well with the same sample water. Samples of wells ranging in depth between 15-80 m were taken after operating the well for a sufficient period of time, as well as surface water samples at a depth of 30 cm, in order to obtain typical samples. The physical parameters such as T, TDS, pH, and EC are measured immediately after taking the sample in the field and all samples were preserved in a refrigerator until the time of analysis. The name of the stations and their locations are listed in Table 1.

Table 1, Station Name, coordination of Studied stations.

Stations Name	Latitude	Longitude
R.1	E 42 19’ 51.96”	N 34 12’ 39.53”
R.2	E 42 23’ 01.42”	N 34 13’ 45.26”
R.3	E 42 23’ 10.01”	N 34 13’ 45.26”
R.4	E 42 23’ 14.21”	N 34 06’ 48.16”
R.5	E 42 23’ 22.02”	N 34 04’ 11.65”
R.6	E 42 24’ 32.45”	N 34 01’ 07.71”
W.1	E 42 22’ 39.99”	N 34 10’ 20.66”
W.2	E 42 22’ 05.09”	N 34 09’ 53.28”
W.3	E 42 20’ 04.02”	N 34 06’ 44”
W.4	E 42 22’ 00.71”	N 34 08’ 26.75”
W.5	E 42 22’ 10.62”	N 34 03’ 20”
W.6	E 42 24’ 19.57”	N 34 01’ 42.92”
W.7	E 42 22’ 24.56”	N 34 02’ 17.8”
W.8	E 42 18’ 08.68”	N 34 09’ 05”
W.9	E 42 23’ 58.74”	N 34 08’ 14.17”
W.10	E 42 26’ 47.37”	N 34 08’ 15.05”
W.11	E 42 29’ 57.32”	N 34 11’ 19.22”
W.12	E 42 28’ 12.92”	N 34 08’ 53.43”
W.13	E 42 24’ 01.81”	N 34 06’ 31.02”
W.14	E 42 23’ 45.07”	N 34 05’ 28.14”
W.15	E 42 24’ 44.74”	N 34 05’ 16.16”
W.16	E 42 23’ 41.67”	N 34 04’ 27.83”
W.17	E 42 25’ 29.32”	N 34 02’ 23.28”

2.3. Laboratory work

The hydrochemical analysis of water samples such as major cations (Ca2+, Mg2+, Na+, K +) and anions (Cl- ,SO42-, HCO3-) in addition to NO3was done in the laboratory of General Commission for Ground water using a standard procedure of [10]. Techniques, equipment, and methods of measurement are shown in Table (2).In the current study, (the accuracy present) the results of U% of the hydrochemical analyses for all samples selected within the proposed limits (less than 5%), indicate that all the results are ready to be used to interpret chemical processes.

Table 2. Techniques and measuring instruments used in the measurement and analysis of samples

Measured parameter	Standard methods and equipment
pH	pH meter
Ec & TDS	Ec meter
Ca2+, and Mg2+	EDTA titrimetric method
Na+, K+	The flame photometric method by a flame photometer (AFp100)
HCO3-,	Titration method using indicator titrated with HCl
SO42-	Uv-Spectro-photometer
Cl-	Titrimetric method (silver nitrate method)

3.Results and Discussion

3.1 Hydrochemical Properties

The physical and chemical results of 23 water samples are shown in Tables (3), For surface water, the lowest value of pH (7.18) was recorded in the station (R5) and the highest was (7.29) in the station (R3). The lowest value of electrical conductivity (EC) 1063 µs/cm was recorded in the station (R2) and the highest was 1245 µs/cm in the station (R5). Total dissolved solids (TDS) ranged from 696 mg/l in the station (R1) to 816 mg/l in the station (R5), while in groundwater samples the lowest value of pH (7.12) was recorded in the station (W12) and the highest was (7.28) in the station (W6). The lowest value of electrical conductivity(EC) 2110 µs/cm was recorded in the station (W16) and the highest was 9370 µs/cm in the station (W12).

Total dissolved solids (TDS) ranged from 1370 mg/l in the station (W16) to 6080 mg/l in the station (W12).The results of cations concentrations of Ca2+, Mg2+, Na+, and K+ range between (66-84 mg/l),(47-61 mg/l),(102-140 mg/l),(2-3 mg/l) with mean values (70.8, 50.8,112, 2.1)mg/l respectively. While the concentrations of Cl, HCO3, SO4, and NO3 ranged between(210-253 mg/l),(199-296 mg/l),(35-45 mg/l),(0.6-1.2)mg/l with mean values of (244,221.5,38.8,1.05) mg/l respectively, while for groundwater, the cations concentrations of (Ca, Mg, Na, K) ranges between (113-579 mg/l),(63-249 mg/l),(153-979 mg/l),(4-33 mg/l) with mean values(294.3,146.5,493.7,18) mg/l and the anions concentrations of Cl, CO3, SO4, NO3) ranged between(214-1269 mg/l),(560-1860 mg/l),(82-763 mg/l),(0.1-1.4 mg/l) with mean values of (603.5,1108.7,371.9,1.005) mg/l respectively. From the results above there is a high variation between surface water and groundwater samples in the study area due to the differences in Climate effect, water level, lithology, and geochemical process.

Table 3. Physical parameters and chemical analysis for water samples

Samples	T (°C)	pH	EC (µS/cm)	TDS (mg/l)	Ca2+)mg/l(	Mg2+)mg/l(	Na+)mg/l(	K+)mg/l(	Cl –)mg/l(	SO42-)mg/l(	HCO3-)mg/l(	NO3-)mg/l(
R 1	29.6	7.19	1065	696	68	48	108	2	221	199	36	1.1
R 2	29.4	7.28	1063	697	66	47	102	2	210	201	35	1.2
R 3	27	7.29	1078	706	69	49	109	2	219	209	39	1.2
R 4	27.2	7.24	1086	711	68	50	103	2	215	211	39	1.1
R 5	27	7.18	1245	816	84	61	140	3	253	296	45	0.6
R 6	27	7.20	1087	714	70	50	110	2	226	213	39	1.1
W 1	25	7.23	2390	1556	179	63	233	4	297	586	155	1.2
W 2	25	7.25	5860	3790	339	184	565	27	659	1490	460	0.9
W 3	25.4	7.22	5820	3787	335	183	562	32	656	1481	457	0.8
W4	27	7.14	5550	3589	332	166	595	11	705	1237	502	1.2
W 5	25	7.16	7380	4790	441	161	894	23	956	1860	326	1.1
W 6	25.6	7.28	5660	3670	388	169	534	33	760	1400	335	0.4
W 7	25	7.25	4600	2975	145	125	575	29	515	920	576	1.3
W 8	28	7.18	6180	4010	326	221	602	27	743	1235	616	1.1
W 9	25.5	7.20	5350	3470	220	150	712	12	655	1231	441	0.7
W 10	26	7.16	6990	4526	418	249	665	33	792	1614	593	1.1
W 11	24.4	7.25	4880	3154	539	151	401	10	800	1157	342	1.2
W 12	25.4	7.12	9370	6080	579	221	979	25	1269	1742	763	1.3
W 13	25.4	7.25	2120	1380	167	96	157	5	290	570	109	1.4
W 14	26.1	7.23	2940	1906	151	102	266	12	376	591	210	0.8
W 15	28	7.21	2250	1460	113	75	250	6	214	560	194	1.4
W 16	24.6	7.16	2110	1370	146	106	153	12	269	580	82	0.1
W 17	24.3	7.24	2460	1599	186	70	250	5	304	594	162	1.1

3.2. Hydrochemical Facies

In this study when the Piper classification [11] and Stiff diagram [12] were used to study the hydrochemical facies, the results show that all surface and groundwater samples are clearly in the (e) hydrochemical facies. This means the type of all the water samples of the study region is " earth alkaline water with increased portions of alkalis with prevailing Sulphate and chloride" (Fig.3). While water samples in the Stiff diagram shown in (Fig.4) , it seems clear the ratio of (Cl) and (Na) concentrations in surface water are high, while groundwater samples clear that the ratio of (SO4) and (Na)are high in this region.

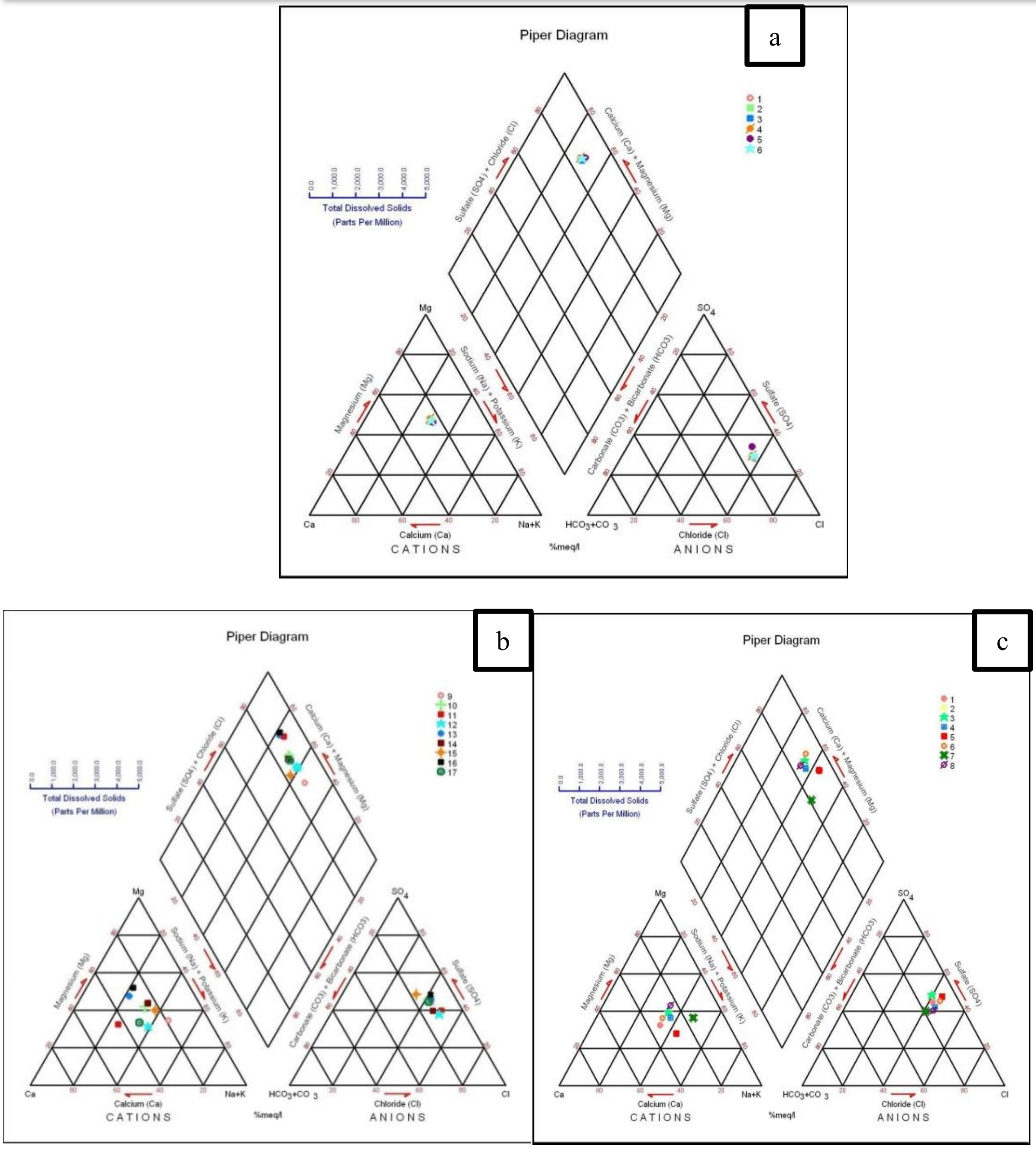

Figure 3. Type of water according piper [11].(a) for surface water . (b , c)for groundwater

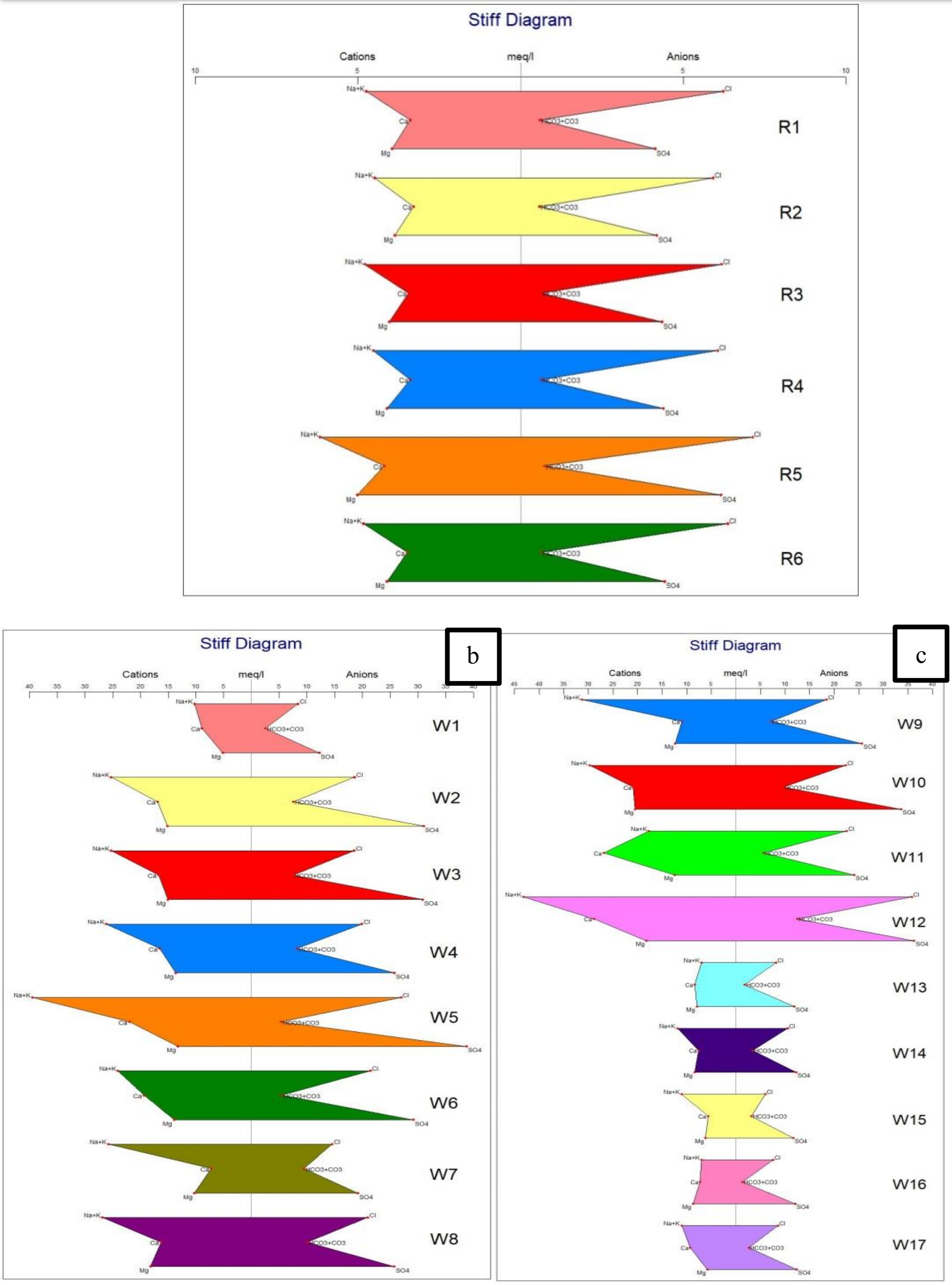

Figure 4. Type of water according to stiff classification. (a) for surface water . (b , c) for groundwater.

3.3 Water quality index procedure (WQI)

The WQI gives a general idea of water problems in any area, so it is considered a primary indicator of water quality [13]. It is an important method for demarcating the quality of water and its suitability for human consumption [14]. WQI values were calculated to determine the suitability of water quality for drinking purposes, which were defined by [15] as a mathematical tool that integrates complex water quality data into a single numeric score that indicates the overall water quality status. WQI is computing from the following equations,

$$Wi = k / Si = 1 / Si$$

$$Qi = (Vi / Si) * 100$$

$$QPH = (V\,pH - 7.0) / 1.5 \; * 100$$

$$WQI = \Sigma(Qi.Wi) / \Sigma Wi$$

Where as,

Wi = is the unit weight, K = is the constant of proportionality, Si = water quality standards, and Qi = water quality rating

Vi = averages of the data observed. QpH = is the quality rating for PH, and VpH = is the value of pH observed.

To simplify the method assumes that K=1, for PH, assuming the same unit weight as that for chlorides (0.004)and the unit weight Wi obtained from the above equation with K=1 as shown in the (table 5).

The weights of the different water quality parameters are supposed to be inversely proportional to the recommended standards for the corresponding treatments, meaning that Wi=K/Si, this is because that the more harmful the pollutant, the lower its permissible value for the recommended standard for drinking water.

To determine the suitability of water for human drinking purposes, World Health Organization [2] and Iraqi standards [16] are used relying on TDS, pH, EC, TH, and the ionic concentrations of water. On the basis of the WQI, the quality of the water is categorized into five types [17] (Table 4),

Table 4. Classification of water quality depending on WQI values [17]

WQI values	Water quality	Possible use
0-25	Excellent	Drinking, irrigation, and industrial
26-50	Good	Drinking, irrigation, and industrial
51-75	Poor	Irrigation and Industrial
76-100	Very poor	Irrigation
>100	Unsuitable	Proper treatment is required before use

The range of ions concentration in the study area is shown in (Table 5) and the calculated WQI data shown in (Table 6)confirmed that the surface water in these districts is suitable for drinking purposes, just as the groundwater is not suitable for drinking purposes except W1 – W13 –W15– W16-W17.

Table 5. The ranges of ion concentrations of the surface and groundwater in the study area and comparing them with the acceptable limits of the World Health Organization [2] and the standard Iraqi specifications [16] of drinking water.

Parameter	Rangesfor surface water	Rangesfor ground water	WHO, 2017	IQS 2009	Unit weight(wi)
pH	7.18 – 7.29	7.12 – 7.28	6.5-8.5	6.5-8.5	0.004
TH	358.2 – 460.8	590.8 - 2355.3	500	500	0.002
EC (µS/cm)	1063 – 1245	2110 – 9370	1000-2000	1500	0.0005
TDS (mg/l)	696 – 816	1370 – 6080	1000	1000	0.001
Ca^{2+}(mg/l)	66 – 84	113 – 579	75	200	0.013
Mg^{2+}(mg/l)	47 – 61	63 – 249	100	150	0.01
Na^{+}(mg/l)	102 – 140	153 – 979	200	200	0.005
K^{+}(mg/l)	2 – 3	4 – 33	12	3	0.083
Cl^{-}(mg/l)	210 – 253	214 – 1269	250	250	0.004
SO_4^{2-}(mg/l)	199 – 296	560 – 1860	250	250	0.002
HCO3 (mg/l)	35 – 45	82 – 763	350	200	0.004
NO^{-}(mg/l)	0.6 – 1.2	1.1 – 1.4	50	50	0.02

3.4 Suitability of water for irrigation purposes

To assess the water samples for Irrigation purpose (Table 6) show all the results of Na%, SAR, RCs, and PI.

Table 6. The measured values of SAR, Na% RCS, PI and WQI of water samples.

Sample No.	SAR	Na%	RSC	PI	WQI
R 1	2.45	39.29	-6.75	45.41	30.24
R 2	2.34	38.49	-6.58	44.75	29.75
R 3	2.45	39.07	-6.83	45.36	30.58
R 4	2.31	37.63	-6.87	44.03	30.37
R 5	2.83	40.1	-8.47	45.41	39.34
R 6	2.45	38.83	-6.97	45.03	30.85
W 1	3.8	41.94	-11.58	48.28	61.20
W 2	6.15	44.14	-24.46	48.31	216.29
W 3	6.11	44.224	-24.31	48.28	238.81
W4	6.65	46.35	-22.07	51.19	139.31
W 5	9.25	52.79	-29.96	55.54	219.10
W 6	5.68	41.92	-27.81	45.2	247.99
W 7	8.5	59.66	-8.1	66.14	192.81
W 8	6.3	43.8	-24.4	48.39	219.18
W 9	9.08	57.33	-16.07	62.04	129.59
W 10	6.35	41.8	-31.68	45.54	264.61
W 11	3.92	30.99	-33.69	34.86	154.75
W 12	8.77	47.86	-34.6	51.43	258.94
W 13	2.39	30.006	-14.44	35.42	65.071
W 14	4.11	42.77	-12.49	48.87	100.14
W 15	4.48	48.34	-8.63	55.84	62.82
W 16	2.35	30.29	-14.67	34.45	95.03
W17	3.97	42.3	-12.38	48.3	67.75

7There are a variety of classifications adopted in this study depending on many principles such as Na%, SAR, RCS, and PI were utilized to carry out the assessment of the suitability of water quality for irrigation purposes, which are mentioned briefly below

Don classification [18] relies on the concentration of sodium ion percentages (Na%), which can be counted through the following formula,

Na%= (r Na + r K / r Ca + r Mg + r Na + r K) *100

Where the concentrations of ions in epm units.

Generally, Na% should not exceed 60% in irrigation water. When comparing the values of Na% of surface and groundwater samples with the proposed limits according to a table (7) it was found that all samples fall into the good to the permissible category. The percentage of sodium ions affects plant growth because an increase in this percentage will affect the efficiency of the soil, as it leads to a decrease in its porosity and permeability.

Table 7. Classification of water depending on the concentration of sodium for Irrigation

Na%	Water Type	Study area
20	Excellent	
20 – 40	Good	R1 R2 R3 R4 R5 R6 W11 W13 W16
40 – 60	Permissible	W1 W2 W3 W4 W5 W6 W7 W8 W9 W10 W12 W14 W15 W17
60 – 80	Doubtful	
80	Unsuitable	

Turgeon classification [19], which relies on the ratio of Na ions to the ratio of Ca and Mg ions are known as SAR and can be estimated through the following formula [20].

SAR = r Na /{(r Ca + r Mg)}

As well as concentrations of ions mentioned in the above formula in epm units. The SAR values of all samples in this study were below 10, which inferred that the water is an excellent class. Generally, SAR values should not exceed 26 in irrigation water, for this reason, the sodium adsorption ratio is an important parameter because it is a gauge of alkali/sodium dangers [21].

Table 8. The Turgeon classification, [19] depends on SAR for irrigation

SAR	Water Type	Study area
10	Excellent	All samples
10 - 18	Good	
18 - 26	Suitable	
> 26	Poor	

Eaton classification [22] relies on Residual sodium carbonate (RSC), which is the concentration of bicarbonate relative to the concentrations of Ca and Mg. The bicarbonate hazard expresses by RSC, which can be calculated utilized through the following formula,

RSC = [(HCO3 + (CO3) (Ca + Mg)] (meq/l)

Where all ions are measured by the equivalent weight (epm). When comparing the values of wells and river samples with the proposed limits according to table (9) it was found that all the water samples are considered excellent for irrigation purposes.

Table 9. Eaton classification depends on RCS for irrigation.

(RCS)	Water Type	Study area
< 1.25	Excellent	All samples
1.25 – 2.5	Intermediate	
>2.5	Bad	

The final classification for Nagaraju [23] relies on Permeability Index (PI). PI is defined by the following formula [24]

PI, Na+ (HCO3)2 / Ca+Mg+Na *100 (meq/1)

Generally, PT should not exceed 75 in irrigation waters. Overall, When comparing the values of wells and river samples with the allowed limits according to table (10) it inferred that the water of all wells and river samples falls into class II, which indicates that it is within the category of good for irrigation.

Table 10. Classification is for Nagaraju [23]

PI Class	Range	Water Quality	Study area
Class-I	<25	Very good	
Class-II	25-75	Good	All samples
Class-III	>75	Unsuitable	

4. Conclusion

This study provided a brief description of the physiochemical properties of surface water and groundwater, which represent the Euphrates River and the main aquifer of groundwater in the study area. The chemical analysis showed that all the water samples in the study areas are dominated by Sodium and Chloride ions in surface water and dominated by Sodium and sulfate ions in groundwater. From the results of the piper classification clearly visible that the type of surface and groundwater is earth-alkaline water with increased portions of alkalis with prevailing Sulphate and chloride. While the groundwater samples in stiff's diagram indicate that the predominant ions are Sulphate and sodium except for W11, the predominant ion is Ca^{2+} and W16 is Mg^{2+}.While for surface samples, the Chlorine and Sodium ions were dominant. The WQI clearly that all River samples are good water for human drinking but all wells samples are not valid except W1, WI3, W15 and W17 indicates poor water while W16 indicate very poor water for drinking. The validity of the water for irrigation depends on a set of classifications. It was clear that the surface and groundwater in this region is excellent quality by SAR, and RCS, good quality with PI, and permissible with Na% except for W11, W13, and W16 for groundwater while Surface water is good quality for irrigation.

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Evaluation the Suitability of Irrigation Water in Karma Island for Agriculture

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Abstract. To evaluating the suitability of surface and groundwater which used in agriculture in Karma Island in Anbar Governorate, eight wells depending on the topographical variation in the area as well as the surface water (Euphrates River) were selected. The water samples were collected during the winter and summer seasons at period 2021-2022. The tests included some chemical measurements of the water, its classification, and assessment of its suitability for agricultural purposes and its quality according to the Baber classification. The results showed significant difference between water sources and date of sampling in terms of studied indicators, the rates of the electrical conductivity ranged between 1.20-12.05 dSm-1 and the values of the degree of reaction in general was tend towards equality (6.9-7.3). The reason of spatial and temporal variation in this chemical water indicators refer to the geological rocks from which these ground waters pass through. As for salinity is concerned, the water of all wells was within the sever category, which indicated the magnitude of the use of this water in agriculture, because its proportion exceeds the limits of this chemical characteristic, while the surface resources water was within light to moderate category. In terms of the degree of reaction do not exceed the recommended index in the manual. As for its content of calcium, sodium, chloride and sulfate, all wells water was outside the usual range category, magnesium concentrations was within the permissible limit, while bicarbonate was within the slight to moderate category. The permeability index showed no objection to the use of this water for agriculture. Classified, all waters was in terms of salinity within class C4, as for the sodium hazards, the sources of water used for irrigation in sites W1, W2, W3, W4, and W5 were of low class S1, while wells W6, W7, W8 and W9 were within class. S2. According to geochemical properties and on basis of Cations, it became clear that there is water sovereignty Na+ and Ca+2, while according to anions, it was chloride-sulfur water.

1.Introduction

Water resources are a great wealth that cannot be dispensed with, as they are the source of life for all living beings, and that man, through his multiple uses of the land, has become a factor affecting, important, and badly the ecosystem of the waters of rivers, lakes, and oceans. The increase in the demand for water requires the development of a general strategy to regulate the demand for it in the various sectors (agricultural - industrial - domestic uses) and the creation of an optimal water management that guarantees the optimal and permanent use of water, and limits the indiscriminate use and takes any measure that would reduce the consumption of the amount of water Fresh and water resources.

The lack of renewable water resources is becoming a matter of concern all over the world. The physical and chemical properties of water play an important role in evaluating water quality[25].

Groundwater in Iraq can play an important role in the development of agricultural areas, as only 25% of agricultural land is irrigated by surface water, and the remaining 75% of agricultural land can be developed by groundwater (Ministry of Water Resources Technical Report, (2006).

The study of [9] indicated very high salinity values for wells water of Anbar province ringed between (360-5500 micro moses cm-1) which made the groundwater in it unsuitable for agricultural and irrigation purposes. Alsanjari and Alqattan [11] showed that the quality of the water of the lower Zab river (water of an alkaline nature) contains high levels of calcium and magnesium ions and low levels of sodium and potassium ions, with a predominance of the bicarbonate ion, as it is affected by the calcareous rock components that the river passes through. The quality of the water in all the samples tested using of Richard diagram, is good and suitable for irrigation.

Ali Muhammad [8] was conducted for study the purpose of assessing the groundwater quality in Kirkuk Governorate by selecting five wells distributed in the areas of 1June, 1March, Tariq Company, Al-Askari district, and the industrial area. The results showed that there are monthly variations in the water quality according to its different locations the values of the pH ranged between 6.2-8.4, and the electrical conductivity values have between 620- 1784 micro Siemens cm-1. The results showed the possibility of using groundwater for cultivating salt-resistant plants, with the presence of severe leaching of salts. Highly salinity according to American salinity laboratory, where the concentration of dissolved salts was C3 (633-1591 mg L-1).

Mohammed [20] studied the evaluation the water of Lake Dalmaj in Al-Qadisiyah Governorate for irrigation according to the Canadian Council of Environment Ministers. The results of the study showed only two indicators (pHw and Nitrates concentration) are within the permissible environmental standards, while other indicators are within the poor water category. Al Maliki et al. [7] confirms that all groundwater samples near Al Kufa City area are suitable for agriculture, and water type quality is acceptable for irrigation purposes, with no hazard on the soil structure. Singh et al. [30] Studding 50 groundwater samples in the Udham Singh Nagar, Uttarakhand, showed that most water samples were fall in the C2S1category, while seven samples fall in the C3S1 category, which being medium to high salinity which is safe to agricultural use to different soil types, but its need to take into account the limited sodium index in this water. Using Piper diagram to know the type of waters indicated that 50% of samples belonged to the Mg^{+2}-Ca^{+2}-HCO_3^- type and 48% was classified as the Ca^{+2}-Mg^{+2}-Cl^- type.

Ben Moussa et al. [13] Notice the dominance of cat ions in the groundwater at Mornag region, northeastern Tunisia, in the following order, $Na^+ > Ca^{+2} > Mg^{+2} > K^+$ and an ions $Cl^- > SO_4^= > HCO_3^- > NO_3^-$, in general the Cl –Ca, SO4– Ca and Na–Cl was the major water types in the region. Calculated irrigation water quality index showed that 55% of the Mornag groundwater samples are distinguished by elevated SAR and Permeability index, which suggesting their unsuitability for irrigation. The Karma Island area is primarily an important agricultural area for the governorate. This area is characterized by limited surface water and a decrease in the amount of precipitation that does not exceed 100 mm annually, in addition to the high rate of evaporation that exceed the amounts of precipitation several times. The aims of this study was determine the goodness of available water in Karma Island for irrigation and compared it with the specifications of the FAO guide and their suitability for agricultural uses.

2.Materials and Methods

2.1.A study area

Karma Island was chosen in Anbar Governorate-western Iraq, for study which was located between longitudes 44°32′ 00″- 43°30′00″E and latitudes 33°43′05″- 33°28′50″N, it is located on the eastern bank of Euphrates River. It is bounded by the center of Karma district the from the south, from the north by Salah al-Din governorate, from the west by Saqlawiya district, and from the east by al-Khayrat district. Its area is 48927.8 hectares, and it is primarily an very important agricultural area and for the governorate, it is abounds in orchards and crop cultivation. In addition, this region is characterized by the state of variation in the level of groundwater affecting the genetic and formative state of the gypsiferious soils in the region, The Figure (1) shows the geographical location of Karma Island.

2.2.Field procedures

2.2.1. Water samples Collection . Samples from Euphrates River water in the region were collected, in addition to eight wells that were selected based on the variation in the geomorphological location within the study area Fig.1, which used as an irrigation source during the months of December 2021 and July 2022, with three replications. Wells samples has been acquired after running pump 15 minutes. Water collected in one liter polyvinyl container which was pre-washed with diluted HCl (0.5 N), then with distilled water. It was filled up to the nozzle. Water reaction (pHw) and salinity (ECw), was estimated directly in the field by HANNA device. Then the samples were transported to the laboratory and kept in the refrigerator until analyzes are performed, depending to [1]. Fig. (1) appears water samples locations.

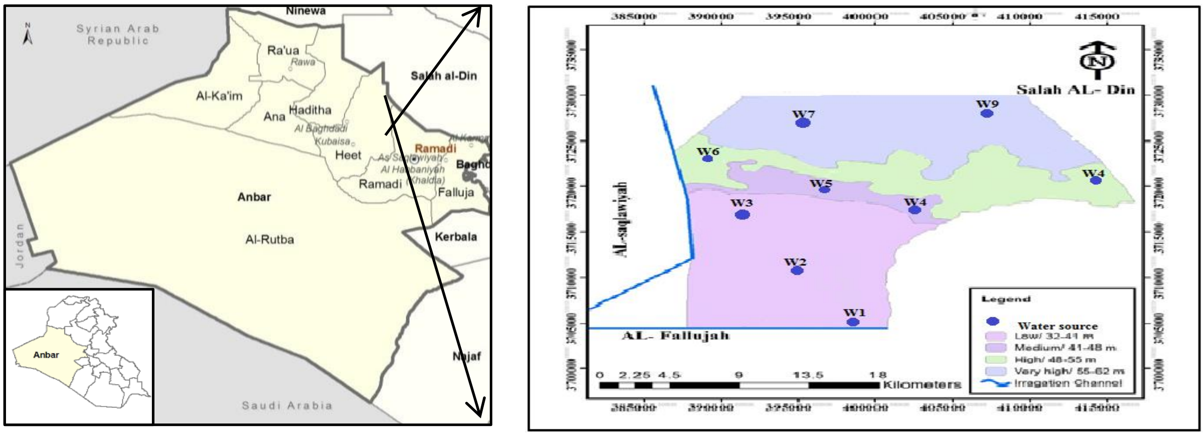

Figure 1. Location of Karma Island administratively from Anbar Governorate.and water source location

3.Laboratory Procedures

3.1. Chemical parameters of water samples.

1-The chemical analyses included estimation of water salinity (Ecw), pHw and estimation the concentrations of cat ions and an ions according to [28]. Boron [15], and nitrates using the phenol disulfonic acid method reported in [26].

2. Sodium Absorption Ratio values were calculated according to equation given incoming in [28],

$$\text{SAR} = [\text{Na}] \,/ \left(\frac{[\text{Ca}] + [\text{Mg}]}{2}\right) 1/2$$

3.2.The water quality.

This index for irrigation purposes was evaluated according to FAO guide [12], also we used Piper diagram to know the type of waters according to the method of [27].

3.Results and Discussion

3.1.Evaluation and classification of irrigation water quality.

The laboratory results (Table,1) showed variation between water resources at Karma island area. Values of electrical conductivity was ranged between 1.20-12.05 dSm-1 for the water of the irrigation canal W1 and well W9, respectively, the recorded variation in this water property is due to several factors, including the dry environment, as well as the movement and transmission of water and its sources, which affect the salinity of the water [31,29] indicated that the variation in the electrical conductivity values of well water in some agricultural districts within Anbar Governorate is due to the variation in the locations of the wells and their impact on the geological formations present in the region. [3] pointed that the variation in amount and type of soluble ions in the water effect direct on the salinity value. It is also noted from the results existence a significant variation between studied seasons in this chemical property values, so the average in the winter was 8.32 dSm-1 Table (1), which is lower than the summer average, which amounted to 9.15 dSm-1, its attributed to rise temperature during summer season also accompanying high rates of evaporation, as well as the lack of precipitation during this period of the year [4].

Results of pHiw shows that it's ranged between 6.9-7.3, which was indicated that the values of this water property in general tend towards equality, the reason for this is attributed to the nature of the gypsum parent material constituting the study area, and the slight variation in the values of the pHiw is originally due to the change in the load of materials, the nature of dissolved substances and alter its sources [5]. in addition to the presence of the bacteria and microorganisms in the water which changed water pH values [5]. While the seasonal variation did not showed significant impact on the values of this chemical property in the region. Calcium concentrations the studied water sources in area ranged between 3.0-31.0 mmolL-1 in both water sources W1 and W5, respectively, this variation may be attributed to the source of these water which formed from calcite $CaCO_3$, $CaMg(CO_3)_2$, and $CaSO_4.2H_2O$ [17]. Seasonally, the lower average of calcium showed in winter season reached 19.54 mmolL-1, while in the summer, was amounted to 21.44 mmolL-1.

The reason for the dominance of the concentration of calcium over magnesium in region waters is due to the ability of the calcium ion to reaction with CO_2 more than magnesium, so calcium is converted into dissolved bicarbonate. It may also be attributed to the calcareous nature of the sedimentary materials in the region[32].

The results indicate that magnesium concentration was between 0.3-5.9 mmolL-1 for the water sources W1 and W3, respectively. The results about this ion was showed a statistical differences between the water sources which used for irrigation in the region in terms of the concentration of magnesium ion, its ranged between 0.30-5.70 mmol L-1, this variation in water resources is due to contact of water with dolomite rocks $CaMg(CO_3)_2$ as well as exposure this rock to chemical weathering, allows an increase in the concentration of magnesium in the water [21].The results of this element showed a significant differences in its concentrations in the water according to the change of season of sampling, in winter its amounted to 2.00 mmolL-1 compared to the summer, when it reached an average of 2.18 mmolL-1, and this is consistent agreed with what was stated by [24].

The laboratory results of Na^+ concentration in water, also showed a significant variation between water resources, less value 4.65 mmolL-1 was recorded in water resource W1, while the highest value 60.80 mmolL-1 was in the water of well W8. This difference is due to the high kinetic ability of sodium in aquatic environments as well as its multiplicity of sources, which contributes to its presence in aquatic environments, its high concentration in sedimentary rocks, and its high ability to move from its sources to very long distances by surface and groundwater[18]. Results also indicated that the amount of this ion reached 37.57 mmolL-1 during the winter season, while its value in the summer reached 41.05 mmolL-1, the reason for this variation because increasing in amount of water withdrawn from the wells during the summer compared to winter, which causes increase in concentrations of ions in the water, and this corresponds to [10 ,

Water resource symbol No.	Location	Date of sampling	Season	Depth of Wall (m)	ECiw dSm-1	pHiw	Ca+2	Mg+2	Na+	K+	Cl-	SO4-2	CO3-2	HCO3-	SAR (mmolL-1)1/2	Water class
							mmolL-1									
W1	397871	02/12/2021	Winter		1.1	6.9	3.0	0.3	4.3	0.3	2.8	3.8	0	0.7	2.37	C3S1
	3704885	01/07/2022	Summer		1.3	7.0	3.5	0.3	5.0	0.3	3.2	4.4	0	0.9	2.56	
	A.V				1.20	6.95	3.25	0.30	4.65	0.30	3.0	4.1	0	0.80	2.47	
W2	393665	05/12/2021	Winter	30	7.1	7.1	19.4	1.9	25.7	1.9	18.1	24.5	0	4.5	5.57	C4S1
	3710759	03/07/2022	Summer		8.3	7.2	22.5	2.2	29.7	2.2	21.0	28.4	0	5.2	6.00	
	A.V				7.70	7.15	20.95	2.05	27.70	2.05	19.55	26.45	0	4.85	5.79	
W3	390370	10/12/2021	Winter	20	8.5	7.3	21.3	1.9	36.6	1.8	22.3	27.1	0	5.3	7.59	C4S1
	3715442	05/07/2022	Summer		8.9	7.1	22.4	2.0	37.4	1.9	24.2	29.3	0	6.0	7.60	
	A.V				8.70	7.20	21.85	1.95	37.00	1.85	23.25	28.2	0	5.65	7.60	
W4	401880	13/12/2021	Winter	38	3.9	7.0	10.3	1.9	13.8	1.3	10.6	12.5	0	3.0	3.95	C4S1
	3717744	05/07/2022	Summer		4.6	7.1	11.7	2.2	15.8	1.5	12.2	14.3	0	3.4	4.24	
	A.V				4.25	7.05	11.00	2.05	14.80	1.40	11.40	13.40	0	3.20	4.10	
W5	396006	18/12/2021	Winter	43	11.1	7.2	28.8	5.5	39.0	3.7	30.2	35.4	0	8.0	6.66	C4S1
	3720245	07/07/2022	Summer		12.0	7.1	31.0	5.9	42.1	4.0	32.5	38.2	0	8.6	6.94	
	A.V				11.6	7.10	29.90	5.70	24.75	3.85	12.60	19.3	0	3.35	6.80	
W6	390013	22/12/2021	Winter	32	9.1	7.1	19.5	2.1	46.2	1.3	24.4	28.7	0	6.5	9.94	C4S2
	3722824	07/07/2022	Summer		9.9	7.2	21.3	2.3	50.4	1.4	26.6	31.2	0	7.0	10.37	
	A.V				9.50	7.15	20.4	2.20	48.30	1.35	25.50	29.95	0	6.75	10.16	
W7	395212	26/12/2021	Winter	57	11.3	7.2	24.3	1.4	57.4	1.6	30.3	35.6	0	8.0	11.32	C4S2
	3726150	10/07/2022	Summer		12.2	7.2	26.2	1.5	62.0	1.7	32.7	38.4	0	8.6	11.78	
	A.V				11.75	7.2	25.25	1.45	59.70	1.65	31.50	37.00	0	8.30	11.55	
W8	407119	02/12/2021	Winter	68	11.5	7.2	24.8	1.4	58.5	1.6	30.9	36.3	0	8.2	11.43	C4S2
	3727579	10/07/2022	Summer		12.4	7.3	26.7	1.5	63.1	1.7	33.3	39.0	0	8.4	11.88	
	A.V				11.95	7.25	25.75	1.45	60.80	1.65	32.10	37.65	0	8.30	11.66	
W9	413389	9/12/2021	Winter	45	11.3	7.2	24.5	1.6	56.7	1.6	30.9	34.2	0	7.8	11.10	C4S2
	3720356	10/07/2022	Summer		12.8	7.2	27.7	1.8	64.0	1.8	34.9	38.6	0	8.8	11.78	
	A.V				12.05	7.20	26.10	1.70	60.35	1.70	32.90	36.40	0	8.30	11.44	

Winter Average	8.32	7.13	19.54	2.00	37.57	1.67	22.27	28.30	-	5.77	7.77
Summer Average	9.15	7.15	21.44	2.18	41.05	1.83	24.51	29.08	-	6.32	8.12
LSD 0.05 for Water location	1.354	0.053	6.631	0.962	10.553	0.631	6.651	10.551	-	1.422	0.982
LSD 0.05 for Season	0.103	N.S	0.655	0.081	1.272	0.093	0.675	0.655	-	0.205	0.052

Notes: Each value is an average of three replicates.

As for the potassium concentrations, its average ranged within the sampling sites between 0.30-3.85 mmolL-1 within W1 and W5 water resources respectively, with significant differences. The decrease in K+ concentrations comparison to the Na+ in the waters of the region is a result of weak weathering of potassium contented minerals comparison to other minerals [4]. Average of K+ in winter reached 1.67 mmolL-1, while its average in the summer was rose up to reached 1.83 mmolL-1.

Results of an ions analysis showed less value of the Cl- 2.8 mmolL-1 at source W1, while the highest concentration was recorded in the water of well W9, it was 34.9 mmolL-1. It's high solubility and its difficulty to participating, which allows it to remain in the dissolved ionic state under normal conditions [22]. In addition, the main source of chloride ion in the water is the contact of this water with sedimentary rocks [23]. It was also noted from the results a significant variation in the concentration of chloride in the water with the difference in the examination season, as the highest rate of this ion was recorded in the summer, amounting to 24.51 mmolL-1, while the lowest concentration was recorded in the winter, reached 22.27 mmolL-1, this variation was due decrease the ground water level during the summer and thus increases the chloride content in the ground water [32].

As for the sulfate ion concentration in the examined irrigation water, its ranged between 4.10 - 37.65 mmolL-1, which was recorded at sites W1 and W8 respectively. It was also observed a significant difference in its concentration according to the season of water modeling, the less amount 28.30 mmolL-1 was showed during winter season, while higher amount 29.08 mmolL-1 was showed at summer. The reason for higher concentration to this ion in the waters of in the region is back to rock types through which this waters moves, the nature of the parent material and the geological formations present in the study area [4]. Gypsum rock is the main resource of sulfate ion in arid regions, also poorly drained soil is a source of sulfate[14]. As for the concentration of bicarbonate ion in the irrigation water, its ranged between 0.7 - 8.8 mmolL-1 (Table 1). The less value was 0.80 mmolL-1 recorded at W1, while the highest value 8.30 mmolL-1 was recorded at sites W7, W8 and W9. In winter its average reached 5.77 mmolL-1, while the concentration of HCO3- increased in summer which reached 6.32 mmolL-1, this variation mainly back to impact to the decomposition salts or Calcite, as well as weathering chemical composition of soil minerals, as well as vital activity [16], these results was agrees with what was stated by [10].

Table (1) showed that lowest value of SAR for water resources within the study area was 2.47 at W1, but the higher rate was 11.66 at site W8. The SAR rates ranged between 2.37-11.88 (Table, 1). Significant differences were observed between the two examination seasons, it was reaching 7.77 in winter and 8.12 in summer, the reason for this seasonal or local difference in the SAR values is due to the variation in the ratios of Na+, Mg+2 and Ca+2 [5].

3.2. Evaluation of water quality according to the system of the World Food and Agriculture Organization

The water quality was analyzed according to the International Food and Agriculture Organization's Water Quality Guide (Water Quality For Agriculture, FAO Publication No.29,1994)[12]. This bulletin gives irrigation water specifications which was suitable for agriculture and shows the effect of the chemical composition of irrigation water on plants and the chemo physical properties of the soil. Therefore, when presenting the data obtained from the well water and river water, and describing variation in water quality, the following appears,

3.2.1Electrical Conductivity ECiw. The results of the study of this characteristic (Table 1) showed that all well water was within the sever category of high-risk water for use in agricultural purposes, because its exceeded the value of 3.0 dSm-1. While river water was in the category of light to medium, and since the electrical conductivity is an indicator of the concentration of salinity, exceeding the permissible limits leads to a decrease in the availability of water for the crop as a result of the increased osmotic stress and the accompanying salt stress for the plant, to the extent that it affects the crop, especially if the cultivated crop is wheat, as the yield reaches 100% when the irrigation water salinity is 4.0 dSm-1 and the soil salinity is 6.0 dSm-1, while its decreases to 50% when the irrigation water electrical conductivity is 10dSm-1, and the soil salinity is 15dSm-1[12].

3.2.2. The degree of reaction pHw. Results of this chemical characteristic showed that all water modeling sites did not skip the limit value which ranged between "(6.5-8.4)". The values of this indicator fluctuate between high and low, affects the nutritional balance of nutrients in the soil, in addition to that, the direct problem of the water pH is its interaction effect on systems used in irrigation, as It leads to rapid erosion of parts of the irrigation systems.

3.2.3. Calcium. The study of the calcium ion concentration showed that all well water was outside the usual range (10 mmolL-1), and outside the normal limits because its exceeded permissible limits in the manual. Iincreasing Ca^{+2} concentration poses a problem, as it is one of main components of hardness the water. Water with monstrous content calcium and magnesium ions is Not recommended for home use [2]. In addition, presence of high concentrations of poorly soluble salts such as calcium in irrigation water causes the problem of forming white scales on leaves or fruits when used in sprinkler irrigation systems. The sprinklers are also exposed to clogging due to existence these salts [12]. And that the main problem of calcium is that it combines with bicarbonate and sometimes with sulfate, and thus precipitates form (even at very low concentrations), especially when using sprays (in conditions of air humidity less than 30%, which results in high rates of evaporation). The droplets that remain on the leaves partially evaporate to become concentrated salts, and when they are deposited, they will not dissolve easily during the successive wetting when the sprinklers rotate, and thus these deposits increase gradually.

3.2.4. Magnesium. When comparing the results of Mg^{+2} analysis in the irrigation water which was available in the study area, with water quality index, its became clear that all water resources were within the permissible limits for agricultural uses, except for well W5. Problem of high Mg^{+2} in the irrigation water lies in fact that it leads to adding it to the soil, and therefore the soil containing high levels of magnesium causes problems in soil infiltration. In addition, soils with high magnesium or irrigated with water with high magnesium concentration may be a cause of calcium deficiency, and the yield of some agricultural crops such as barley, wheat, maize, and sugar beet decreases, when the ratio of calcium / magnesium in the soil solution is less than 1, and if it is close or less than 1, the absorption and transfer of calcium from soil water to the growing parts of the crop above the ground decreases, as a result of the antagonistic effects of high magnesium or competition for absorption sites to the extent that little calcium is absorbed.

3.2.5. Sodium. It is noted from the results of the irrigation water analysis, that all the waters of the study area were within the sever category, as they exceeded the value of 3.0 mmolL-1, Which confirms that it cannot be used for agricultural purposes, especially for surface or sprinkler irrigation. The increasing in Na^+ concentration of in water leads to increase its percentage in soil, and it may reach toxicity limits with time.

3.2.6. Chlorides. The results indicated that all water sources, except for the water of the river W1, It was in the severe category as its concentration exceeded 10 mmolL-1, Which confirms the existence of a specific use of this water to irrigate crops grown under sprinkler irrigation systems to exceed the concentration values of 3.0 mmolL-1. The increased water content of chlorides causes a direct toxic effect on sensitive plants, and increase in soil salinity [2].

3.2.7. Sulfate. Comparing the sulfate concentration data in irrigation water with FAO index, it is clear that all groundwater resources were within the usual range above the category and exceeded 10.0 mmolL-1(natural limits), and there are limitation on its use for irrigation purposes. And the presence of large amounts of sulfate and magnesium reduces hardness and thus limits the negative effects of sulfate when used, and increase soil salinity, and that sulfate is a nutrient for the plant and its high concentration in the water may lead to interference with other elements absorption, so that $SO_4^{=}$ presence in irrigation water has benefits fertility effect.

3.2.8. Bicarbonate. It is noted that all well water available in the region was within the category slight to moderate (1.5-8.5 mmolL-1), except for site W1, which was within the category None(<1.5 mmolL-1), which mean within the natural limits and can be used to irrigate crops, while the sites that fall within the slight to moderate category, have limitation on its use for crops irrigation, especially by using the pivot spray method, especially the water of sources W7, W8 and W9 due to its proximity to the critical limits set by the International Organization for Food and Agriculture.

3.2.9. Infiltration (using ECw and SAR together) The results indicate that all sites were in the Non category, so we can usage of these water for irrigation. SAR danger was its effect on the soil infiltration. Because the relatively high content of sodium in the soil and water, as well as low content of calcium, reduces the rate of entry of irrigation water to the extent that sufficient water cannot filter to adequately supply the crop between one irrigation and another.

3.3. Irrigation water classification

The results indicated (Table 1) that all sources were of category C4 (high salinity) quadrate to the USA classification for salinity and are considered unsuitable for irrigation without the availability of some methods through which it can reduce its impact on the plant, such as using this water to irrigate well-permeable soil with the addition of leaching requirements, and need to grow salinity-tolerant crops. This indicates these water may cause danger when its used for irrigation, so its use requires an effective irrigation methods and private management practices to avoid risks of salinity, with need to choose medium-tolerant crops for salinity in the region, when using this type of water for irrigation. This is consistent with what was observed by[29] who showed that 48% in Anbar Governorate wells water was within class C4. As for the sodium hazard, the water sources used for irrigation in sites W1, W2, W3, W4 and W5 were at low grade S1, which mean the possibility of using this water for all types of soil, with no severity of increasing the scale of ESP in the soil, while the results of well water classification indicated that W6, W7, W8 and W9 were within class S2.

Interpretation of the results based on water characteristics, as in Figure (2), which is get to know as three-line graph of water. It appears clear from the side of the cat ions that water of the region is supremacy by Na+ and Ca+ 2, while for group of anions it was chloride and sulfate, The predominance of the anions was in the following order, SO4=, Cl- and HCO3-, it is noted from the chart that all water in the region was similar in terms of the concentrations of positive and negative ions prevailing, what water wells W7, W8 and W9 excelled sodium ion predominance rate is higher as well as sulfate and chloride ions.

According to langguth method was alkaline water in the primary title, and according to secondary title it was with prevailing sulfate and chloride

4. Conclusion

There are statically differences between the water sources in the measured chemical indicators within the study area, and this discrepancy is attributed to several factors, including the environment, as well as the movement and transmission of water and its characteristics, as well as the sources that affect the salinity of the water.The observed increase in the values of the measured chemical indicators of water during the summer compared to the winter is due to the nature of the dry climate prevailing in the region. Evaluatively, salinity of all wells was within the sever category, this indicates that there is a danger in using this water for agriculture. As for concentrations of calcium, magnesium, sodium, chloride, and sulfate ions, all well water was outside the normal limits because it exceeding the limits permitted by the FAO system, while the bicarbonate was within the category slight to moderate, and as for the effect of water on soil permeability, this confirms the possibility of using water in all the test sites for irrigation without the appearance of physical problems in the soil.All the water examined was of high salinity category, and for sodium hazard, most of the water sources used for irrigation were within category S1, with category S2 present.When interpreting the results on the basis of the geochemical properties of the water that was examined according to what is known as the three-line diagram of water used in the geochemical assessment of groundwater, regarding the cat ions, the results showed that the waters of the region are characterized by the predominance of sodium and calcium ions, while regarding the an ions, they were chloride and sulfate.

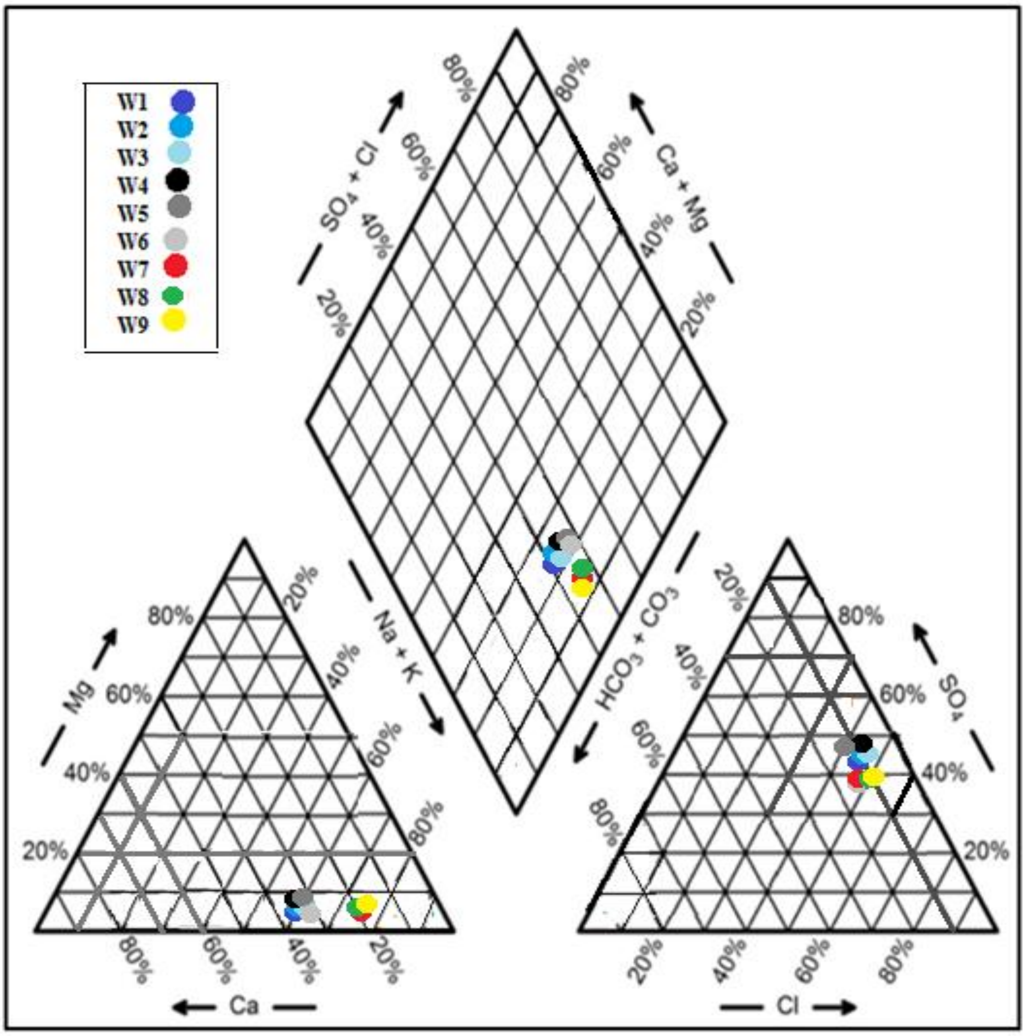

Figure 2.Piper diagram to evaluation quality of irrigation water in the study area.

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Effect of Surface, Subsurface Drip Irrigation and Nanotechnology Perfusion Methods on Irrigation Efficiency and Saved Water Ratio in Plowed and Un Plowed Soils

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Abstract. A field experiment was conducted in Al-Habbaniyah district / Al- Khalidiya district / Al-Anbar governorate, western Iraq, in Silty loam soil during the fall season 2020, to study the effect of surface and subsurface drip irrigation and perfusion irrigation with nanotechnology on irrigation efficiency, the amount of added water and the percentage of water saving in plowed and non-plowed soils. Perfusion was done when 50% of the prepared water was depleted, the treatments were distributed according to the Nested-Factorial Experiments Design (NFED) with three replications. The yellow corn, cultivar Euphrates, was planted on 2020/15/7. The American evaporation basin, type A, was used in the timing of irrigation. According to the rate of water consumption in terms of the equivalent depth of the added water, the total yield and the efficiency of water use. The results of the study showed the uniqueness of the drip irrigation system by giving the highest irrigation efficiency of 100% for the two plowing modes, while the surface drip irrigation system gave an irrigation efficiency of 83% in the uncultivated soil, and the lowest amount of water was added during the season, which amounted to 5215 m3. ha-1 in the nano-technology perfusion irrigation method with a savings rate of 29.97 and 13.19% compared with the surface drip irrigation method, while it reached 15.23 and 8% compared with the subsurface drip irrigation method in the plowed and non-plowed soils sequentially, the highest average total production was 11.7 tons of grain per hectare for the tillage and no- till treatment, and it decreased significantly to 7.5 tons ha-1 in the surface drip irrigation method, while the tillage treatments did not record significant differences in the short-term grain yield.

1. Introduction

Fresh water resources are considere one of the main limitations and development of agricultural production, especially in the arid and semi-arid regions in which Iraq is located, the lack of arable water resources and their limitations are among the main problems to provide food security requirements to avoid the increasing in the population [1]. Therefore, it requires to develop modern methods and technologies of irrigation to reduce the gap between fresh water available on the one side and food security on the other side. Therefore, using the available water is a real target that must be focused on to exploit the largest area of arid and semi-arid lands in the development of sustainable agriculture. The importance of irrigation efficiency studies in Iraq is highlighted because it is located within the borders of the arid and semi-arid regions. The irrigation importance increases with lack of rain water (precipitation) under the arid and semi-arid regions conditions and water scarcity which negatively affects the water resources to supply the crops requirements, so it requires the exploitation of water Efficient and effective exploitation as much as possible, and determining the water requirements of crops is the first important stage for the optimal management of available water. The limited availability of fresh water, modified the researchers to work for finding modern methods in the irrigation side. Irrigation efficiency is defined as the percentage of stored water in the root zone soil over the amount of entered water to the field [2]. Irrigation efficiency is one of the important criteria to choose any irrigation system, especially in the soils of arid and semi-arid regions.[3]

Obtained an increase in the irrigation efficiency values with an increase in the level of SAP and champlain plant powder adding 80%, while it reached 66% in the comparison treatment and reached 73% when adding levels of synthetic polymer, explaining the reason to the role of champlain plant powder and the polymer in improving the structure Soil, increase its porosity, and increase its water-holding capacity for a longer period between irrigations.

This study has been conducted with the aim of, Estimating irrigation efficiency for different irrigation methods under study conditions and to know the effect of different irrigation methods on the rate of saved water and grain yield.

2. Materials and Methods

An experiment has been conducted during Autumn season 2020, in Abu Flees region – district of Habbaniyah - Anbar Governorate, west of Iraq. Morphologically according to [4], the soil classified as a mixed alluvial texture classified sub group Typic Torrifluvent, Fine loamy mixed, Calcareous, hyperthermic. Randomly, representative samples of soil were taken from different regionsat depth 0.0 - 0.30 m, and analyzed some physical and chemical properties of soil, Table (1), according to [5].

Table 1. Some physical and chemical soil properties before planting.

	Sand	Silt	Clay	Bulk density	turated hydraulic conductivity		pH EC
	(cm hr-1)				(ds. m-3	)	
					7.5	1.25	

Mg2+	Na+	K+	Ca2+	SO42-		
HCO3-	CO32	Cl-				
(mmol. L-1)	(mmol. L-1)	(mmol. L-1)	(mmol. L-1)	(mmol. L-1)	(mmol. L-1)	
(mmol. L-1)	(mmol. L-1)					
1.5		4.25		0.35	5.0	1.10
2.50	Nill	6.50				

The irrigation water characteristics calculated according to the proposed methods by the American Laboratory of Salinity. Euphrates's river water has been used to irrigate the corn crop, and table (2) shows the chemical properties of irrigation water.

Table 2. Irrigation water chemical properties.

Class	SAR	NO3= Ppm	) meq. L-11(Ions dissolved CO3=	HCO3-	SO4=	Cl-	K+	Na+	Mg=	Ca=	pH	EC dS.m-1
C3S1	1.15	2.10	0.0	2.0	3.5	4.0	0.14	2	2.89	4.1	7.4	0.98

The experiment studied the effect of three different irrigation systems with nano-drippers, surface, sub-surface drip irrigation systems and nano-technology perfusion irrigation. Irrigation time depended on A pan when depleting 50% of the available water, it was measured by the gravimetric method in the field. Irrigation water was also added by nano-technology in a continuous perfusion manner throughout the season, according to the growth stage, each system has two plowing patterns, zero tillage and conventional tillage.

A plot of 52.2 m long by 21.5 m wide, then divided into three equal sites with dimensions of 14.5m * 17.5 m, a guard area separated the sites with 2.5 m. All the irrigation methods was placed in a location vertically to the winds direction to represent the main slabs. All irrigation methods also included three systems and two tillage patterns were developed in each of replication, which included plowing. A 1.5 m long and 1.5 m wide was leveled by the moldboard, then it smoothed, while a distance of 1.5 m was left from the tilled treatment and the untilled treatment to prevent overlapping of the wetting areas, as well as to facilitating the tractor movement when plowing the treatment, three drip lines were extended in experimental unit, 0.5 m separated distance among them, thus each irrigation method has six experimental units, with 18 experimental units in the experiment, 2m has been left around the experiment to separate them and planted on both sides of the experiment to reduce the effect of dry wind figure (1).

Corn seeds has been cultivated in Autumn season, Furat variety, on 15/7/2020 by putting 3-4 seeds per hole. Then thinned to one plant after two weeks of planting. The distance between line and another is 0.5 m, and between hole to another is 0.25m, with 58 plants in each planting line. The number of plants on each system is 1044 plants, the total plants in the experiment were 3132 plants.

Urea fertilizer has been added in an amount of 400 kg ha-1 in two batches, the first included 200 kgN ha-1 with 260 kg ha-1 of triple superphosphate before planting, after five weeks of planting, the second batch has been added. For all transactions crop service operations were carried out from the weeding process. While the corn stem borer, (Sesamia cretica L.) controlled by using (Diazinon10%) insecticide at a rate of 6 kg ha-1, by inoculating into the heart of the plant after 20 days after planting, for three times with 10 days an interval. .

Actual water consumption (ETa) has been calculated, which is equivalent to added water depth (d), irrigation time based on the actually depleted moisture by using gravimetric method depending on evaporation basin data as a primary indicator, as follows,

$$d = \frac{\theta f.c - \theta wi}{100} * D \qquad \dots (1)$$

When,
d= added water depth(cm) which is equivalent (ETa)
D= active depth of roots (cm).

Calculated evapotranspiration-reference (ET0) which mentioned in [6] as fallow,

$$ETo = \frac{ETa}{Kc} \qquad \dots (2)$$

ETo, reference- evapotranspiration, mm day-1
ETa , actual evapotranspiration, mm day-1

Kc , crop coefficient which theoretically adopted for different growth stages (0.94, 1.05, 1.69, and 0.82) for emergence, vegetative growth, flowering and maturity stages respectively, which mentioned in [7].

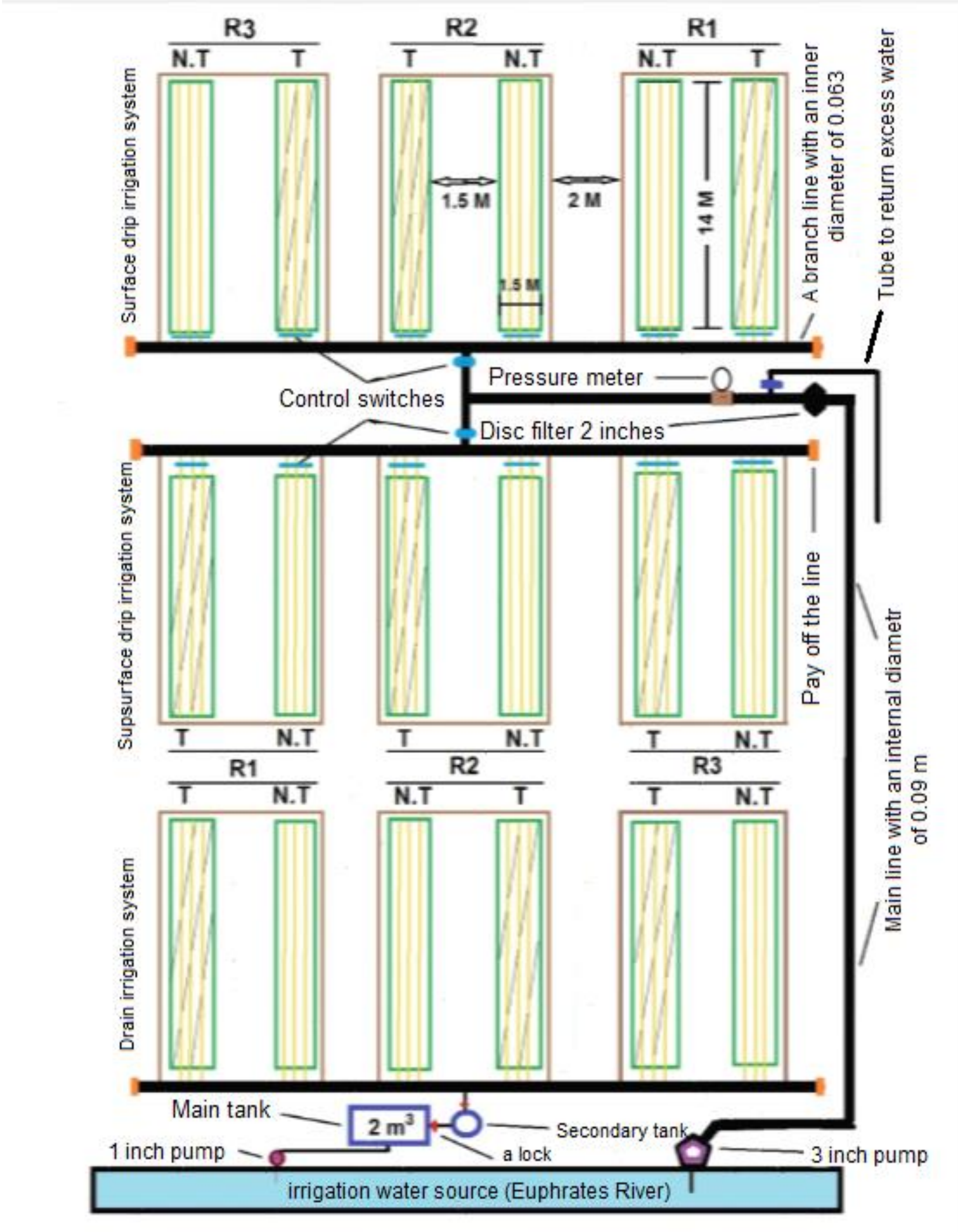

Figure 1. Field diagram and irrigation systems.

The Epan value was calculated according to the equation mentioned in [6] as fallow,

$$\text{Epan} = \frac{\text{ETo}}{\text{Kp}} \quad \dots (3)$$

As,-

ETo, Evaporated water from the evaporation basin(mm).
Kp, a specific evaporation basin coefficient which varies according to the type of basin, the vegetation cover surrounding the basin, and the soil surface nature [6]. The value of 0.8 was adopted in this study based on [8].
The added water amount to the soil as a requirement for leaching salts, amounting to 6.25% of the added water depth was calculated according to the equation mentioned by [9] for drip irrigation system, as follows,

$$\text{LR} = \frac{\text{ECwi}}{2\max\text{ECe}} * 100 \quad \dots (4)$$

As,-
LR, Leaching requirement, (%).
ECwi, salinity of irrigation water, ds m-1.
Max ECe, the maximum value of soil salts (dS m-1) which the crop yield is equal to zero, and it is a value that varies according to the type of crop, and it is equal to 10 for the corn crop [7].

Perfusion efficiency has been calculated according to [2] and according to the following equation

$$\text{Ea} = \frac{\text{Ws}}{\text{Wf}} \times 100 \quad \dots (5)$$

Since,
Ea = Irrigation efficiency (%).
Ws = Volume of stored water in root zone (m^3).
Wf = Volume of arrived water to the field (m^3).

$$\text{WUEf} = \frac{\text{Yield}}{\text{Irrigation Water applied}} \quad \dots (6)$$

Since,
WUEf = Water Use Efficiency (kg m-3).
Yield = total yield (kg ha-1).
= the total used water volume during the season (m3 ha-1).

The total grain yield has been measured by separating the ears from the vegetative part and according to the total ears for each experimental unit. Then estimated the total yield after dried by air and separating grains (Ton ha-1) according to [10].
Genstat v.12.1 software has been used to analyze the results and compared the averages according to the Least Significant Difference (LSD) test at a probability level of 0.05.

3.Results and Discussion

3.1. Irrigation efficiency (%).

The results show the effect of the study factors on the irrigation efficiencies, as it gave the highest irrigation efficiency by using the perfusion irrigation method with the tillage and no-tillage systems, while it was the lowest value by using the fixed surface drip irrigation method in the untilled soil, as it reached 83%, and this value is low rate 17%. Compared with the value of the characteristic in the perfusion irrigation method for both of tillage patterns, which reached 100%, but in subsurface drip irrigation method, it was completely different from surface drip irrigation method, and it reached the highest value in untilled treatment to 96%, and it decreased to 94% in the tilled treatment which decreased at rate 2.08%, while it was lower by 14 and 16% than the irrigation efficiency in the perfusion irrigation method in a tilled and un-tilled soils respectively. In subsurface irrigation and perfusion methods, the reason for the low irrigation efficiency in the treatment of untilled soil compared to the tilled soil of the surface drip irrigation method is due to evaporation losses and lateral run-off because of the small soil pores and un-disturbed by tillage.

Which led to made larger quantities of water on the surface of the soil subject to evaporation and runoff, which caused the decrease in infiltration of the added water above the soil surface compared to the tilled soil, which allowed water to permeate between its large pores in a shorter time than in the untilled soil, as for the high value of the characteristic in the subsurface drip irrigation method compared to surface drip irrigation is due to less evaporation losses in this method because it is based on adding water below the soil surface, which prevented it from rising to the surface and losing it by evaporation, while the reason for the superior efficiency of subsurface irrigation is in untilled soil compared to tilled soil, it may being undisturbed soil and kept its structure, which made it retain moisture for a longer time than it did in the tilled soil, which gave a greater distribution of the added water and its distance from the measurement point (0.15 m), while the continuous supply of water along the season in perfusion irrigation method had a major role to preserve soil moisture at field capacity limits and because of the exposure of the water surface in the water column reservoir to atmospheric pressure (free water surface), the backwardness in the moisture of the tilled and untilled soil is self-compensated by the cause of the structural potential difference in the soil of the root zone, which led to the equal value of irrigation efficiency for the two treatments.

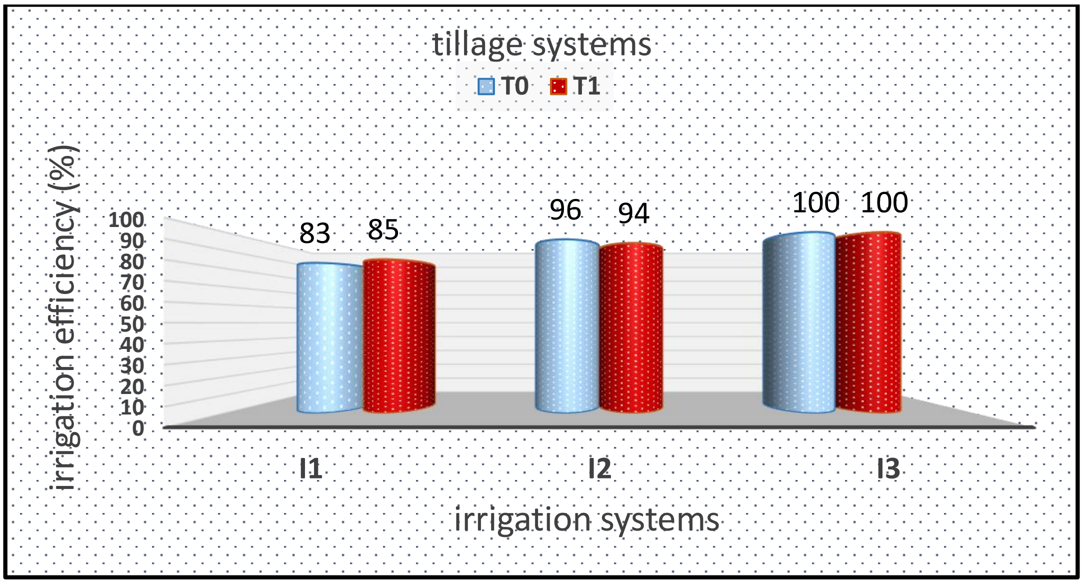

Figure 2. The effect of the study coefficients on irrigation efficiency (%)..*(%)*

3.2. Added water volumes and water saving percentage (m3 ha-1).

Tables (3, 4, 5, 6, and 7) show the volumes of added water to the tilled and untilled soils using the fixed, subsurface drip and the perfusion irrigation methods. Lowest quantity of added water was 5215 m3 ha-1 in tilled and untilled soils, while it reached 6152 and 5669 m3 ha-1 by subsurface drip irrigation method, 7447 and 6008 m3 ha-1 by surface drip irrigation method in tilled and un-tilled soil respectively, that is due to the high efficiency of sub-surface drip irrigation method, which made the soil retain moisture for a longer time between irrigations compared to the fixed surface drip irrigation method, and this led to a decrease in the number of added irrigations during the season. The reason for decreasing the amount of added water by the perfusion irrigation method for the two types of tillage compared to the surface and subsurface drip irrigation methods, it is due to the instantaneous hydraulic mechanism associated with the plant physiological state and the surrounding environment, and the water surface in the tank equipped for the system is exposed to atmospheric pressure, making the perfusion increase and decrease according to the plant's need, in addition to low temperatures and relative humidity in the field.

The same tables show the quantities of added water differed according to different tillage patterns, the highest being 7447, 6152 and 5215 m3 ha-1 in the tilled soil for the surface, subsurface drip and perfusion irrigation methods respectively, while it decreased in the untilled soil and reached 6008, 5669 and 5215 m3 ha-1 for the same irrigation methods mentioned above, respectively, that is due to the advantage of untilled soil in retaining water for a longer time because of the preservation of its structure from deterioration and its high porosity [11].

The perfusion irrigation method saved amounts of added water reached 937 and 453 m3 ha-1 by rate 15.23% and 8% compared with the subsurface drip irrigation method in tilled and untilled soils respectively. When comparing the amount of saved water by drip irrigation with surface drip irrigation, we find that it amounted to 2232 and 793 m3 ha-1 at a rate of 29.97 and 13.19% in tilled and untilled soils respectively, and that water can be used to exploit new lands of 0.427 and 0.152 hectares can irrigated by nanotechnology in tilled and untilled soils respectively.

The tillage factor also affected on water saving, as the untilled soil left a quantity of irrigation water amounting to 1439 and 483 m3 ha-1 at a rate of 19.32 and 7.85% compared to the soil tilled under surface and subsurface drip irrigation methods, respectively, and that water can be used to exploit new lands with an estimated area of 0.086 and 0.027 hectares, respectively.

Table (3) The volume of water added by the surface drip irrigation method to plowed soil.

The Number Stage	TCIV	TFIV	LR(m) of irrigation	(m3 ha-1)	(m3 h-1)	d(m)
Germination	0.019400	0.001213	7	1358.0	1697.541	
ve.. growth	0.027500	0.001719	8	2200.0	2750.023	
flowers	0.036300	0.002269	9	3267.0	4083.776	
maturity	0.031100	0.001944	2	622.00	777.505	
the total	0.74875	0.046805	26	7447	9303.845	

Perfusion efficiency = 0.85 Experimental area = 65.25 m2

TCIV = The total crop irrigation volume *
TFIV = The total field irrigation volume *

Table (4) The volume of water added by the surface drip irrigation method in unplowed soil.

The Number Stage	TCIV	TFIV	LR(m) of irrigation	(m3 ha-1)	(m3 h-1)	d(m)
Germination	0.019400	0.001213	7	1358.0	1738.445	
ve.. growth	0.027400	0.001713	8	2192.0	2806.072	
flowers	0.026200	0.001638	8	2096.0	2683.180	
maturity	0.036200	0.002263	1	362.00	463.4096	
the total	0.6048	0.037812	24	6008	7691.106	

Perfusion efficiency = 0.83 Experimental area = 65.25 m2

Table (5) The volume of water added by subsurface irrigation in plowed soil.

The Number Stage	TCIV	TFIV	LR(m) of irrigation	(m3 ha-1)	(m3 h-1)	d(m)
Germination	0.018100	0.001131	7	1267.0	1432.095	
ve.. growth	0.028500	0.001781	7	1995.0	2254.967	
flowers	0.036400	0.002275	7	2548.0	2880.053	
maturity	0.034200	0.002138	1	342.00	386.5744	
the total	0.6204	0.038772	22	6152.0	6953.689	

Perfusion efficiency = 0.94 Experimental area = 65.25 m2

Table (6) The volume of water added by subsurface irrigation in unplowed soil.

The Number Stage	TCIV	TFIV	LR(m) of irrigation	(m3 ha-1)	(m3 h-1)	d(m)
Germination	0.018200	0.001138	6	1092.0	1208.625	
ve.. growth	0.028200	0.001763	7	1974.0	2184.802	
flowers	0.037500	0.002344	6	2250.0	2490.250	
maturity	0.035300	0.002206	1	353.00	390.6875	
the total	0.5669	0.035439	20	5669.0	6274.36	

Perfusion efficiency = 0.96 Experimental area = 65.25 m2

Table (7) The volume of water added by the nano-perfusion irrigation method (for the two types of cultivation).

The Number Stage	TCIV	TFIV	LR(m) of irrigation	(m3 ha-1)	d(m) (m3 h-1)
Germination	0.096900	0.006056	-	969.00	1029.560
ve.. growth	0.179200	0.011200	-	1792.0	1904.000
flowers	0.210900	0.013181	-	2109.0	2240.810
maturity	0.034500	0.002156	-	345.00	366.5600
the total	0.521500	0.032594	-	5215.0	5540.93

Perfusion efficiency = 100% Experimental area = 65.25 m2

3.3. Total Yield (ton ha-1).

The effect of irrigation methods on the total yield of corn grains showed in table (8), which indicates significantly increasing in perfusion irrigation, with an average 11.7 ton ha-1, with an increase of 55.37 and 35.70% compared with surface and subsurface drip irrigation and the two tillage patterns respectively. This is due to adding water continuously according to plant's need (without irrigation interval) in perfusion irrigation with increasing the soil moisture content in the root zone. That is reflect positively on production by made the nutrients in a state of continuous solubility in the soil [12].

The same table indicates the effect of tillage patterns on the production average, rate of the total yield, as the highest production rate was 9.6 ton ha-1 in the untilled soil, with an increase of 7.14% compared to the tilled soil for all irrigation systems, and the reason for this increase is attributed to undisturbed soil in the case of no tillage and preserving its structure, which made the soil retain moisture for a longer time compared to the tilled soil, which loses a larger part of the irrigation water by evaporation and deep percolation, as a result of the large size of its pores between the particles, [11].

Table. 8, Effect of study coefficients on total grain yield (ton h-1).

tillage pattern / Irrigation systems	T	NT	irrigation average
Surface drip irrigation	7.960	7.110	7.530
Subsurface drip irrigation	8.020	9.210	8.620
Drain irrigation	10.910	12.490	11.700
LSD	N.S		1.955
Tillage average	9.600	8.960	
LSD	N.S		

4. Conclusion

The results of the study showed the uniqueness of the drip irrigation system by giving the highest irrigation efficiency of 100% for the two plowing modes, while the surface drip irrigation system gave an irrigation efficiency of 83% in the uncultivated soil, and the lowest amount of water was added during the season. The nano-technology perfusion irrigation method with a savings higher saving compared with the surface drip irrigation method in the plowed and non-plowed soil, respectively. The highest average total production was achieved for the tillage and no- till treatment, and it decreased significantly in the surface drip irrigation method, while the tillage treatments did not record significant differences in the short-term grain yield.

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Daily Evapotranspiration Prediction at Arid and Semiarid Regions by Using Multiple Linear Regression Technique at Ramadi City in Iraq Region

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Abstract. For many decades, because of the climate change, the interest in water resources management have been increased. The researchers curried out huge efforts to investigate the factors that influence the water resources quantities. Many of these efforts focused on studying the water losses by evapotranspiration. In the current study, a new mathematical model is introduced. It was built based on Multiple linear regression method (MLR). This model was utilized to estimate the daily evapotranspiration in Ramadi city which characterized with arid and semiarid environment and to investigate the influence of different parameters on the evapotranspiration process. The field data were collected from the digital meteorological station at the Upper Euphrates basin Developing Centre during the period from 23/11/2020 to 1/10/2022. These data include the evapotranspiration, maximum temperature, the minimum temperature, the average temperature, wind speed, relative humidity, and solar radiation. The model was calibrated using 80% of the data set, while 20% of the data set were used for validation. The solar radiation shows the highest impact on ET, while the lowest was recorded by relative humidity. High performance of the model was proved by testing it using Performance Indicators such as RMSE, NAE, MAPE, NSE, and R^2.

Introduction

The dramatic rise of the population and the climate change increase the issues of the water scarcity. More attention is required to manage the water resources to avoid the lack of water which is necessary for irrigation and human consumption. Different strategies and studies have been adopted by the planners and the researchers to manage water resources. Some of these studies focused on the hydrological cycle parameters especially the water losses due to the evapotranspiration at the arid and semi-arid regions [1]. One of the most difficulties that faces the researchers is how to quantify the ET with high accuracy [2]. Many techniques have been employed for this purpose, these include direct and indirect methods [1].

For the last few decades, many researchers have developed these techniques to quantify the ET with higher accuracy [1-8]. They introduced different models for this purpose. In 1977, Doorenbos and Pruitt suggested that it possible to quantify the ET based on evaporation in pans by multiplying the measured evaporation with a specific pan factor which depends on the pan type, pan location, and the surrounded area [9]. Huge efforts were carried out by The United Nations Food and Agricultural Organization (FAO) to get better understanding about ET phenomenon [9]. It defined the ET as the average of evapotranspiration from soil surface with a vegetation green cover that has 8 cm to 15 cm height with no water deficit in the soil. The organization had suggested four different methods to estimate the ET that are radiation balance method, Blaney Criddle method, pan evaporation method, and penman method[10]. Later, an important method, the Penman-Monteith methos, had been introduced by (FAO) to estimate the reference ET. This method is applicable for a specific study area when all meteorological parameters are recorded in this area[11].later, a new method was presented by Chen [12]. He estimated the daily reference ET by employing the least square vector machine and compare the result with other techniques such as ANN models and penman-Monteith equation. Different study was carried out by Kisi and Cimen [13] to estimate the ET. They built their model based on support vector machine (SVM). They showed that their model has reasonable result. For more investigation to present better models, Kisi [14] estimated pan evapotranspiration by employing different techniques that were utilized computer software.

Later, Kaya et al. [15] utilized the M5T method in addition to Ture formula to study the daily ET. They found that the result of the utilized methods varied significantly based on the hydrological characteristics of different zones. The presented models weren't applied to investigate the ET for arid and simi- arid regions. One of these studies was done by Shan, X et al. [16]. The researcher estimated the daily ET by using the (MARS) model and compared the result with four different models. It is found that (MARS) model has the optimum prediction. More recent, Jia, Y et al. [17] investigated the semiarid regions in China. They built their extreme learning machine model (ELM) by utilizing the sparrow search algorithm (SSA). They found that the computed result is the most accurate compared to the reference models.

In this study, a new mathematical model has been introduced. It is built based on multiple linear regression method (MLR). This model has been utilized to estimate the daily Evapotranspiration ET for Ramadi city in west of Iraq and to investigate the main factors that influence the ET Process. These daily ET values could be employed by researchers to estimate the monthly and annually quantities or average ET values. It is well known that the estimation of the water losses by evapotranspiration process is significant for water resources management which includes plans of irrigations, water supply system, water storage management in reservoirs. Thus, this research is important for planners to manage the water resources in Ramadi city. As a result, this will lead to better understanding and more accuracy of future predictions of water quantities to develop the plans which are used for water management based on the estimated ET.

Materials and Methods

Study Area and Meteorological Data

The daily data of evapotranspiration were collected from the digital meteorological station (model Daivs instrument, 3465, U.S.A) at the Upper Euphrates basin Developing Centre, University of Anbar, Ramadi, Iraq. This station is located at 33.43o N latitude and 43.33o E longitude and 50 m altitude above mean sea level (figure 1). The study area is distinguished by a semi-arid climate, little rainfall, a significant difference in temperatures between daytime and night-time, as well as a low relative humidity (between 19% and 82%). During summertime the temperature may reach 40^{o} C, while during wintertime, it may decrease to reach 9^{o} C and the wind speed may reach to 20 m/s. The dryness coefficient (evaporation/rain) ranges between 25 to 35 due to highly average annual evaporation reach to 3000 mm. The collected data include minimum temperature, maximum temperature, average temperature, wind speed, relative humidity, solar radiation, and evapotranspiration for periods from 23/11/2020 to 1/10/2022.

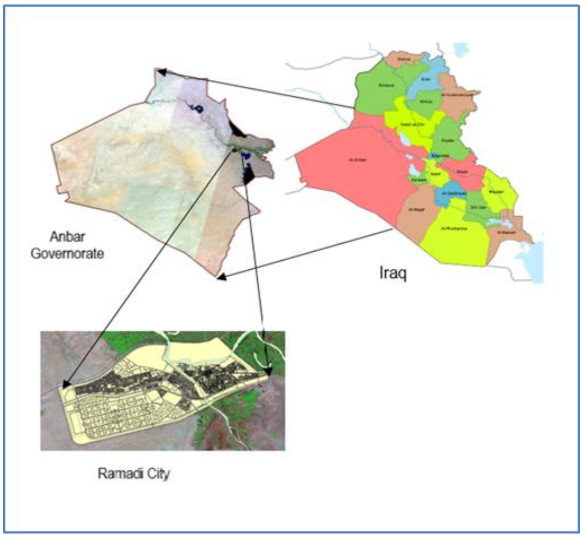

Figure 1. Ramadi city location

Multiple linear regression. Multiple linear regression is a popular approach for linear modelling that is used for investigating the relationship between a dependent (response) variable and many independent (predictor) variables[18-21]. The following equation can be used to calculate MLR [21].

$$y = b_o + b_i X_i + \cdots + b_k x_k + \varepsilon, i = 1,2, \ldots k$$

where, b_o , b_i, …., and b_k are constants of fitting y_i , $x_{1,i}$ ….. , $x_{k,i}$ represent the observations of each of the variables, respectively; ε_i is a random error term representing the remaining effects on y of variables not explicitly included in the model. The Method of linear regression seeks modelling of the relations between two variables according to the observed data to produce the best fit linear equation. statistical regression methods is the simplest models that can predict evaporation from its independent variables [22].

Results and Discussion

Selected dataset for the calibration and validation

The whole dataset, which comprises of daily meteorological data, was used to choose the calibration and validation data sets; T_max_T_min , T_av , wind speed WS, relative humidity RH% and solar radiation during the period from 23/11/2020 to 30/9/ 2022, calibration phase (80 % from dataset N=432) and for the validation phase (20 % from dataset , N=109).

Evapotranspiration Correlation Analyses. To understand the relationship between the daily evapotranspiration and the independent variables, The correlation analysis is adopted (see Table 1). The highest positive correlation was found with solar radiation, T_max and T_av were 0.863, 0.86 and 0.858 respectively, while high negative correlation was found with RH with - 0.840. Moderate correlation with wind speed was 0.570. The present investigations of the relationships of the evapotranspiration to T_max, WS, RH % and SR are proven to be consistent with previous researcher's work.

Table 1. The evapotranspiration dataset correlation coefficients

	ET	T_max	T_min	T_av	RH	WS	Solar_rad
Pearson Correlation	1	0.860**	0.838**	0.858**	-0.840**	0.570**	0.863**
Sig. (2-tailed)		.000	.000	.000	.000	.000	.000
N	432	432	432	432	432	432	432

** Correlation is significant at the 0.01 level (2-tailed).

Model development

Multiple linear regression (MLR). Regression daily evapotranspiration prediction models from climatic data were developed using the multiple linear regression, also to identify the parameters are relevant to the daily evapotranspiration predicted. During the MLR technique, important independent variables were used, which are directly related to the prediction of daily evapotranspiration. Finally, the MLR prediction models were accomplished. MLR of the evapotranspiration versus the significant independent variables and finally, the prediction models of MLR were achieved.

(a) Development of the MLR Model. The predictive equation for evapotranspiration was created by utilizing Stepwise and backward linear regressions. This method is capable to identify the significant factors that contribute to the evapotranspiration prediction. Table 2 demonstrate same regression results that were established by two different methods and the parameters that were chosen for MLR equation. The selected variables were temperature, solar radiation, and wind speed. It is found that the coefficient of determination was 0.952 which means that the independent variables can explained 95.2% of the variation of the evapotranspiration prediction. It is obvious that the relative humidity has no impact in the evapotranspiration prediction model were R^2 remained as ac constant value. The regression results for the calibration stage for Stepwise and backward methods are shown in figure 2 and figure 3 respectively.

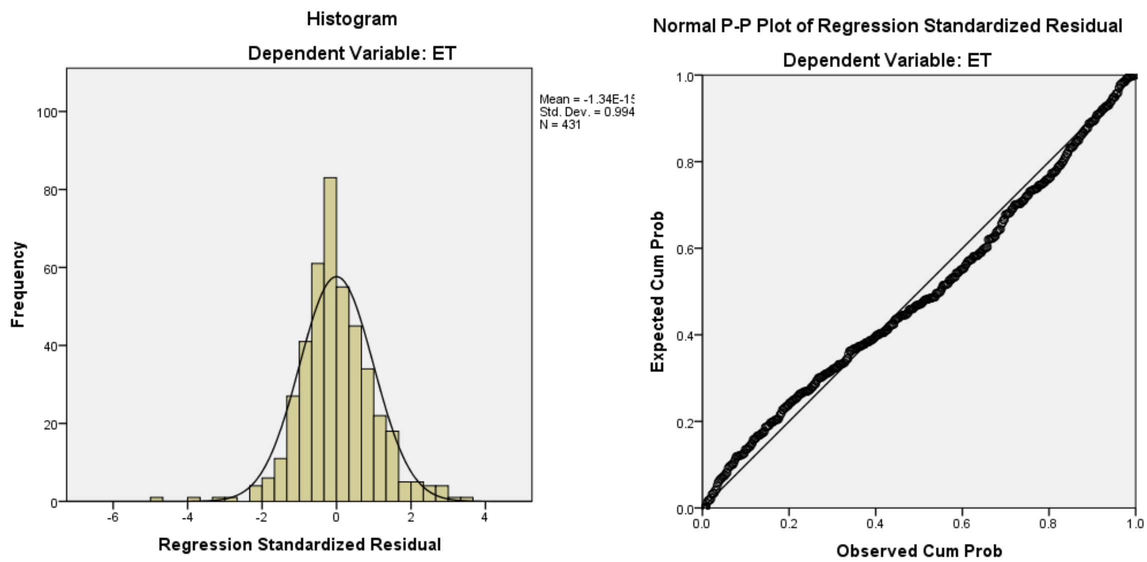

Figure 2. The regression results using stepwise method for dataset calibration stage

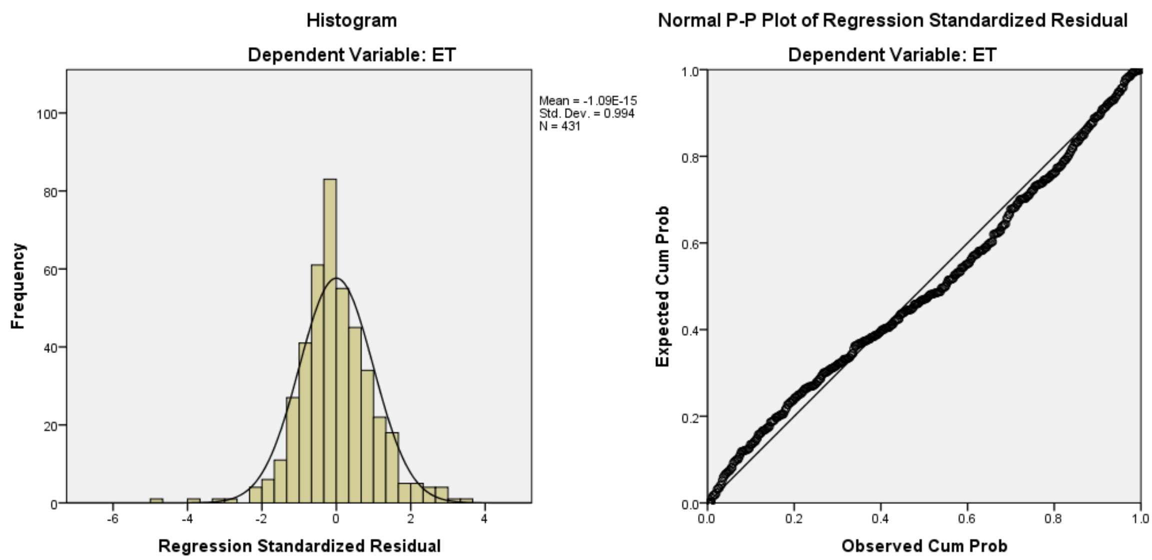

Figure 3. The regression results using backward method for dataset calibration stage

Table 2. Evapotranspiration developed model

Method	Model No	Equation	r	R^2 adjusted	Std error
Stepwise	1	=-1.347+0.015*solar_rad+ 0.025*T_min+0.711*ws- 0.025*RH+0.099*T_max	0.987	0.974	0.453
	2	0.491+0.017*Solar_rad+0.112*T_min +0.623*WS-0.035*RH	0.984	0.969	0.491
	3	-2.165+0.021* Solar_rad+0.145*T_min+0.643*WS	0.976	0.952	0.608
Backward	1	=-1.347+0.015*solar_rad+ 0.025*T_min+0.711*ws- 0.025*RH+0.099*T_max	0.987	0.974	0.453

(b) Model Validation. Model validation is required to adopt the developed model for predicting the daily evapotranspiration and to utilise the result for future plans of water management. For this purpose, a sample of 100 dataset number which represent 20% of the whole dataset was employed. To relate the predicted and observed evapotranspiration in MLR's stepwise and backward methods, Figure 4 was introduced. It shows that there is a strong relationship between the two types of data. The R^2 value was calculated as 0.923.

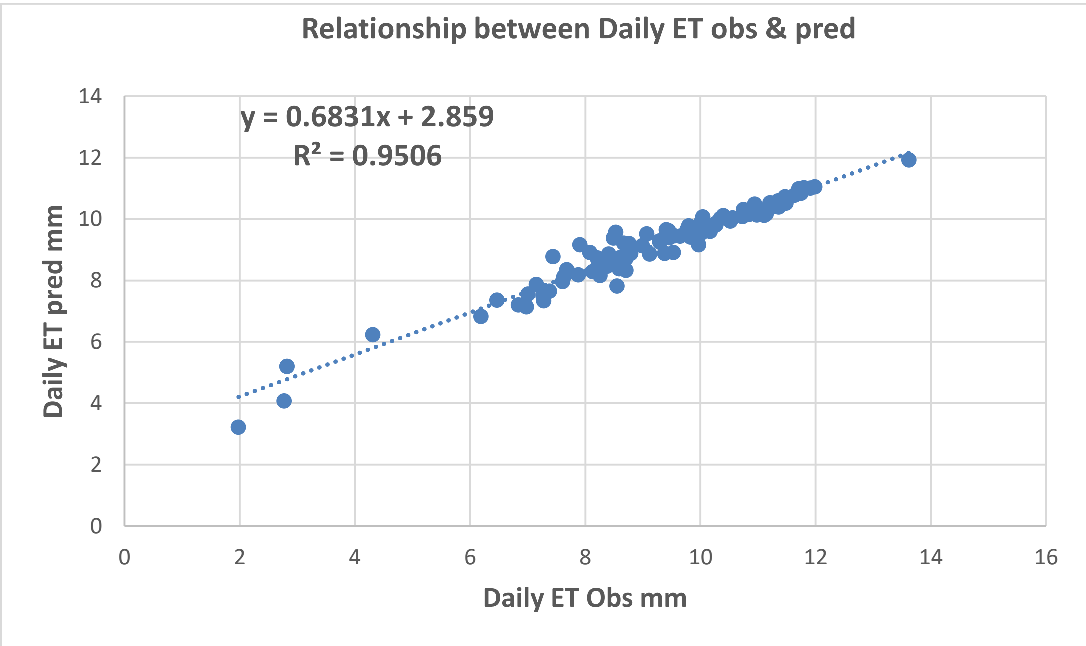

Figure 4. Scatter plot of daily evapotranspiration for data validation

The compression of the daily evapotranspiration between the predicted and observed data was plotted as shown in figure 5. It shows a good agreement for the all months.

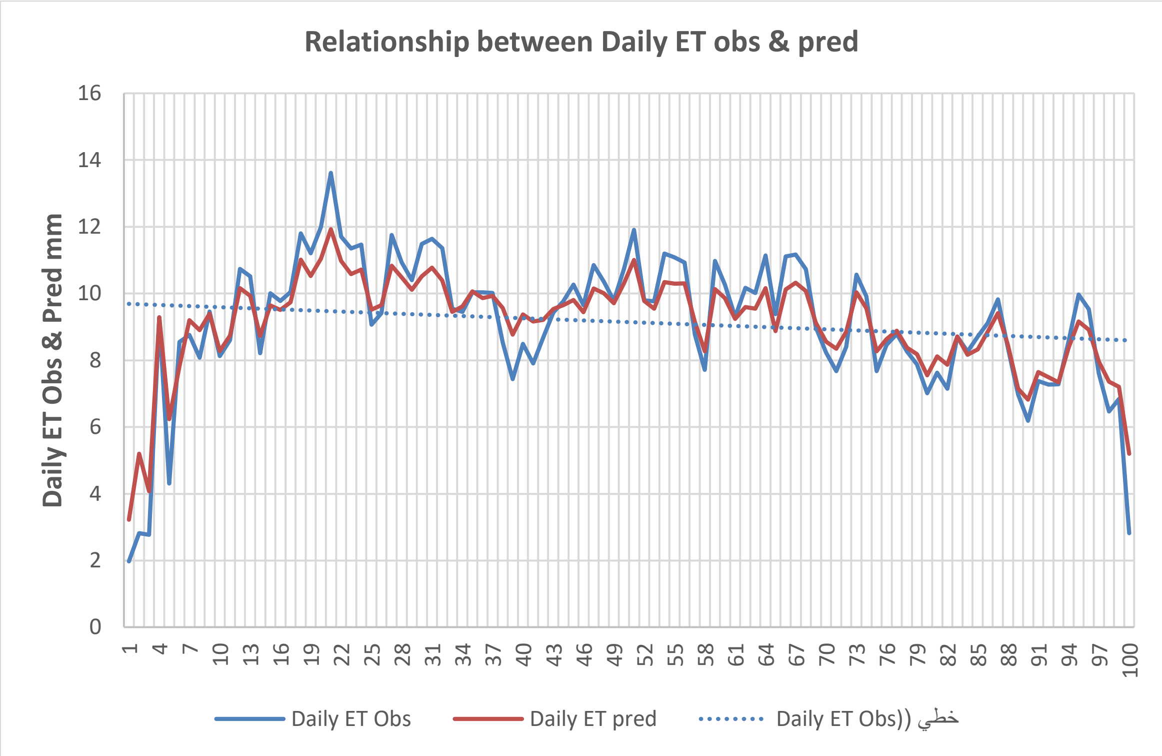

Figure 5. The comparison between predicted and observed daily evapotranspiration for validation data

To investigate the model performance, different performance indicators were used. It was found that the model has high performance according to R^2, RMSE and NAE values as shown in Table 3.

Table 3. The calculated Performance Indicators for Developed MLR Daily Evapotranspiration validation model

Performance Indicator	Predicted Evapotranspiration
r	0.975
R^2	0.95
RMSE	0.723
NAE	0.061
MAPE	7.465
NSE	0.978

The predicted results of developed daily evapotranspiration model are consistent with some related studies

Conclusion

In the current study, the authors presented a new mathematical model which is built based on multiple linear regression method. From previous studies, it is very difficult to find a model that capable of predicting the ET in Middle East region which characterized by the arid and semiarid environment. Therefore, the researchers presented this model which shows its capability to estimate the ET for arid and semiarid regions. In addition to above, the researcher investigated the independent variables that influence the ET. The result shows that the solar radiation has the greatest impact on ET value, while the relative humidity has no effect on the ET. Furthermore, the wind speed shows moderate influence on ET. To sum-up, the current model, can be employed to estimate and quantify the daily ET accurately for arid and semiarid regions that have similar weather conditions to Ramadi city especially at the Middle East. This will lead to better planning to manage the water resources at the region.

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Application of Weap Model for Managing Water Resources in Iraq - A Review

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Abstract. Due to the construction of dams in upstream countries and the usage of surface irrigation systems, Iraq has been experiencing a water shortage. Due to population increase and the expansion of the industrial and agricultural sectors, the country is having difficulty keeping up with the rising demand for water. Many previous studies carried out to optimize the water resources management in Iraq over the two decades using Water Evaluation and Planning (WEAP) modeling considering various aspects and different water resources throughout Iraq provinces. This study aims to find out if the WEAP modeling is reliable to optimize water resources management, fourteen previous studies were reviewed to figure out the fields they focused on, the study limitations, and the obtained results. It was found that the WEAP model is reliable for assessing, planning, and optimization of water resources management.

Introduction

The current framework of the water allocation system is becoming extremely inefficient as the demand on available water resources increases [1]. The inadequate water management practices used in the past are to account for the existing system's failure to satisfy the current water demands [2]. The development and management of water resources can be influenced by interactions between several sectors [3]. Due to population expansion, climatic changes, and economic development, there is intense rivalry for access to water resources on a global, national, and local level [4]. A substantial association exists between the pace of water consumption, urbanization, and rising living standards, and this relationship is straining the available water resources [5]. Climate change has a significant impact on the hydrologic cycle, in addition to the reasons mentioned above [6]. Even under the most optimistic projections of emissions and climatic sensitivity, the effects of climate change are unavoidable [7]. As a result, the planning of water resources requires a multidisciplinary strategy that incorporates all the system's intricacies. The only effective management technique, then, can be the design of water allocation regulations that use an integrated approach [8]. The regulation of both naturally occurring and artificially created water resource systems for the benefit of people and the environment is known as water resources management [9]. The following services are included in the management of water resources: To provide enough water for human societies, the environment, and domestic and agricultural usage, as well as for hydropower generation, water transportation, recreation, and sewage treatment to improve water quality, aquatic life, and wildlife, among other uses. To cope with surplus water and preserve human communities and the environment from calamities caused by flooding, inundation, and sediment**.** To develop social consensus to establish appropriate policies and programs that coordinate trade-offs between various water uses while considering social limits and disputes [10].

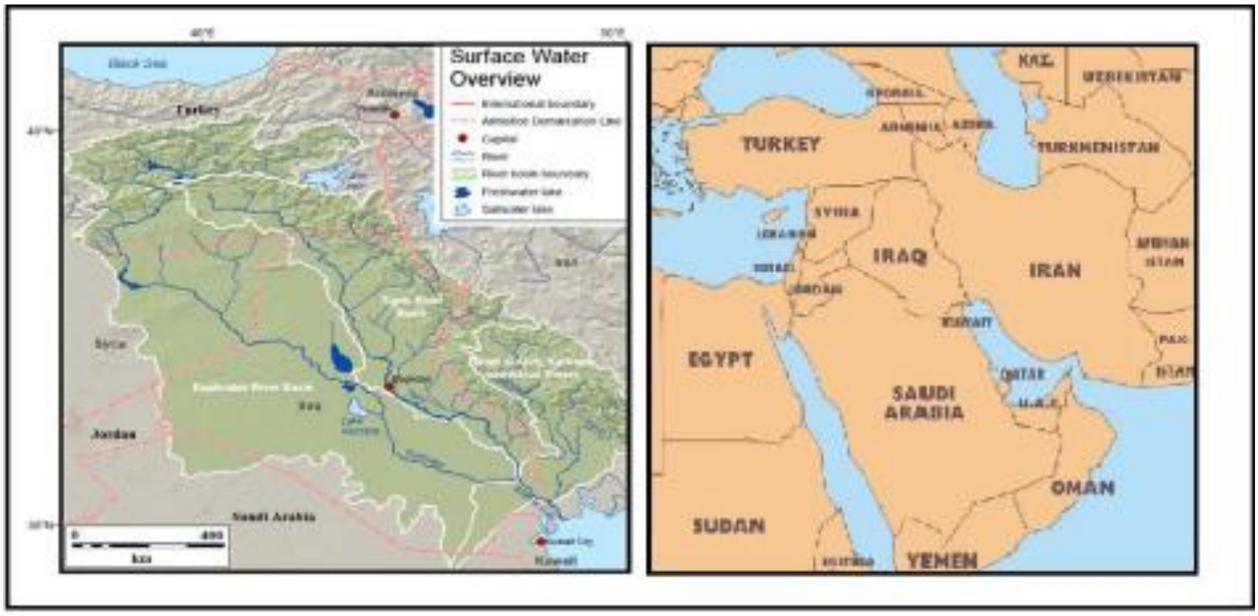
The typical supply-oriented simulation models are generally insufficient. An integrated strategy for water development has arisen over the past ten years, placing water supply projects in the context of difficulties with demand, water quality, and ecosystem preservation [11]. WEAP is a powerful computational system for water assessment and planning that evaluates and implements IWRM. Its ultimate goal is to simulate the water conditions of the present and the future in a chosen study region to estimate water supply and demand. The Engineering Hydrologic Center of the US Army provided assistance to the Stockholm Environment Institute in the development of this model. Both agricultural and drinking water storage systems can use it by maintain information on supply and demand and simulating water demand based on the priority-preference data supplied to the model [12], WEAP21 can be utilized as both a database tool and a forecasting tool [13]. The studies successfully used in water quality modeling, urbanization, climate change research, hydrologic simulations, groundwater management, and irrigation water management are highlighted. Since its inception, WEAP has been used in a variety of sectors worldwide, but this manuscript only highlights a small number of those uses to illustrate how well-accepted it is [14].

2. An overview of the reality of water in Iraq

The Tigris and Euphrates Rivers serve as the lifeline that has long sustained Iraq's civilization, and they continue to perform this function [15]. Water is acknowledged as the most fundamental element that governs human existence on Earth. Iraqi people have been economically, politically, intellectually, and ideologically linked to these two rivers for thousands of years [16] since they were the catalyst for the birth of a civilization that influenced the rest of the globe. Since Iraq is geographically located among the riparian countries, forcing it to be a downstream country. Due to human factors, such as those relating to neighboring countries, who follow their own water policies without taking into account Iraq's water and historical rights in these two rivers, in addition to the establishment of large water projects, they now form part of a faltering ecosystem [17]. Due to the water shortage in the Arab world's considerable negative effects on the region's economy and development, its strategic role has been enhanced by the region's low average annual rainfall, which reaches maximum levels of (166 mm), as well as the reduced amounts of water flowing from upstream to downstream countries [18, 19]. According to studies, the region would experience a worsening water deficit in the future, whether it be in the form of surface water or groundwater [20]. This situation afflicted Iraq since there are no other water supplies that are suitable for use, and Iraq is mostly dependent on surface water, represented by the Tigris and Euphrates [21]. One of the areas most severely impacted by climate change is the Middle East suffering from drought and reporting high record temperatures [22, 23], which are anticipated to rise and have a substantial impact on both populations [24]. The amount of rainfall in Iraq will significantly decrease as a result of these climate changes [25], which will therefore have a negative impact on the Tigris and Euphrates flow. The Tigris and Euphrates rivers will dry up if the neighboring nations continue to implement their water policies and long-term plans for their water projects [25, 26]. The rivers Tigris and Euphrates, as well as their tributaries, provide most of the water for Iraq. The watershed area of the Euphrates River extends around 125,000 km2 (28.2%) in Turkey, 7,600 km2 (17.1%) in Syria, and the remaining 177,000 km2 (39.9%) in Iraq. However, it should be recognized that a portion of the river's catchment area (66,000 km2) is located in Saudi Arabia.

Despite this, the region rarely experiences precipitation, hence the river does not receive any water from Saudi Arabia. The Euphrates River typically has high discharges from March to June, when 63% of the annual flow passes through. The minimum flow phase is between July and August [27]. The Tigris River has a length of 1,718 km and a drainage area of 235,000 km2, which is divided among four countries in the following proportions: Turkey 17%, Syria 2%, Iran 29%, and Iraq 52% (Figure 2). The river's source is in southeast Turkey, close to Lake Hazar. It extends for roughly 45 km toward the Syrian-Turkish border, forming the border between these two countries, before reaching into Iraq 4 km north of Fieshkhabur, close to Zakha city.

Five major tributaries feed the main river in Iraq over its length which are Khabur, Greater Zab, Lesser Zab, Adhaim, and Diyala (Figure 3). These tributaries originate primarily in the Zagros Mountain range.



They convey both snow melt and rainfall, and as a result, the Tigris flow changes dramatically depending on the timing of these two types of flows [28].

Figure 1. the map of Iraq

3. WEAP Model

A computer software named WEAP (Water Evaluation and Planning) is applied to plan water resources [29]. The Stockholm Environment Institute (SEI) created the WEAP model, which stands out for its policy emphasis and integrated approach to simulating water systems [30]. By defining the relationship between regional water supply and demand utilizing the fundamental concept of water supply and demand balance, the WEAP Model is widely used to study the distribution of water resources [31]. For integrated water resource planning, the model applies traditional linear programming to resolve problems with water resource allocation at each Time-step of analysis

[32].By adopting alternate assumptions about how different water demand and supply strategies will affect the future, the WEAP model may also construct and assess many future scenarios [33]. This program implements a continuous rain-runoff hydrological model that uses a straightforward algorithm and is based on an area of study made up of a number of connected sub-basins that integrate the various land uses and coverages over the entire study region. Additionally, this model features two water receptors or buckets that divide superficial runoff, infiltration, evaporation, base flows, and percolation depending on a collection of climate data that incorporates variables for temperature, precipitation, relative humidity, and wind speed [34]. The WEAP modeling tool is comprised of a number of modules, one of which is the hydrological module, which includes a rain-runoff model with five distinct calibration options. The water allocation module was an additional one that was utilized during this project. The latter is a decision-support system that makes it easier to manage water resources by maximizing the fulfillment of various users' expectations [35]. This software's key benefit is that it produces analysis scenarios depending on border conditions such as political and technological limitations, priorities, and costs, as well as other elements that affect supply and demand in a region. Incorporating these possibilities into the model allows for the creation of variables that can be independent of one scenario from another, which assists in the process of optimizing the model [36].

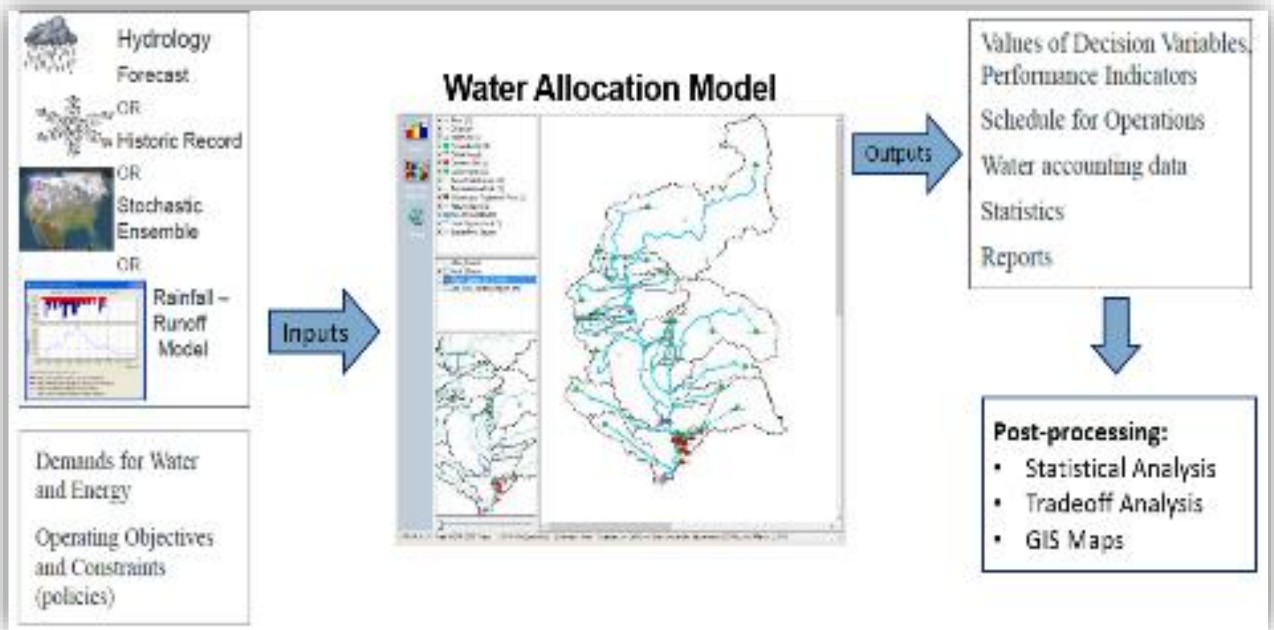


Figure 3. General Workflow FOR WEAP [36]

In addition, WEAP provides additional advantages due to its adaptability in integrating various water resource management elements for decision-making, including a sectoral analysis of water demand, monitoring, and quality, along with the ability to set priorities for water distribution and consumption, as well as the ecosystem [37].

Other case studies around the world that evaluated the effects of climate change on supply availability, variations in water demand for various economic sectors, as well as data on unmet water demand and its correlation with population dynamics requirements and cost-benefit projections for future scenarios, have also been successful in using this water modeling tool [38]. Every schematic node and link in the system has a water mass balance that WEAP keeps track of on a monthly time step [39].

The modelling procedure of the WEAP tool consists of four key processes, which are summarized in the flowchart below [40]:

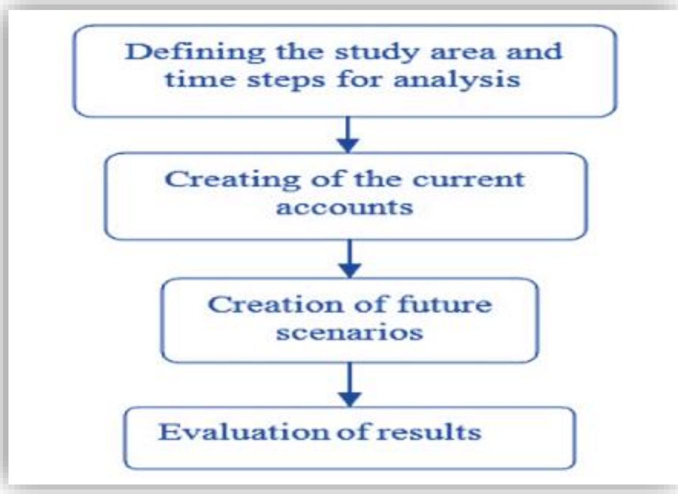


Figure 4. Key steps in the modeling process within WEAP tool [40]

3.1 Selected applications of WEAP tool in Iraq

Iraqi has employed the WEAP software in a number of water-related projects. Modeling the impact of climate change on water resources and ecosystem services, water use planning, environmental planning, model creation for hydrological engineering projects, and water supply augmentation for different cities have been some of the primary areas of application. In this part, we present a selection of earlier research projects that were conducted in Iraq using the WEAP modelling

A. **Isam M. Abdulhameed in 2022** investigated the effects of reusing treated wastewater in agriculture on water conservation and the expansion of agricultural areas to grow a variety of crops in western Iraq (using Ramadi City as a case study). The study used the Water Evaluation and Planning System (WEAP) for the years 2018 through 2035. The four steps of this study's methodology are as follows: (I) assessing the Euphrates River's water supply in light of decreased water imports as a result of the construction of dams in Turkey and Syria; (II) determining the current and future water needs of the residential, industrial, and agricultural sectors; (III) increasing water productivity (WP) by using less water; and (IV) calculating the financial benefits of more efficient water use. The findings indicated that Haditha Dam, which is regarded as the vital water storage facility for Iraq's central and southern regions, would have a significant storage capacity issue in the upcoming years. The analysis showed that in order to reduce the water deficit, it is imperative to apply innovative water management practices and explore alternate sources of water supply [41].
B. **Ameen Noon in 2022** used a WEAP model to manage water resources in accordance with the development plan for 2040. The reference scenario and the scenario utilizing wastewater treatment facilities were both applied to the domestic sector based on the base year to determine water consumption. The findings show that the reference scenario for 2040 has a 719.15 MCM water demand for inhabitants (Urban and Rural). The water demand for urban residents alone in the treatment plant scenario for the year 2040 was 373.77 MCM, of which 56.06 MCM was actually utilized and 317.70 MCM returned to the sewage network could be reused in the residential, industrial, or agricultural sectors. These will contribute to addressing Iraq's problem with a shortage of water [42].
C. **Fouad Saeed in 2022** conducted research on the relationship between conflict resolution and the management of water resources in light of climate change. A novel methodology has been developed for this purpose; the daily minimum temperature, maximum temperature, precipitation, and streamflow recorded in 1990-2019 as a Reference Period (RP) for 22 climate stations and 7 hydrologic stations for streamflow distributed over Tigris River Basin were projected into three

future periods: 2021-2040 (P1), 2041-2060 (P2), and 2061-2080 (P3). The same RCPs, future periods, and GCMs were also used to predict the irrigation and environmental water demand for twelve provinces inside the Iraqi portion of the Tigris River Basin. Furthermore, based on predicted population increase and per capita water use, municipal and industrial water demands were estimated. With the assistance of Water Evaluation and Planning (WEAP), the adaptation plans were place a multi-criteria decision-support VI system; to sustain the current conditions of water usage as scenario-1 (S1), increasing irrigation water efficiency to 70% was adopted as scenario-2 (S2), and decrease per capita water use for domestic to reach 450 liters/day while computation in scenario-2 was proposed as scenario-3 (S3).

- The outcomes and findings showed that the Tigris River Basin is possible to become hotter and drier, with the worst case scenario in P3 and RCP 8.5 showing that streamflow will decline by 10, 17, 1, 21.6, 48.5, 17, 3, 64.6, and 76.5% for MDW, GZW, DDW, DBW, ADW, DRDW, and HDW, respectively. There will also be significant changes in the peak timing of streamflow for MDW, GZW, and D With a smaller magnitude, the baseflow allocation to the streamflow has the same trend in RP. Additionally, compared to RP, the water demand for agriculture, domestic, industrial, and environmental uses are predicted to rise by 9.1, 197, and 3.9%, respectively [43].

D. **Ameen Noon in 2021** investigated the use of the Water Evaluation Model (WEAP) to predict future water demand and unmet demand for the province of Anbar in Iraq. The study took into consideration two scenarios: the reference scenario (years 2008 to 2019) and the tax on water scenario (financial sums imposed on the water in the residential sector). It was discovered that applying this taxing decreased the amount of water utilized by approximately 25%. According to the study's findings, the following conclusions can be made:

1- The study's findings suggest that the Euphrates River's flow rate may decline in the years to come, which may cause the demand for water to exceed the supply and lead to a water shortage.

2- The findings of the water demand for the three domestic, industrial, and agricultural sectors for the year 2040 were 2819.35 million cubic meters, and the unmet water demand was 153.19 million cubic meters, according to the reference scenario.

3- The findings of the water demand for the three residential, industrial, and agricultural sectors in 2040 were 2,639.54 million cubic meters, and the unmet water demand was 126.22 million cubic meters **.**[44]

E. **Mustafa Al-Mukhtar in 2021** concentrated on using WEAP to predict the water supply and demand in Baghdad. Data from 2000 to 2018 were utilized to feed the model, whereas data from 2008 to 2016 from Baghdad station (Sarai) were employed to calibrate and validate it. This research aims to figure out how much water should be distributed across Baghdad's residential, agricultural, and industrial sectors under the various scenarios that could occur in the future. The five future scenarios—the reference scenario, which assumes normal population growth, the high population growth rate scenario (5%), the halved flow scenario, which reduces the Tigris River's streamflow to half its previous levels, the combined scenario (high population growth rate scenario plus halved water flow scenario), and the dry water year method scenario—all demonstrate that the demand for and supply of water are not met. Future unmet demand will vary, but it will occur in different percentages and years. For instance, the unmet demand will be present throughout the entire future period according to the reference and high population growth rate scenarios, with the exception of 2024, which will not experience unmet demand. The greatest amount of unmet demand will occur in the final five years from 2036 to 2040. Additionally, all water demands for all sectors will be supplied from 2028 through 2033 and 2035. The last three possibilities also demonstrate that there would be unmet demand during the study period (2020-2040). The combined and halved flow scenarios will have the most unmet demand, whereas the other scenarios would have less unmet demand [45].

F. **Isam M. Abdulhameed in 2021** examined predicting the volumes of wastewater and greywater for Ramadi city throughout the ensuing years (2020-2040). The study also suggests the possibility of utilizing these amounts again as a renewable water supply. These liquid wastes are 99.9% water and 0.1% particulates. In order to minimize the effects of dust storms, the study suggests using the treated wastewater to plant a green belt around the city and using greywater to irrigate vegetables and fruits. The study employed water evaluation and planning (WEAP) to assess water use and wastewater reuse in the present and in the future. According to the findings, the Euphrates River will receive 63 million m3 of domestic water this year, along with 11.7 million m3 of greywater, which will meet around 22% of Ramadi's irrigation needs. Domestic water use would rise by around 24% in the next years, reaching 78.4 million m3 in 2030 and 95.5 million m3 in 2040, while greywater use would rise to 21 million m3 in 2030 and 34.3 million m3 in 2040 [46].

G. **Amir Nima M. Al- Zobaei in 2021** investigated the water resources and management strategies in the Yusufiya sub-district, one of the most significant agricultural regions in the Baghdad governorate. As the study demonstrated methods for managing water at the local level, it concentrated on a very critical challenge facing the aspect, namely (the mismanagement of water resources) and the associated phenomena of waste and pollution, which are among the most significant internal risks that threaten the citizen's water security. Several methods to reduce water waste were also introduced by the Water Evaluation and Planning System (WEAP), including the construction of temporary concrete water storage to supply the agricultural area, the use of closed irrigation systems, the covering of irrigation canals with solar panels, and the lining of irrigation canals to ensure sustainable development and water management in the area. Water supply requirements for the area are (242.13) million m3 per year in 2020, (348.04) million m3 per year in 2025, and (454.05) million m3 per year in 2030 [47].

H. **Arkhawan Jawhar Sharef's in 2021** researched the management of water resources in international basins including the water authority in the Greater Zab River Basin (GZRB) in the Kurdistan area of Iraq using the WEAP model using the past 33 years' debt and the revalued GZRB performance. Three possibilities that consider: According to the initial reference scenario that MOP proposed, which was based on the average population growth rate of 3.4%, water supply in August and September of 2046 will not be able to meet demand. In the second scenario, where there is a rapid population increase and a ratio of 5% that has been identified by the MOP, the water supply is unable to meet the demand for water and there is a deficit in August and September of 2032. In the third scenario, the Tigris River's monthly environment river flow need in this scenario is 50 m3 per second, and the conclusion indicates that there will be unmet demand in August and September of 2021 [48].

I. **Abu Baker A. Najm in 2021** investigated how to enhance the Ramadi irrigation project with 28342 hectares and an annual budget of 326 million m 3 for the time period (2018-2019). The findings showed that the annual water use totaled 111.5 million m 3 and accounted for 34.2% of the Ramadi irrigation budget. For Ramadi irrigation, the annual production was 39.3 million kg, and the overall economic benefits were 16.04 million dollars. The report suggests two options for enhancing the agricultural area. In the first scenario, water volume increased from 111.5 million cubic meters per year to 272.12 million cubic meters per year. This resulted in an increase in annual productivity from 39.3 million kilograms per year to 144.57 million kilograms per year and an increase in economic return from 16.04 million dollars per year to 65.25 million dollars per year. When using additional pumps for projects 2, 3, and 5, the second scenario recorded increased annual production for the current year from 39.3 million kg to 192.27 million kg and economic return from 16.04 million to 86.79 million. Additionally, while using the second scenario, the flow loss increased from 16.72 million m 3 per year for the present year to 48.47 million m 3 per year, which is equal to 15% of the water budget for Ramadi irrigation [49].

J. Using the WEAP program, **Sura Mohammad in 2020** assessed water usage and future demand in the Upper Euphrates Basin, Iraq. Five scenarios have been considered, with the reference scenario illustrating the effects of an increase in water demand from (100) million cubic meters in 2015 to (397) MCM in 2035 with a water deficit of (38) MCM. The water deficit is reduced from (38-2.9) MCM by using conventional irrigation techniques. While using groundwater, the shortage was reduced from (38-26) MCM. Regarding the wastewater reuse scenario, the shortage dropped from (38-35) MCM. The water deficit did not decrease after reducing the per capita share [50].

K. To obtain the K c parameters (Kcb and Ke) and determine the water requirement for various soil textures, **K. Abu Baker A. Najm in 2020** employed the Dual-K c approach within the FAO-56 document through water evaluation and planning (WEAP). Results were compared to Single-Kc method outputs for both summer and winter crops as well as trees. Results showed that when using the Dual-K c strategy, water usage was higher than when using the Single K c technique, with the exception of the tomato, eggplant, and broad bean crops, which had decreases of 5%, 4%, and 17%, respectively. Additionally, there were differences in the coefficient values between the two approaches. For example, the Dual-K c approach increased the coefficient for wheat by 62% with 20% during the initial and final stages while the values for trees ranged from 26 to 58% throughout the year with more variations for other winter and summer crops. Depending on the soil texture, crops have various water needs. With varied irrigation intervals of 11 and 12, the sandy loam and clay loam had differing net water requirements for wheat, while the silt loam recorded a water need of 417 mm with 8 irrigation intervals [51].

L. The Water Evaluation and Planning (WEAP) models were used by **L. Ahmed Z. Jaber in 2018** to evaluate the Shatt Al-Hillah basin's management system under several scenarios. Three scenarios were used to evaluate the trend in watershed supply and demand. The first scenario is considered to be a case of high population expansion, whereas the second relates to demand side management (DSM) effects. Evaluation of DSM and Non-Revenue Water (NRW) effects was conducted in the third scenario. Results demonstrate that reducing NRW and implementing DSM can greatly decrease the impact of unmet demand on mitigation [52].

M. **Imran Alslevavni in 2017** investigated the development of a conceptual groundwater model for several locations in the province of Nineveh. Groundwater is modeled in three dimensions. With the aid of a conceptual model created with the application, a numerical model called "MODFLOW" has been adopted (GMS). Using the (WEAP) tool, this model was turned into a numerical model and connected to the water surface model. to minimize the supply limitations for various water needs [53].

N. **Hedi Rasul in 2010** investigated the management of the water resources of the Alana valley in the Kurdistan Region of Iraq for the years 2002 to 2015 using Water Evaluation and Planning (WEAP). They adopted six scenarios of future water demands, including a reference scenario with actual data used as the base scenario for all other scenarios and any sub-scenarios that were necessary, and a quality added scenario where the quality of demand sites were initiated in accordance with minimum requirements, a scenario for groundwater addition to determine the anticipated amount of groundwater withdrawal to meet the demands, Gali-Bla Dam data from the final design report were used in this reservoir addition scenario. a scenario for climatic change in which the reference scenario is utilized to create sub-scenarios of climatic change, as in WEAP's primary usage of water years (Very wet, Wet, Normal, Dry, and Very Dry) to acquire runoff in various circumstances and compare its outcomes to other scenarios, A scenario using advanced irrigation techniques, such as drip irrigation and sprinklers, is used to simulate irrigation and use a downstream requirement scenario to investigate the recent flow decline in Gali-AliBeg fall, which is the primary downstream requirement in the region as a summertime recreation destination, Results from the WEAP software show that annual runoff in a typical year was about (69.8 MCM), non-agricultural needs only comprise 7.3% of total demands, and overall demand was (8.8 MCM), with Khalifan village accounting for about 75% of non-agricultural demands. Even though there is a high need for irrigation, only 486 ha, or 10% of all arable land, is irrigated. The remaining 90% depends on rain or is not cultivated. This region needs a reservoir or network of reservoirs with a capacity of at least 5MCM to meet summertime demands, which are now primarily met by groundwater resources [53].

3.2. Evaluation and criticizing the previous studies

The aforementioned research studied water resources management in Iraq focusing on various aspects, for example, the optimization of the water resources in the present and future, reusing the treated wastewater, improving the irrigation water systems, and reducing water waste. The studies conducted for a pre-allocated area throughout Iraq provinces and different water resources, the optimization of water resources management studies carried out by suggesting a certain scenario of the water supply/demands in the present according to the available data and anticipation of the future data. Table 1 shows the suggested scenarios by the previous studies in Iraq, and figure 6, also, shows the percentage of each scenario used by the researchers:

Table 1. Scenarios suggested in previous studies

Researcher	Scenario													
	Reference	Reuse Waste Water	Increase Irrigation Effecincy	Reduce Water Waste	High population Growth	Reduce domistic water use	Ground water	Environment	Reduction in the Streamflow	Increase in the Streamflow	Increase Plants Producttion	Demand side management (DSM)	DSM and Non-Revenue Water (NRW)	Water Quality
Isam M. Abdulhameed in 2022	■		■				■							
Ameen Noon in 2022	■	■												
Fouad Saeed in 2022	■		■			■								
Ameen Noon in 2021	■					■								
Mustafa Al-Mukhtar in 2021	■				■			■	■					
Isam M. Abdulhameed in 2021		■												
Amir Nima M. Al-Zobaei in 2021				■										
Arkhawan Jawhar Sharef's in 2021	■				■			■						
Abu Baker A. Najm in 2021										■	■			
Sura Mohammad in 2020	■	■	■			■	■							
Abu Baker A. Najm in 2020			■											
Ahmed Z. Jaber in 2018					■							■	■	
Imran Alslevavni in 2017							■							
Hedi Rasul in 2010	■		■	■			■	■	■					■

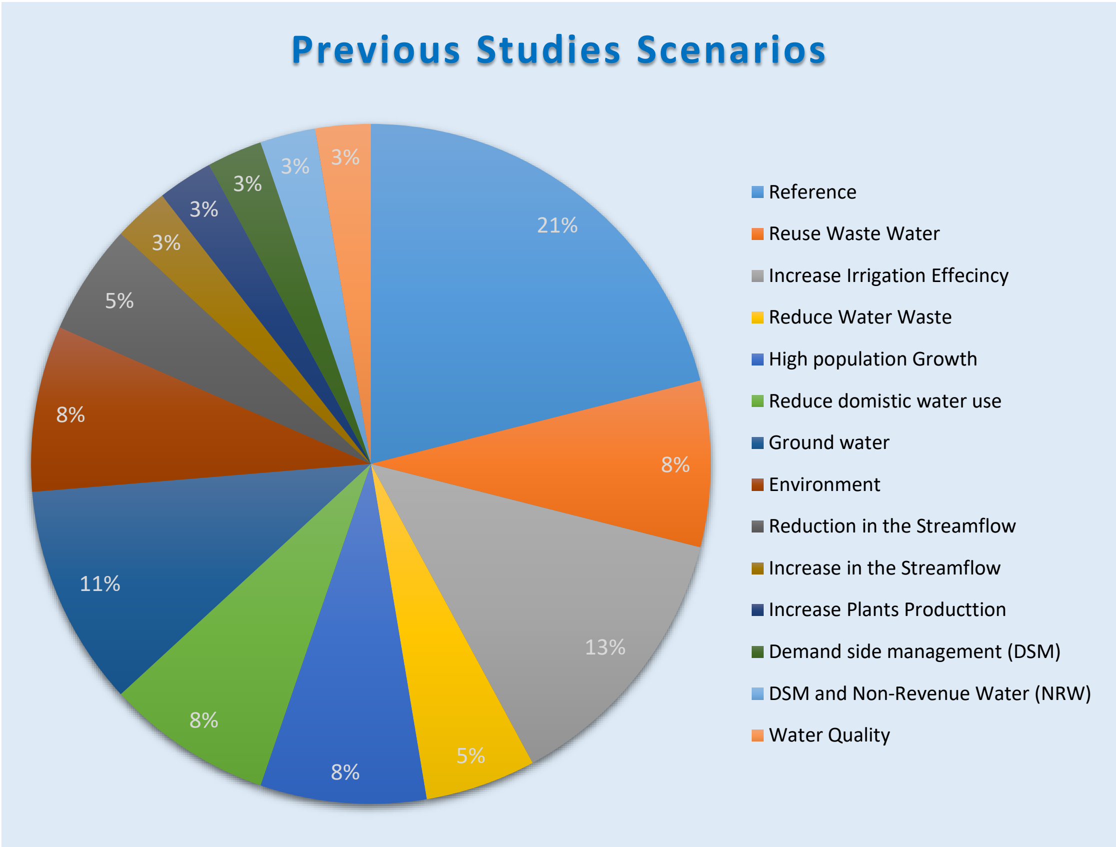


Figure 5. The percentage of the scenarios suggested in previous studies

Table 1 and figure 5 show that in each study, there are one or more scenarios suggested to study water resources management, the scenarios were suggested according to the focus of the study and the available data. They also show that the reference and increase the irrigation water efficiency scenarios were the highest percentage of suggestions in previous studies with 21% and 13 % respectively, while other scenarios used by only one study such as water quality and increase plants production.

5. Conclusion

- Iraq is facing a water scarcity challenge in the present and near future and these challenges should be addressed to optimize water resources management.
- Many researchers studied water resources management in Iraq over the previous 13 years using Water Evaluation and Planning (WEAP) model focusing on different aspects and examining various options.
- The studying of water resources management optimization was conducted for the pre-allocated areas and the different studies focus on suggesting certain scenarios for the water supply/demands in the present and future based on the available data.
- The future water supply/demands were anticipated according to different methods using the technical assumption.
- After reviewing the previous studies' inputs, limitations, and findings, the Water Evaluation and Planning (WEAP) model is considered to be reliable and precise to study and evaluate water resources management optimization.

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One-Dimensional Model to Study the Sediment Transport of the Euphrates River Upstream of Ramadi Barrage

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Abstract. One of the main variables influencing the Euphrates River's river morphology is sediment. The design engineer's principal aim during the construction of hydraulic structures like a dam or irrigation channel would be sediment transport. The Euphrates River is the biggest in Iraq and has considerable interest because of strategic and environmental conditions regarding water resources project planning, agriculture, hydropower, and industrial scope. Therefore, to reduce the issues brought on by changes in river morphology, the study of sediment movement and the features of river beds is crucial. The river reach is selected upstream Ramadi barrage. In this study, a hydraulic analysis of the sediment transport model was created using the Hydrologic Engineering Center's River Analysis System (HEC-RAS). The HEC-RAS model was run for 70 days to calibrate the model results with field measurements. We found an excellent convergence between them, which allows the model application to predict the amount of sedimentation upstream of Ramadi Barrage. The model's output indicates that the amount of sediment retained by the upstream Ramadi Barrage is 2749 tons per day.

Introduction

Excessive deposition and bank erosion occur in rivers as a result of both natural and human processes. Depending on the location and hydrological regime, the long-term impacts of erosion and accumulation result in significant changes in river geomorphology. River sediment transport is influenced by several variables, including sediment type and particle size, drainage area size, land use and vegetation near the catchment areas, temperature and climate change patterns, flood occurrences, and basin slope [1–3].

3. The process of sediment transport and sedimentation upstream of the Ramadi Barrage caused a problem that resulted in a rise in the level of the river bed and negatively affected the functions of the source. This problem arose in the early years when the water was impounded in the river section at the front of the Ramadi Barrage, but having frequent high discharges at that time greatly reduced the problem [4]. In recent years, due to the increasing water scarcity and the significant decline in the discharges of the Euphrates River, the sediment problem in the river section before the dam has increased to a large extent, which affects the characteristics of the river section and the operational viability of the structure, as well as the continuous increase in the cost of sediment removal [5,6]. All this requires finding some practical solutions to this issue. The research simulates the sediment transport through the Euphrates River upstream of the Ramadi Barrage and the impact of this deposit on the operation of the project. This study will help to manage the Ramadi Barrage operation and estimate the annual quantity of sedimentation upstream of the Barrage.

The modelling of rivers needs more physical relationships for sediment transport processes. It is challenging to present the fluvial processes because they are complicated and controlled by continuity, flow resistance, sediment movements, river bank stability, and variations in channel width [7–9]. Typically, modifications in the river bed profile, slope, channel pattern, and river channel roughness occur concurrently with changes in the river's width. Any factor that is forced on the river will be absorbed with a combination of the aforementioned reactions since all those changes are connected and maintain a dynamic state of balance [10–12].

The HEC-RAS 1D model is frequently used to simulate sediment transport. The geometry of river cross-sections is modified at each time step. This process is achieved by moving the entire cross-section. Also, it can be achieved by assuming an equal amount of deposition and erosion. The ability to simulate a large network of streams, channel dredging and encroachment options and the use of several sediment transport equations are all noteworthy features. The model HEC-RAS bases its computations in large part on the fundamental principles underlying fluvial hydraulics and river mechanics.

2. Materials and Methods

2.1 study area

The research is related to Ramadi Barrage, one of Iraq's most important water resources projects which was constructed in 1957 on the Euphrates River. The Euphrates River, which flows through Turkey, Syria, and Iraq, is regarded as one of the international rivers [13–15]. In Anbar, the Euphrates River stretches for about 450 km, accounting for 43% of the entire length in Iraq [16–19]. In this study, a part of the Euphrates River upstream of Ramadi Barrage was selected, as shown in Figure 1, with a length of 3000 meters, since the problem of sedimentation resulting in this part is affecting the operation of the Ramadi Barrage [20–22]. The Barrage is located in the city of Ramadi, which is the largest city in the Anbar Governorate in Iraq. Ramadi Barrage is 209 meters long and consists of a concrete building with 24 openings, each 6 meters wide and 8 meters high. The Barrage is designed to discharge 3600 m^3/s at the height of 51.50 meters above sea level.

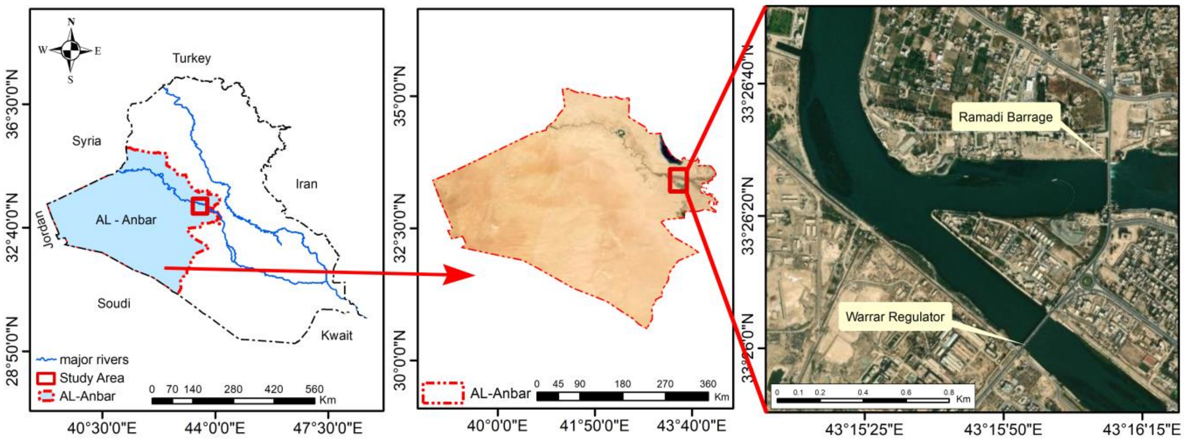

Figure 1.The location of the study reach

2.2 Field measurements

To accurately mimic the sediment data analysis of a specified river reach, the HEC-RAS 6.3.1 model needs precise input data. The input data for the simulation model can be divided into three categories: geometric data, quasi-unsteady data, and sediment data.

The river survey works included 24 selected cross-sections along the study area. The river's topographical characteristics and geometric changes determine the distance between the cross-sections. Using the Acoustic Doppler Current Profile (ADCP) technology, the following parameters were measured: bed elevation, top breadth, water level, area of cross sections, water velocity, and discharge. SonTek River Surveyor Live software version 4.2 were used for this purpose. All information about fieldwork which lies in computed discharge, cross-section area, and other hydraulic properties appears in the SonTek River Surveyor Live program starts recording all information after interconnecting with the ADCP device. The total river width was divided into five vertical widths for sampling suspended load and bed load. The measurement point is situated in the middle of each of the five verticals.

A sampling of Suspended Load: There are 490 Suspended load samples taken. A depth-integrating suspended-sediment sampler was used to measure the transport of suspended loads of sediment, as shown in Figure 2.

A sampling of Bed Load: Bed Load is the amount of sediment that is always in constant touch with the river bed and carried forward by rolling, sliding, or hopping. For this test, there are (350) samples of the bed load sediment were taken by using the bed load sampler as shown in Figure 3. bed load movement measured for a period of (30 minutes) at each sample**.**

A sampling of bed material: Bed material samples were taken for each vertical width of the river cross-section by using Van Veen grab sampler as shown in figure 4. The grain size distribution considers one of the most important characteristics of sediment. The grain gradient of the soil was determined using the sieve analysis method. Figure 5 displays the grain size distribution curve.

Figure 2. depth-integrating suspended sediment sampler

Figure 3. Bed load sampler

Figure 4. Van Veen grab

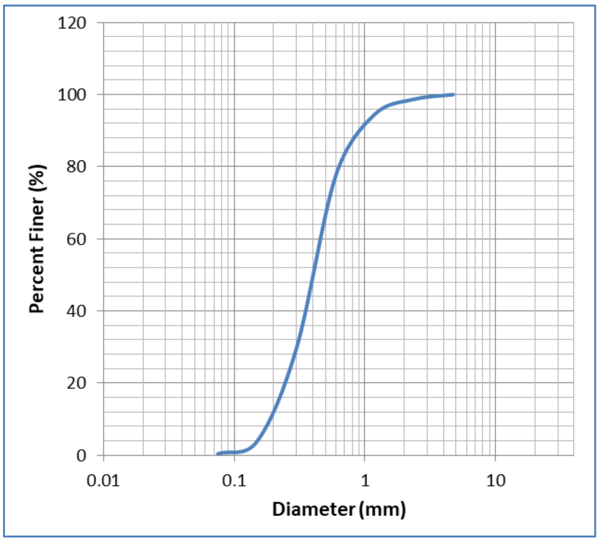

Figure 5. Grain size distribution curve

3. Results and Discussions

Calibration of the model and results verification are crucial procedures for applying the model, and these two processes are what determine model reliability. The calibration and verification processes took place from July 26, 2022, to September 30, 2022, and from October 1, 2022, to December 31, 2022, respectively, show that the roughness coefficient for the study site equals (0.033), resulting in the lowest error ratio between the calculated and observed water surface elevations. Model calibration was followed by sediment investigation to determine the best sediment transport equation. The HEC-RAS system has seven transport equations, the Engelund-Hansen formula produced better-fit results with the field data. Thus, the Engelund-Hansen formula is chosen for further simulation.

Figure 6 shows cross-section No.24. Figure 7 shows the velocity of flow along the study area, and its lowest value is at the end of the reach due to the presence of the Ramadi Barrage. The concentration of sediment increased upstream of the study area due to the high velocity of flow, this concentration reached 204 mg/L see Figure 8. Figure 9 illustrated the stage and Flow Hydrograph for cross-section No.24 and Figure 10 represented the Sediment concentration for the first and last cross-sections of the study area. Figure 11 shows the simulated sediment discharge produced by the Engelund-Hansen formula and the measured sediment discharge. One of the leading causes of the sedimentation phenomenon can be the sudden reduction of flow velocity upstream of Ramadi Barrage. Because there are so large aggregated sediments in the river and because necessary precautions weren't taken early on, these sediments have solidified into bars and are now a part of the river section. Large sand bars that have formed as a result of sedimentation and a lack of routine river dredging have led to several issues, such as a reduction in the river's ability to pass flood discharge, high cost resulting from the removal of this sedimentation, severe deterioration in the water quality of the Euphrates, and a negative impact on the appearance of Ramadi city. High discharges resulting from rainy days could cause increasing in sediment load up to 400 mg/L and this could make the problem of sedimentation very huge and need a heavy cost for treatment and effect negatively on human life and activities.

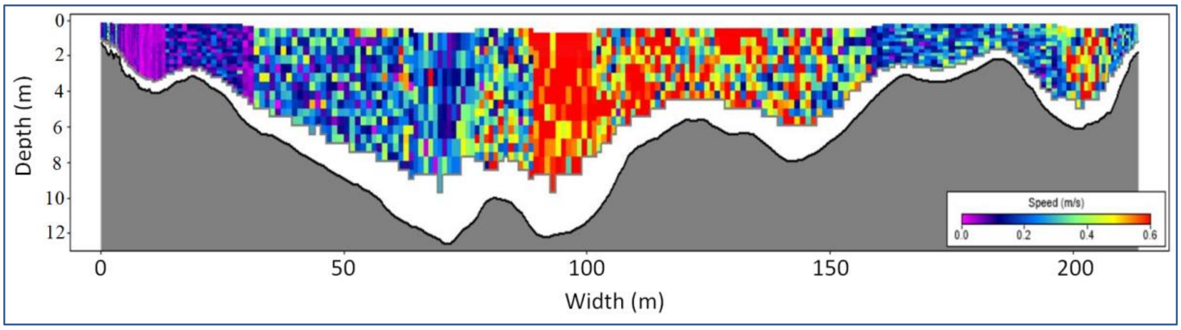

Figure 6. cross section No. 24

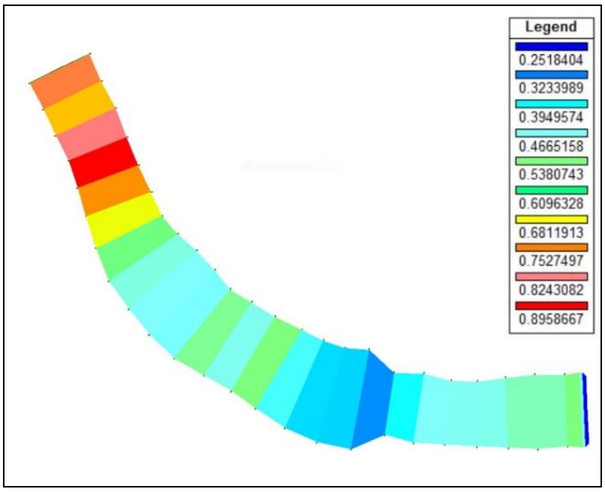

Figure 7. velocity along the study area

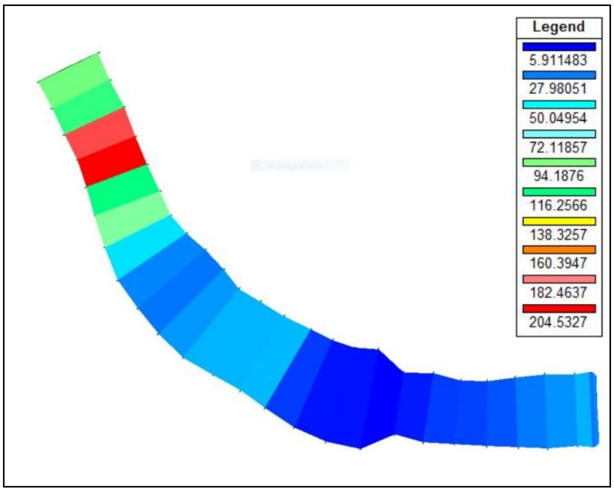

Figure 8. Sediment concentration along the study area

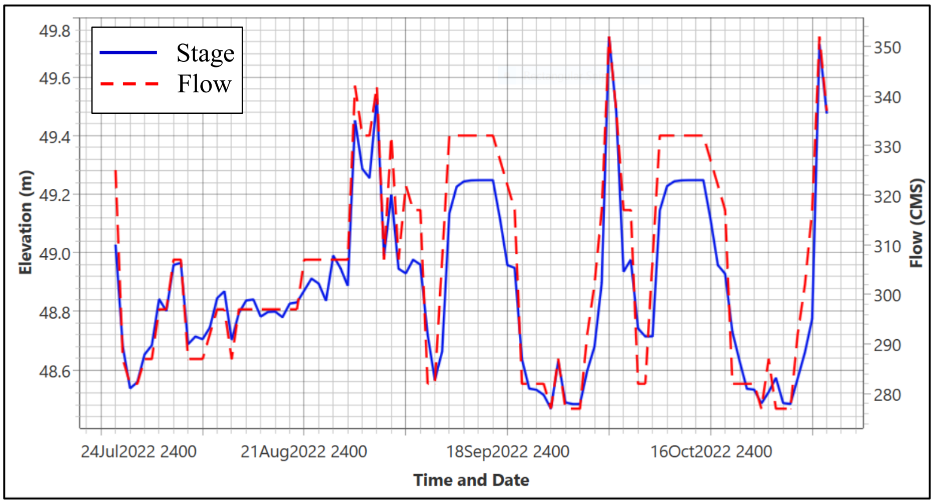

Figure 9. Stage and Flow Hydrograph for cross section No.24

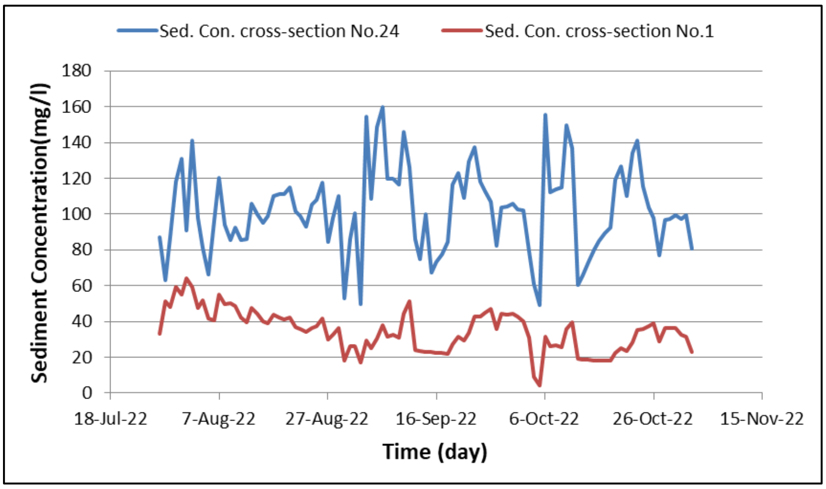

Figure 10. Sediment concentration for the first and last cross-section

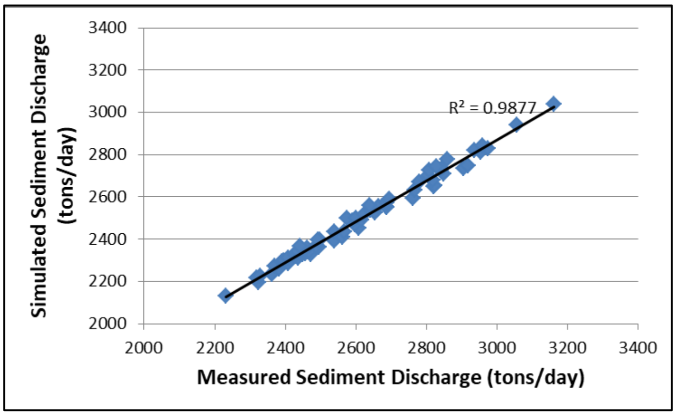

Figure 11. Measured and Simulated Sediment Discharge using the Engelund-Hansen formula.

4. Conclusion

The significant findings of this study are. The analysis of the resulting model indicated that significant sedimentation in the Euphrates River upstream of Ramadi Barrage agrees with the actual river situation. The sediment transport model indicated that the river bed level rises more near the Ramadi Barrage with A maximum deposition is about 3.17 m. The annual sediment yield calculated for the Euphrates River is 1002240 tone which is equal to 378203$\boldsymbol{m^3}$/year . It has been noted that sedimentation has been more prevalent in places with broad transverse sections, whereas erosion has been more prominent in areas with tight transverse sections. The Engelund-Hansen equation obtained accurate sediment discharge calculation. The Ramadi Barrage management may benefit from the projected sediment transport from this model in the long run. The capacity of the river reach, the nature of the river, and the physical characteristics are all examined as part of sedimentation research, which is crucial for making practical decisions about water management. The results of this study will also be helpful to water managers and decision-makers to prevent sediment erosion or deposition and so limit the consequences on the stability of the economy that may result from effects on bank infrastructure.

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Hydrology modeling of the Lak Basin using the AGWA2 extension

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Abstract:
This study focused on analyzing the Hydrology factors and processes that led to the discovery of its characteristics represented by sedimentary drainage and production. The problem of the study emerged in the difficulty of identifying the volume of water discharges, the volume of sediments, and what is the effect of the course of the geomorphological processes that exercise their activity in the basin and the resulting environmental effects, which can be used in the reconstruction of the ecosystem of the basin. Therefore, the temporary flowing Lak basin was chosen, located between latitudes 24 45 34 and 36 09 35 N and longitudes 18 44 51 and 44 48 58 E, with an area of 856.45 km2. It originates from the Kormor hill range, specifically in the Belkana series, located in the northeastern side of the cities of Daquq and Tuz Khurmato, and flows into the Zghaitoun Valley. The importance of the study comes in the treatment of water scarcity in arid and semi-arid regions. Which contributes to the management of rainstorm water and the methods of its exploitation, which has become one of the challenges of this era. These facts were detected and identified by the AGWA2 extension, which is the effective tool in this study. Which supported the research with a future scenario on the hydrological status of the basin. Therefore, the AGWA2 extension showed high efficiency in the study of water basins in arid and non-arid regions, and basin modeling at the surface and channel levels. Therefore, the study reached the development of the aforementioned extension, which serves most of the natural aspects of geography, and the expansion of agricultural activity in the region to mitigate erosion, reduce the volume of sediments, and reduce the phenomenon of desertification.

Keywords
- Hydrological
- Sedimentary revenue
- water revenue

Introduction :

Studies of valleys and their basins have gained special importance because they provide an important water resource for the population and development projects. Many human activities and activities are concentrated in river basins and their drainage areas, whether in wet regions or in dry and semi-arid regions. They constitute a unique environmental system characterized by natural diversity.

The basins are affected by the geomorphological processes, which give an indication of the extent of the damage caused by the deterioration of the productive capacity of the land and the resulting amounts of river load and flow velocity. The current study (Hydrologymodeling of the Lake basin using the extension AGWA2) came as a quick response to replace the traditional means and methods of description, especially Concerning the analysis of river drainage networks and unmeasured basins.
The study seeks to model the relationship between climatic and geomorphological variables and their impact on the surface runoff of the basin and its sedimentary output through the extension *AGWA2 (Automated Geospatial Assessment of Water Basins). .
The study relied on satellite data (DEM) and (LANDSAT8) on 12/4/2013, soil data of the FAO Organization (FAO) for the year 2006, and daily climatic data for the Kirkuk station for the period (1980-2000).

1.1 - The problem of the study and its questions:
The study problem can be defined as follows:

(The study area suffers from the difficulty of classifying, analyzing and processing morphometric measurements by traditional methods, which requires the use of modern technical means represented by the extension (AGWA2) to avoid this problem, to achieve accuracy of the data elicited from satellite visuals, analyze them, and diagnose the factors affecting the imbalance in the environmental balance of the geographical phenomenon). During this problem, the following questions can be asked:

- Do climatic factors have a major role in causing an imbalance in the environmental balance through active demolition and construction?
- How can the severity of the floods that affect the volume of water discharges in the basin be measured?
- What are the means and techniques used to make measurements of the pelvis and build models?
- The predominance of the phenomena of drought and desertification, whose causes can be identified and their effects mitigated?

- Difficulty in identifying the volume of water discharges that can be utilized and reconstructed in the basin ecosystem.

2.1 - Hypotheses of the study:

The following hypotheses can be identified:

1- The spatial data (land cover, land uses) have a prominent role in the volume of water flow and its peak on the one hand, and the volume of sedimentation on the other hand.

2- There is a relationship between the natural factors that form the land appearance and the course of Hydrologyprocesses and their ability to assess the ground cover of the basin.

3- The use of the AGWA2 extension contributes to identifying flood risks and detecting drought phenomena.

4- The future of the region is predicted through a proposed scenario designed on the basis of the prevailing trend in land uses.

3.1 Justifications for the study:

- The geographical library suffers from a lack of Hydrologystudies and digital modeling. Therefore, this study comes to provide the geographical scientific library with a small part that serves as a reference for this field.

The novelty of the subject of the study.

- The proximity of the area to the researcher, which made it easy to visit it constantly.
- Using the AGWA2 extension to study the facts of the basin in terms of hydro. and develop solutions to reduce the volume of water runoff and predict its dangers.

4 .1 The importance of the study:

The importance of the study comes in highlighting the course of the geomorphological processes that exercise their activity in the basin and their environmental effects, as well as the treatment of water scarcity in arid and semi-arid regions. Rainfall and ways to exploit it, which has become one of the challenges of this era.

5.1- Objectives of the study:

The study aims to:

- Supporting the early warning system for environmental disasters, the most important of which are droughts and floods.
- Facilitating the task of many applied studies related to environmental aspects, including hydrological, geomorphological, and other studies, which focus on knowledge of soil saturation and the time of occurrence of the flow of valleys or floods of temporary flowing valleys.
- Knowing the amount of precipitation falling in the basin, and then the volume of sedimentation and the forms resulting from sedimentation in the basin, and the extent of the AGWA2 extension efficiency for studying unmeasured dry basins in order to know the volume of water and sedimentary revenue for the basin.
- Determine the hazardous locations in the basin and reduce their environmental impacts in the study area.

6.1 Contents of the study:

The study is organized with its ideas and the way it deals with the variables related to the subject through the following approaches:

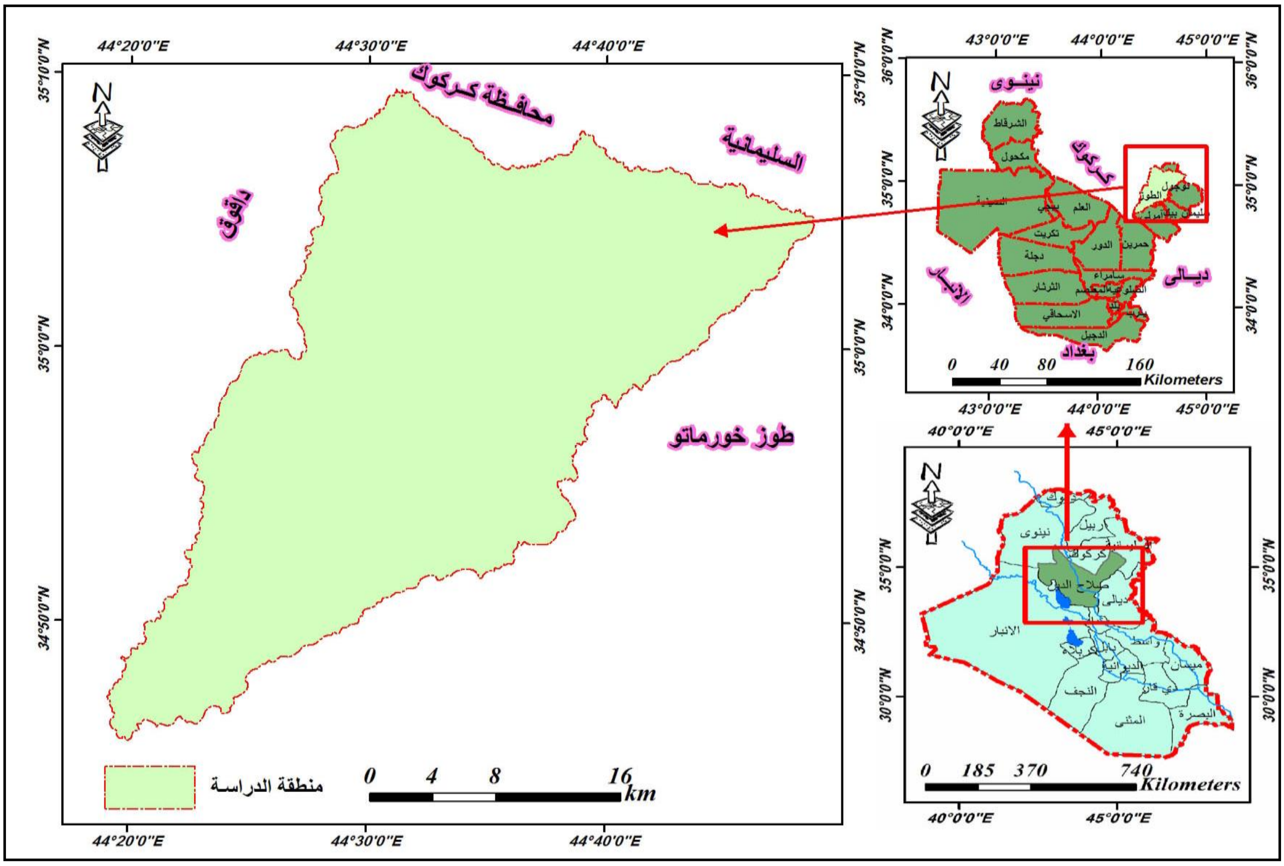
The method of origin and evolution: that is, identifying the way in which the water basin was formed, the factors that formed it, and the developments that took place in the water networks. Any clarification of the impact of the ground structure in its formation.

The barometric approach: which is concerned with the use of the number language through the application of a series of different calculations, equations and statistical analyzes to reach accuracy in the language of expression of spatial variables.

Land Appearance Approach: which is based on the classification of land cover, land uses and land units. However, the study focused on following the barometric approach, due to its suitability with the techniques used, which depend on deriving information from the data feeding the extension.

8.1 Coordinate Location:

The study area is confined between latitudes 24 45 34 36 09 35 N and longitudes 44 18 51 and 44 48 58 E, as shown in Map 1. The area of the area is 856.74 square kilometers. The study area is located administratively within the Salah al-Din Governorate, as it is bordered on the north by the Kirkuk and Sulaymaniyah governorates, and on the south by the Hamrin Hills range, while on the east side it is bordered by the Tuz district, and on the west side it is bordered by the Daquq district. It originates from the Kormor hill range located in the northeastern side of the cities of Daquq and Tuz Khurmatu, and empties into the Zghitoun Valley.



Map (1) the location of the study area

Source: General Directorate of Survey, Administrative Map of Iraq, 2007, 1/500,000

AGWA2 extension structure and basic operations:

AGWA2 stands for Automated Geospatial Watershed Assessment. It includes two tools, SWAT and KINEROS SWAT stands for Soil Water Assessment Tool KINEROS (Kinematics Erosion) stands for dynamic erosion.

The 2AGWA tool addresses both hydrological and geomorphological variables and two types of flow, overland flow and channel flow (2). It is that all its publications have been designed as a tool for relative evaluation and analysis of changes resulting from the change in the use of land cover. The areas known for their large size operate in the SWAT environment, and the results can be presented as immediate or continuous variables for a variety of outputs, and the purpose is to identify the most important areas that need to make efforts and take the necessary protection to prevent risks caused by torrents and floods, and accordingly a risk map will be designed For basins, in which the quantities of water and sedimentary revenues are high. The program depends in its inputs on unmetered water basins for arid and semi-arid regions, and provides the possibility of future prediction through proposed scenarios, as well as monitoring the response of changing water basins.

The SWAT tool is more accurate in the study of non-scaled basins, because traditional methods and other programs work on modeling basins from particles to aggregates, while the tool works by modeling basins from aggregates to particles, and this is more accurate for simulation in the study of arid and semi-arid environments.

The following is a flowchart of the extension structure, as shown in Figure (1).

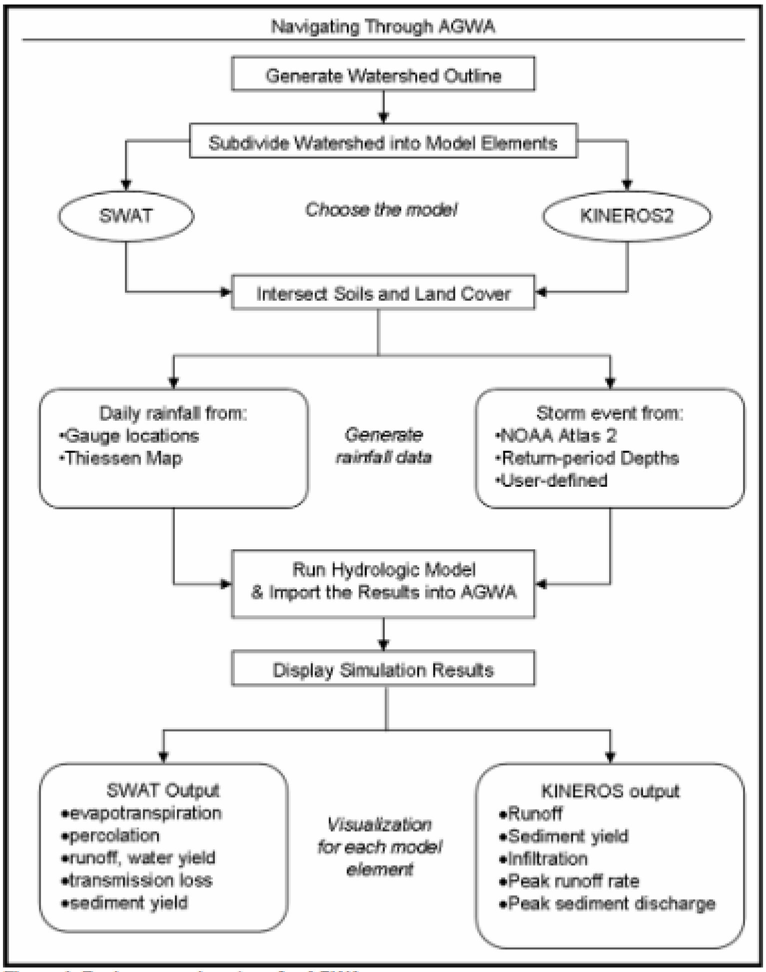


Figure 4. Basic processing steps for AGWA.

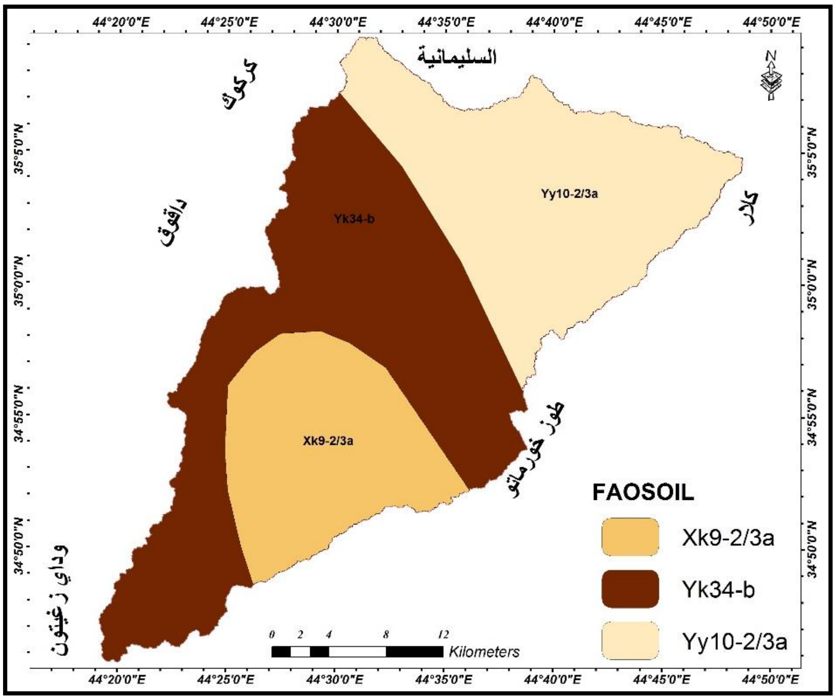
Derivation and hydroponics:

The water basins are derived using the DEM digital elevation model, through which the water network is der soil data

The soil controls the surface runoff processes. Soil tissue controls the amount and speed of water permeation to its depths. The softer its texture, the lower its permeability, and vice versa(2)

The extension is based on a 2006 Food and Agriculture Organization of the United Nations (FAO) map, at a scale of 1/5,000,000. to classify the soil. It is one of the most recent soil classifications worldwide. It contains (soil type, depth, texture, slope, chemical reactions, water drainage) (1), which are encoded with special symbols, as shown in the map (11), and the following is an explanation of the most important symbols:

Map (2) FAO soil classification



The Digital Soil Map of the World, FAO/UNESCO, Version 3.6, January 2006.

Table (1) the types and areas of soils in the study area

The ratio %	Km2 area	Type	Soil symbol
22.26	190.67791	Calcaric Fluvisols	Xk9-2/3a
43.25	370.39003	Gypsic Yermosols	Yk34-b
34.48	295.382065	Gypsic Yermosols	Yy10-2/3a
100	856.45		total

Source: Based on the map (2).

XK9-2/3a: it means gray gypsic soils (Gypsic Yermosols), with a medium texture and a slight slope of less than 8%. This category occupied an area of 190.67 square kilometers, or 22.26% of the study area.

And by researching the type and conditions of (Yermosols) soils. Most of the classifications agreed that it was formed under dry desert and semi-desert conditions. It is considered one of the soils most susceptible to desertification because water is not available for plants or for long periods during the agricultural season, and salts dissolved in water, gypsum, calcium carbonate or all of them are spread in some of its soils, and its section may contain clay, calcareous or gypsum layers(1)

•Yy10-2/3a: it means gray gypsic soils, with a main phase consisting of the saline type, with a medium texture and a slope ranging between.(%30-8)

This type of soil occupies the northern and northeastern regions of the study area with an area of 295.38 km2 and a percentage of 34.48%. This type is also characterized by the presence of a layer of gypsum under the surface (hydrated calcium sulfate) which has accumulated from the precipitation of calcium and sulfate from the percolating water in the soil.

Table (2) Land cover and its equivalent value for curve number CN

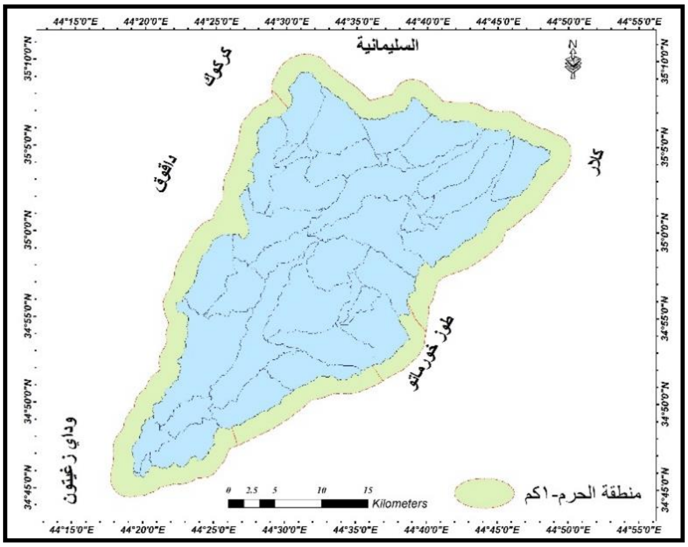
CLASS	NAME	A	B	C	D
11	Open Water	100	100	100	100
12	Perrenial Ice/Snow	98	98	98	98
21	Developed, Open Space	68	79	86	89
22	Developed, Low Intensity	77	85	90	92
23	Developed, Medium Intensity	81	88	91	93
24	Developed, High Intensity	89	92	94	95
31	Barren Land	82	87.7	91	92.7
32	Unconsolidated Shore	82	88	91	93
41	Deciduous Forest	55	55	75	80
42	Evergreen Forest	55	55	70	77
43	Mixed Forest	55	55	75	80
51	Dwarf Shrub	63	77	85	88
52	Scrub/Shrub	63	77	85	88
71	Grasslands/Herbaceous	49	69	79	84
72	Sedge Herbaceous	49	69	79	84
73	Lichens	63	77	85	88
74	Moss	63	77	85	88
81	Pasture/Hay	68	79	86	89
82	Cultivated Crops	71	80.7	87.3	90.7
90	Woody Wetlands	85	85	90	92
91	Palustrine Forested Wetland	85	85	90	92
92	Palustrine Scrub/Shrub	85	85	90	92
93	Estuarine Forested Wetland	85	85	90	92
94	Estuarine Scrub/Shrub	85	85	90	92
95	Emergent Herbaceous Wetlands	77	77	84	90
96	Palustrine Emergent Wetland	77	77	84	90
97	Estuarine Emergent Wetland	77	77	84	90
98	Palustrine Aquatic Bed	77	77	84	90
99	Estuarine Aquatic Bed	77	77	84	90

USDA-ARS Southwest Watershed Research Center Tucson, Arizona , USEPA , Automated Geospatial Watershed Assessment (AGWA) Manual ., p 87 .

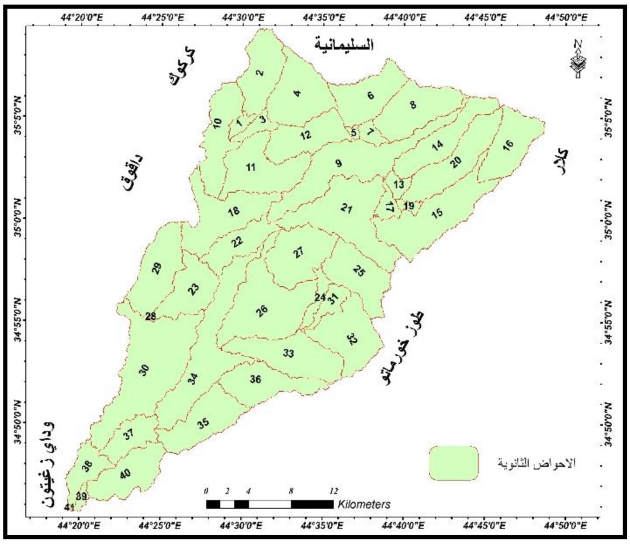
It is also characterized by a lack of organic matter content, and most of these lands suffer from a low ability to retain water. However, by continuing the process of irrigation and adding fertilizers, the properties of these lands will improve, especially in desert areas.

The compounds of calcium carbonate and sulphate happen to granulate and harden to form solid layers that create difficult problems such as the process of root penetration and plowing, especially since these solid layers are located at a depth of 1.25 m from the surface layer of the soil.ived in the v10.Arc GIS program, as in map (12) and the secondary basins are derived by extending AGWA2 through the Discritiziation directive. The secondary basins were divided into 41 basins according to the homogeneity of their hydrological properties, hydrological and morphometric parameters, and soil properties. As in the two maps.

Map (3) the secondary basins of the study area.



Map (4) Carve out the Buffer campus area



Source: Based on DEM data and extension AGWA2

Deduction of the campus area Buffer:

The Buffer layer is configured for the soil and land cover maps of the water basin boundaries, through the Analysis tool command, then the Proximity command, and then choose the distance of 1 km in the Buffer direction outside the boundaries of the basin for the two maps, soil and vegetation cover. After that, the basin is cut again according to this distance, as shown in Map (4).

Outputs of the SWAT form:

It is a model that aims to evaluate the current and future response of water basins to land changes (changes in land cover and land uses). It reveals the change in agricultural density that plays a pivotal role in determining the amount of runoff time and that ultimately supplies the energy mass for hydrological processes and weathering events over long periods of time (more than 1 year). The accuracy of the outputs depends on the length of the data period (1), so the longer the period, the better the results. Below is an explanation of the most important outputs on two levels, the first at the channel level, and the second at the surface level.

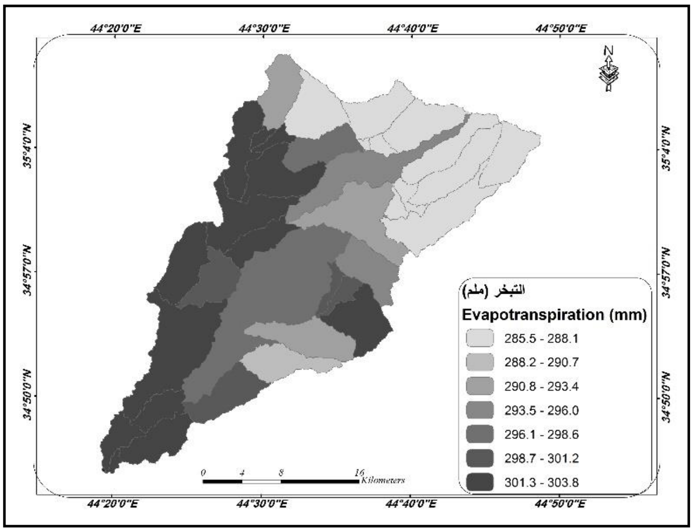
Rainfal:

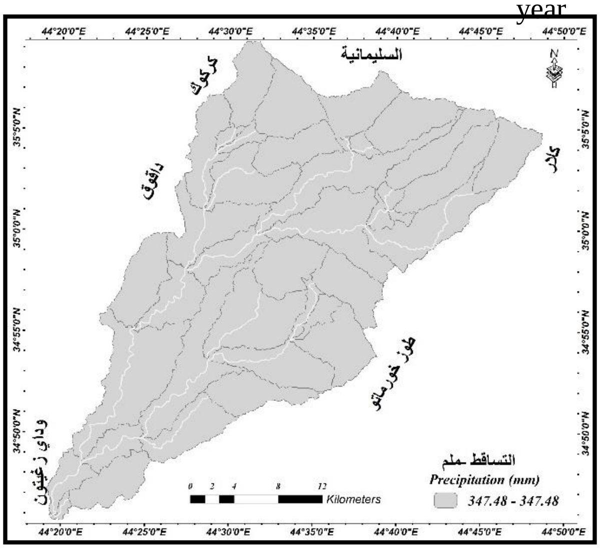
Rain is one of the climatic elements that contribute significantly to the occurrence and acceleration of weathering processes. The program relies on mathematical operations and equations built in a programming language to show the sequence of periods of rainfall.

Daily rainfall data for a period of 30 years has been adopted for the Kirkuk climate station, taking into account the expected fluctuation of precipitation amounts for the future 30 years; It is clear from map (5) the distribution of rain on a regular basis over the basins, due to the presence of a climatic station, while if there were more than one climatic station, a variation would appear in the distribution of rain over the basin. The total rainfall amounted to 347.48 mm.

Map (5) Rainfall distribution over the basins.

Map (6) Evaporation of transpiration for a year





Source: Based on the SWAT tool

Evapotranspiration:

SWAT is based on three methods in calculating evaporation / transpiration, which are (Penman-Monteith, Priestley-Taylor, Hargreaves). The first was based on solar radiation, air temperature, relative humidity and wind speed, while the second was based on the same variables except for wind, while the third was based on air temperature. only (1). It is clear from map (6) that the region suffers from high rates of evaporation / transpiration. Where the evaporation values ranged between 285.5 - 303.8 mm. It appears that the northern basins located in the basin's headwaters are characterized by low evaporation, due to the steep slope and lack of direct exposure to sunlight, while the slope decreases in the middle and south of the basin, and therefore the evaporation amounts increase.

Runoff (mm): Surface Runoff

Surface runoff is the final outcome of the hydrological cycle, and is one of its most important variables because it controls the possibility of establishing water harvesting projects and others. Surface runoff is calculated according to the following equation:

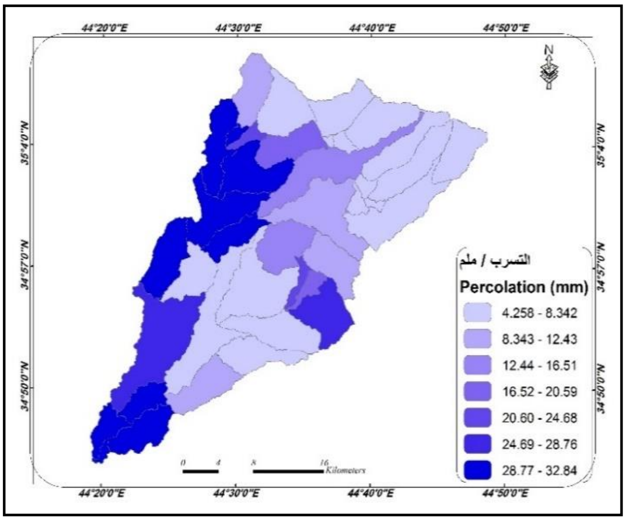
$$Q_{surf} = \frac{(R_{day} - I_a)^2}{(R_{day} - I_a + \mathbf{S})}$$

Qsurf = accumulated water runoff or increased precipitation (mm). Rday = daily precipitation depth (mm).

IA = the interception and infiltration surface storage before re-precipitation (mm). S = is the maximum retention (mm).

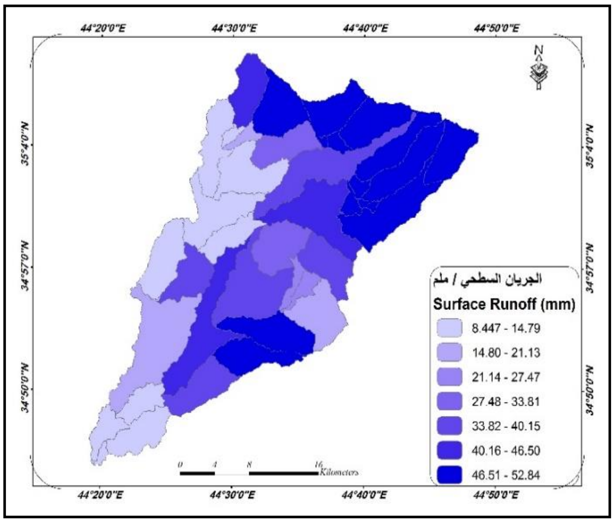
It is clear from map (7) that the rates of surface runoff ranged between (8.4-52.8). It is noted that the rates of surface runoff increased in the northern basins in the upstream and central areas due to the factor of height and the increase in the amount of rain received by the upper basins, which made it the most water-producing area in the basin. Likewise, the predominance of the Muqdadiya and Bay Hassan formations, which is composed of thick layers of gravel, which reduces the amounts of infiltration through them.

Map (7) surface runoff for the year.



Source: Based on the SWAT tool.

Map (8) leakage (mm) for the year 2010



Source: Based on the SWAT tool

Percolation

It means the leakage of water from the surface of the soil to the lower layers, feeding the aquifer of water, and the leakage is affected by several factors, including; The characteristics of the surface and the quality of the materials that cover it, its nature and its cohesion, as well as the degree of permeability and porosity, as it depends on the joints, cracks and rifts that occupy the exposed facades and the northern and central parts of the region. surface runoff, and thus less water retention and lower infiltration rate (2). Map (8) shows that the leakage rates ranged between (4.2-32.84) mm; It was concentrated in the western parts of the basin due to the occurrence of the main stream and its branches in these areas, as well as the predominance of gypsum soils, which have a high percentage of cracks and voids and the speed of their vulnerability to solubility. Which gives the opportunity for water to seep through these joints and cracks.

Sediment yield

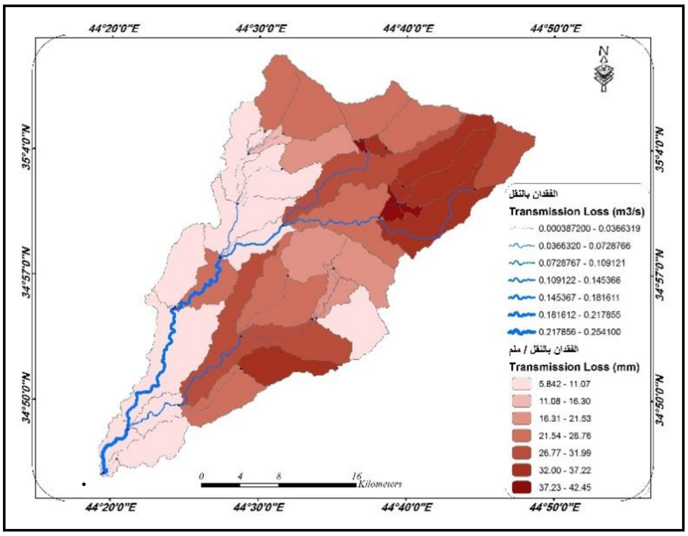
Sediment plays an influential role in the environment of the basin, through its size and type. The sediments are the result of the relationship between the type of rocks on the one hand and the external formation factors on the other hand (3), so the types and sizes of sediments differ from one slope to another, as well as different types of rocks, and the sediments vary from rocky blocks to soft sediments. The SWAT model was relied on to calculate sediments using the Universal soil equation modified, and it predicts the annual erosion rate (tons / ha / year) in the basin according to the equation (Williams, 1995):

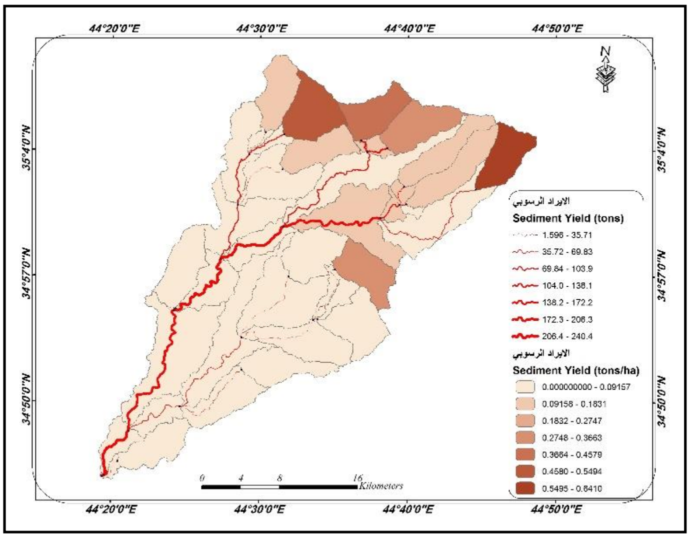
EI: rainfall intensity ((0.017 m-metric ton cm/(m2 hr)), metric ton (cm/m2/hr)
C: surface management modulus
K: soil erosion susceptibility factor.
LS: slope coefficient and length of the slope
CFRG: joint roughness ratio coefficient
P: soil maintenance coefficient
It is clear from the map (9) facts, which are as follows:
- The amount of sediment amounted to (0.54944-0.64100) tons/ha, which is equivalent to (1 ton/km2) (1).
Sediments are concentrated in the northeastern regions of the basin, due to the steep slope.

- The type of geological formations where the Muqdadiya and Bay Hassan formations are exposed, with easy-to-disintegrate pebble and sandy sediments of varying sizes.

The sediments of the canals ranged between (1.59-240.4) tons, which is a very large amount, as it is concentrated in the main channel of the network, and is also an indicator of the danger of basins with high sedimentary output. In addition to providing decision-makers with knowledge of the most dangerous water channels and which ones need maintenance, and choosing the most suitable channels for dam construction.

Map (9) Sedimentary yield (ton/ha) Map (10) Transportation loss (mm)





Source: Based on the SWAT tool Source: Based on the SWAT tool

Transmission Losses

It is the movement of sediment during its journey to the estuary, due to the presence of turns and river depressions in the water network. Not all sediment reaches the estuary. It is noted from map (10) that the losses by transport ranged between (5.84-42.45) mm and were concentrated in the northeastern basins, due to the severe intrusion of the sewers in the upper ranks in the north of the basin, which leads to the formation of pits and depressions. As for the loss in the channels, it ranged between (0.00038-0.254100) m3/sec. It was concentrated in the main stream of the basin due to the large stream and the spread of potholes and river turns in it.

conclusions

The SWAT AGWA2 extension showed high efficiency in its outputs through several results, including:

- High evaporation rate, which ranged between (285.5 - 303.8) mm, especially in the central and southern parts of the basin.

- High rates of surface runoff, especially in the northern basins in the upstream area, as it reached 52.8 mm due to the height factor, which made it the most water-producing area of the basin.

- The highest rates of water leakage were concentrated in the western parts of the basin, as they ranged between (4.2-32.84) mm; Because of the occurrence of the main stream and its branches in these areas, as well as the dominance of gypsum soils, in which the percentage of cracks and voids is high. Which gives the opportunity for water to seep through these joints and cracks.

- The sedimentary output was concentrated in the northeastern regions of the basin, as it ranged between (1.59-240.4) tons in the channels, which is a very large amount due to the steepness of the slope and the exposure of the Muqdadiya and Bay Hassan formations, which have gravel and sandy sediments that are easy to disintegrate.

- This study is one of the most recent studies in the hydrology and . of the arid and semi-arid regions of the unmeasured and temporary flowing basins.

Recommendations:

- Conducting extensive studies using the AGWA2 extension, as it has other options that need to be activated. Which are used to rehabilitate the ecologically degraded pond environment.

- Establishing hydro-climatic stations on the water basins, even if they are mobile every 3 years in a region, which provides detailed data for the region. Knowing the climatic and hydrological conditions of any region helps to simulate nearby basins with semi-homogeneous or similar characteristics, which achieves accuracy in results and speed of work.

- Conducting maintenance practices for the upper basins in the region, as they are the most influential basins in flooding and sediment. And the establishment of small dams on it helps in the reconstruction of the ecosystem that is subject to deterioration.

Margins

AGWA2 Automated Geospatial Watershed Assessment

(1) AGWA Manual, Op.Cit., p 18.

(2) Ahmed Salem Saleh, torrents in the deserts in theory and practice, Dar Al-Kitab Al-Hadith, Cairo, p. 30.

(3) Hassan Ramadan Salama, Formal Characteristics and Its Geomorphological Significances, Publication No. (43) issued by the Geography Department of Kuwait Mosque, the Kuwaiti Geographical Society for the year 1999, p. 125

Spatial analysis of Euphrates River pollution in the sedimentary plain area within Anbar Governorate A case study of freshwater rivers pollution in dry environments

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Keywords: Spatial analysis - Euphrates River - Pollution of fresh rivers - Sedimentary plain - Anbar Governorate

Abstract:

In this research, the effect of Human activities on the pollution of fresh rivers within dry environments was studied, The Euphrates River was chosen in the sedimentary plain area in Anbar Governorate as a case study, as the river extends in the sedimentary plain area within its path in Anbar Governorate, and. The river is exposed to the spread of pollutants on both sides of the river within its path in the sedimentary plain area, which is one of the most serious problems that the river faces within this path. and whose harm is reflected on the person himself, until the problem of water pollution has become one of the most serious contemporary problems as it directly threatens human health. The nature of the landforms in the sedimentary plain area in Anbar Governorate has contributed greatly to the increase in the concentration of pollutants in the river water, the danger of which lies in its cumulative effect, not the effect current and instant. Which has been noticed in recent years as a result of the large number of diseases resulting from the pollution of fresh water in this environment, which requires reconsideration of the bad handling and the dumping of excessive pollutants in the fresh water environment of the Euphrates River, which has become suffering from a clear change in the physical and chemical properties or biological properties resulting from the activities of Humanity used the landforms in the sedimentary plain area in Anbar Governorate and added pollutants and polluting factors to the river environment that the Euphrates River could not get rid of at the same speed as adding them. Many measurements have been recorded from them such as pH in water is one of the basic the annual rates varied between (7.7-7.6-7.6) in the sites of Ramadi, Habbaniyah and Fallujah, respectively

1- Introduction

The study of freshwater river pollution within arid environments takes a curve of paramount importance because of the importance of rivers in the lives of the population and their various activities and increased interest in the study of river pollution in the plain areas because of its direct impact on the lives of the population in those areas and the associated projects at the present time or future and have a direct impact on the life and activity of the population and the impact that may result from those activities on river pollutants within these environments and what these pollutants cause From environmental and health damage and the resulting losses and material losses in those areas, so the indicators of the study and in line with the objectives of the research and its methodology have necessitated that there be accuracy in determining the research steps to study the spatial analysis of the pollution of the Euphrates River in the plain areas within Anbar Governorate in an accurate scientific manner. As pollution is one of the most serious contemporary problems facing man at the present time and the impact of industrial and agricultural development in increasing the amount of pollutants and their concentration in fresh water resources until the problem of pollution has become one of the problems affecting human life, which prompted countries and organizations to evaluate the bad and excessive human treatment towards natural environmental resources, especially the problem of freshwater pollution, which has become a contemporary problem that rises in importance to the rank of natural disasters that threaten the existence of man and his survival on the surface of the earth. Accordingly,

Problem of Research.

Is the Euphrates River a polluted river in the sedimentary plain within Anbar Governorate and what are the most prominent pollutants that affect the pollution of the Euphrates River water.

Hypothesis of Research:

The natural characteristics of the sedimentary plain area and the nature of human activity prevailing in it affected the pollution of the river's water and the change in the characteristics and quality of the Euphrates River water, and one of the indicators of this impact is the placement of the Euphrates River within the dry climate, in the sedimentary plain region within Anbar province.

Objectives of Research:

This research aims to:

1- Analysis of the spatial variation of the problem of pollution of the Euphrates River in the sedimentary plain region within Anbar Governorate.

2- Identify the most important pollutants affecting the change in the quality characteristics of the water of the Euphrates River.

Importance of the study

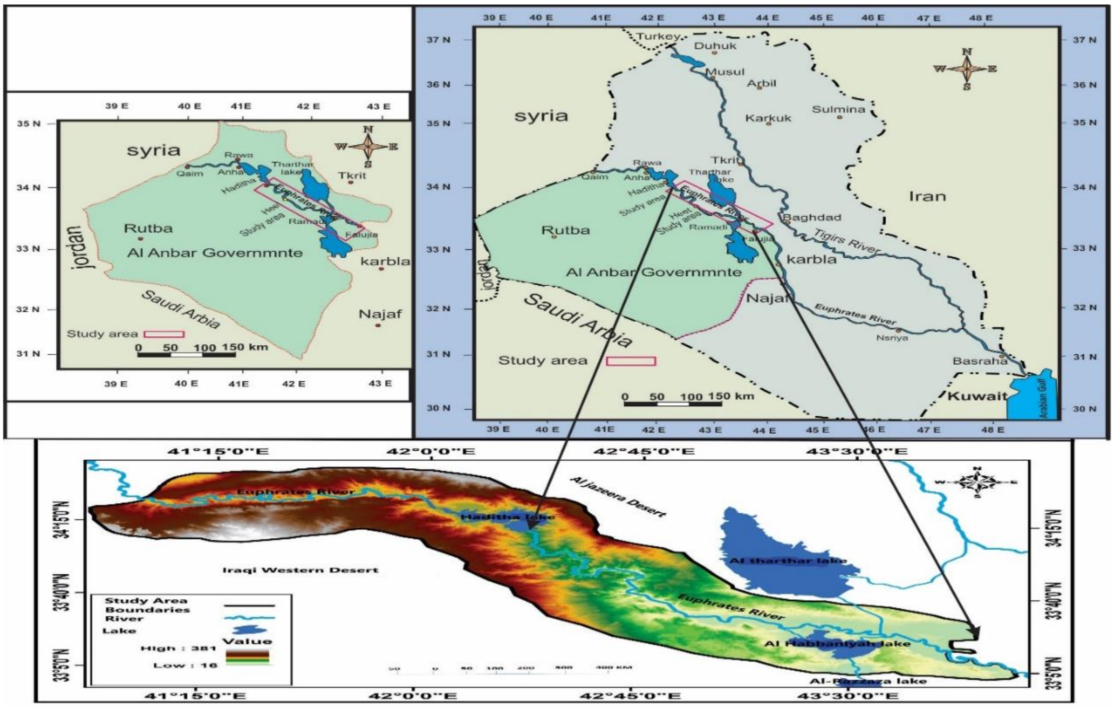
The reasons for studying the issue of environmental pollution of the Euphrates River come from the fact that the Euphrates River is the lifeline in Anbar province in general and the sedimentary plain area in particular as it is one of the dry areas, which leads to almost total dependence on the water of the Euphrates River, as large areas of agricultural land depend on it, as most human activities of various uses in the study area depend on it, and as a result of these activities the environmental risks to that resource increase, so the importance of the study lies in diagnosing the reality of pollution and its sources in the sedimentary plain area in Anbar province

Chapter One: natural geographical characteristics and their importance in the polluting population activity of the waters of the Euphrates River

1- The geographical location of the study area

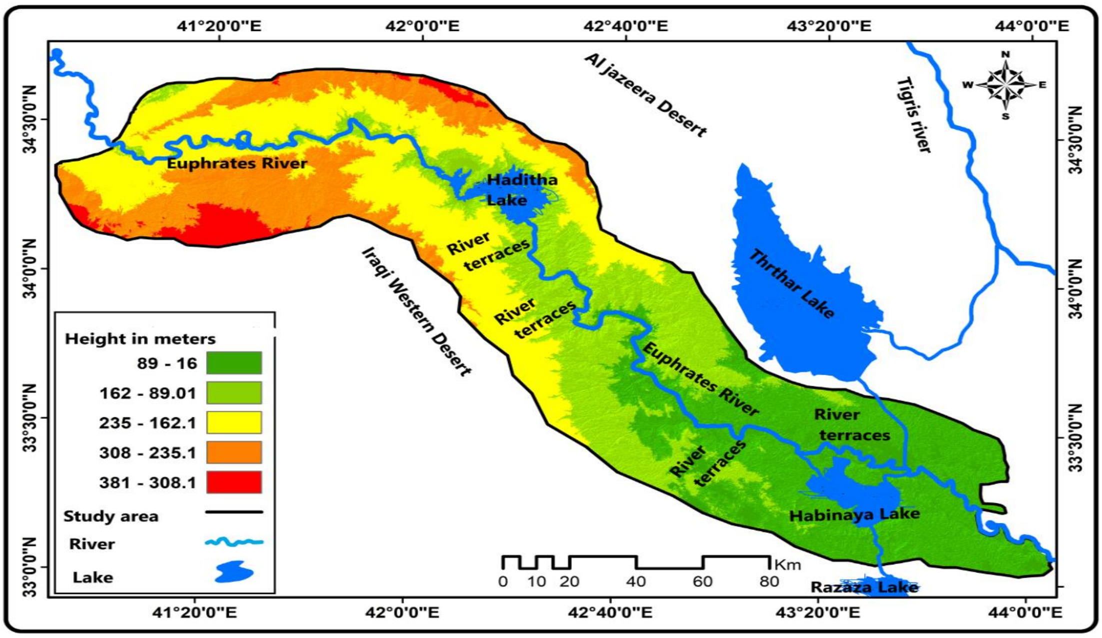
The sedimentary plain area is located in the northwestern and northeastern part of Anbar Governorate and can be determined by well-defined geographical boundaries, as it starts from the northwest at Wadi Al-Muhammadi to the south of the city of Hit and ends at the southwest in the district of Amiriyat Al-Fallujah (Amriyat Al-Samoud) and astronomically the study area is located between two longitudes (30′ 43° - 20′ 42°) east and two latitudes (20′ 34° - 30′ 33°) north. map No 1,2

Map No (1) location of study area in Iraq



Source: [1]

Map No (2) Topographical of study area in Iraq

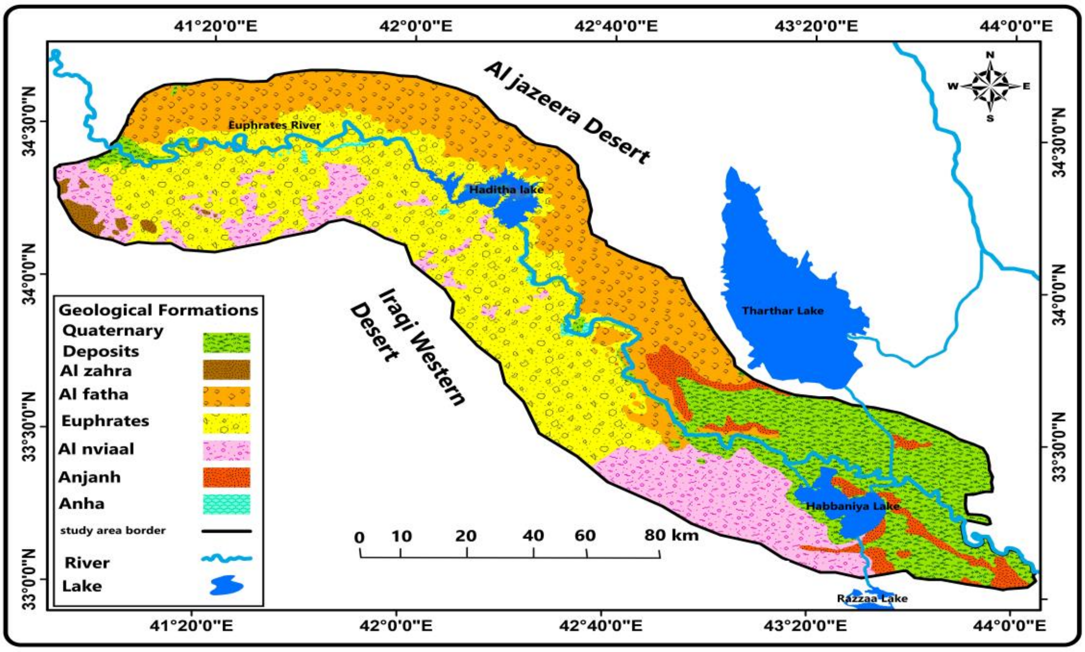


Source: [2]

1.2 Geological characteristics and their impact on the pollution of the waters of the Euphrates River

The geological environment of the sedimentary plain area is represented by the nature of the rocks, their types and characteristics represented in hardness, permeability and the possibility of storing groundwater. These rocks and their nature affect the nature of the extension of the river, the change of its course, the amount of its discharge and the amount of sediment that the river carries with it, in addition to determining the natural structure of the Euphrates River bed in the sedimentary plain area. The formation of the opening, the formation of the Euphrates, the formation of Angana and the sediments of the pulse plain The effect of these formations is in the nature of their formation and the lack of resistance to river erosion, which works to help filter water into these formations, especially when the water level rises in the course of the river, and this process has an impact on increasing the salt concentration in water and soil, especially after the decline of flood waters. map No 3

Map No 3 Geological formation of study area)



Source: [3]

1.3 Climate of the study area

The climate elements are important factors with an effective impact directly or indirectly in the pollution of fresh rivers within dry environments and the impact of climate elements is important in the environmental pollution processes of the Euphrates River as the angle of incidence of solar radiation and the length of daylight hours, especially in the summer, has an impact on the process of thermal gain of moisture for the soil on the one hand and on the other hand leads to an increase in water losses that actively activate the evaporation process that is directly proportional to The capacity of water bodies. While temperatures can be considered one of the most important climatic elements that affect environmental pollution processes through their impact on atmospheric pressure values and its relationship to wind and rain movement and evaporation rate. [4]. Evaporation, as one of the main climatic elements of importance, affects the amount of running water in rivers and its effectiveness is related to other climate elements such as solar radiation, temperature and wind speed, as well as the nature of the surfaces where evaporation occurs. As for the wind element, it has a limited impact on the pollution of fresh rivers within dry environments due to the location of the study area within the subtropical belt located under the influence of high pressure in winter and low in summer, which do not help to blow high speed winds, except for some cases in which atmospheric turbulence occurs accompanying the intensity of heating. While the rains of the study area are subject to the dry climate region system that prevails in the western plateau region and the sedimentary plain within Anbar province, the contribution of rainwater to the pollution of the Euphrates River within the study area in Anbar province is caused by torrential rains that occur in some valleys as a result of seasonal rains, which may contribute to the sedimentation of dissolved solids suspended in it.

1-4- Soil

The soil characteristics of the sedimentary plain area affect the amount of infiltration of the Euphrates River water by identifying the soil types, types and the nature of its texture affecting the determination of the amount of its porosity, which determines the amount of water retention and the degree of water flow in addition to the vertical and horizontal movement of surface and groundwater and determines water losses due to the evaporation process [5] and the most important types of soils that can be observed in the study area are sedimentary soils and gypsum desert soils.

2- Materials and Methods

the impact of human activity on the pollution of the water of the Euphrates River

2.1 Human settlements

Rural and urban human settlements are widely spread in the lands of the sedimentary plain within Anbar province, as the lands of the floodplain are flat along the course of the river, which helped to spread and expand urban and rural centers, as a crowded pattern of linear human stability appeared along the Euphrates River and on both sides of the river's course, as population centers emerged and this human stability resulted in the addition of many pollutants to the waters of the Euphrates River resulting from various activities and waste of domestic use of the population within the lands of the floodplain For the lands of the sedimentary plain within Anbar province

2.2 Economic activities of the population

Among the most important activities in the study area that have a direct impact on the overall pollution of the Euphrates River water in the sedimentary plain in Anbar province are:

2.2.1 Agricultural activities

Agricultural activity flourished in the sedimentary plain area and recent decades have witnessed a great boom in agricultural activity, which led to a significant increase in the quantities of groundwater within the lands of the sedimentary plain have a link to that prevailing activity, which is reflected in the pollution of the water of the Euphrates River and the most prominent of these projects within the lands of the sedimentary plain in Anbar province are

2.2.1.1 Irrigation and drainage projects that flow to the Euphrates River

The most important irrigation and drainage projects within the lands of the sedimentary plain that have an impact on the pollution of the water of the Euphrates River according to its extension in the lands of the sedimentary plain in Anbar province are

2.2.1.1.1 Ramadi irrigation Drainage Project

This project is located in the widest areas of the sedimentary plain in Anbar province between the cities of Ramadi and Fallujah and along both sides of the Euphrates River

2.2.1.1.2 Saqlawiya irrigation and drainage project

The length of the Saqlawiya stream is 18 km and walks at its beginning in the course of the old Karma River a distance of 9 km The remaining distance has been dug in a new stream located close to the left bank of the course of the Karma River and this project branches into other branches.

2.2.1.1.3 Drainage projects that drain into the waters of the Euphrates River

Any irrigation project cannot achieve success if it is not accompanied by the establishment of trocars that work to rid the agricultural land of surplus ground water for the needs of plants and on the basis of this principle and to complement the sustainability of irrigation projects in the study area, a puncture system has been established linked to pumping stations for puncture water to the water of the Euphrates River and the most important pumping stations for puncture water within the lands of the sedimentary plain in the Ramadi district, which pumps puncture water directly to the Euphrates River without treatment:

1- Al Dewar drainage station

2- Zankora drainage station

3- Twai drainage station

4- Al Sreai drainage station

5- Al Buaitha drainage station

6- Al Madeq drainage station

2-3 Sources of pollution of the Euphrates River water in the lands of the sedimentary plain

The period from 2003 to 2023 is one of the worst stages that established the pollution of the water of the Euphrates River in the study area, and the most important sources of pollution of the Euphrates River water in the sedimentary plain area are

picture No (1) Pollution resulting from drainage stations to the Euphrates River

Field study on *20 – 4 – 2021*

2.3.1 Pollution from agricultural activity

It is the most used and wasteful activities of water and the problem of the Euphrates River meets the pollution with agricultural drainage water and its large salinity, but the problem goes beyond the problem of salinity to the arrival of water to the Euphrates River full of toxic pollutants due to the use of chemical fertilizers, pesticides and toxins in the fight against pests and diseases that affect agricultural production in the sedimentary plain area

2.3.2 Pollution resulting from human activity

The human activities in the sedimentary plain within the boundaries of Anbar province are the most polluting of the waters of the Euphrates River, as the remnants of human activities are spread from the waste of industrial and agricultural drainage and health centers from hospitals and other health facilities, as the sewage that was built drainage networks towards the course of the Euphrates River contributes taking advantage of the nature of the flatness of the plain land, and the most prominent remnants of pollution resulting from human activities are:

2.3.2.1 Household liquid pollutants

They are pollutants resulting from the use of water by the population, including kitchen water, sanitary facilities, bathrooms, garages for washing and cleaning cars, and water residues resulting from various domestic uses of the population within the scope of villages, districts, districts and city centers that have taken the land of the sedimentary plain as a place, and these residues contain a percentage of organic and inorganic substances such as salts, fats, mud residues and dust, as well as large amounts of microorganisms of bacteria of different types, viruses and parasites, as well as different types of parasitic worms.

2.3.2.2 Solid contaminants

It includes all solid pollutants from building debris to waste houses and buildings destroyed due to military works, as well as household solid waste that adds new pollutants to the environment and is clearly dangerous to human health, such as some of them contain chemicals that react quickly with water and soil in the lands of the sedimentary plain of the study area

2.3.2.3 Industrial pollutants in sedimentary plain lands

Industrial facilities vary in the degree and intensity of their pollution of the water of the Euphrates River, large industries increase the quantities and concentration of pollutants in the water of the Euphrates River, while small and medium enterprises have a lower impact on the pollution of the Euphrates River water less than the impact of large facilities, although they share the quality of pollutants they offer, including oils, floating fats and suspended substances in the water, in addition to dissolved substances, which include acids, alkalis, salts, heavy elements, pesticides, cyanide, phenol and other substances that affect on aquatic organisms and on the characteristics of river water in terms of color, taste and smell, in addition to its clear effect on the amount of dissolved oxygen in the water

3. Results and Discussion

Evaluation of the pollution of the Euphrates River within the sedimentary plain area

In this section, the most important physical and chemical environmental variables are shown, on which tests were conducted for river water samples within the sedimentary plain area in Anbar

Governorate according to the following context: Table 1 and 2 Validity of Euphrates River water for drinking purposes according to the World Health Organization, Iraqi specifications, natural limits and concentration rates of the main elements (mg / liter) in surface water respectively

3.1 Chemical and physical environmental determinants of Euphrates River water pollutants

The chemical and physical properties of the Euphrates River water vary spatially and temporally depending on the influence of human and natural factors affecting the pollution of the river's water, which plays an important role in the characteristics of the river water within the lands of the sedimentary plain as follows:

3.1.1 Turbidity:

The lands of the sedimentary plain in the study area contributed to increasing the percentage of turbidity in the water of the Euphrates River and turbidity is one of the criteria used in the quality of water that determines the content of the examination sample of mud and silt and these muds and silt work to hinder the respiration of living organisms as turbidity affects the validity and nature of water by obstructing the rarefaction of light in the water column within the course of the river

3.1.2. Total hardness

It is the measurement of the water content of the elements calcium and magnesium and expressed in the unit of mg / liter of calcium carbonate latent and hardness is the ability of water to precipitate soap and water in the course of the Euphrates River within the sedimentary plain and is of somewhat acceptable hardness

3.1.3. pH

The measurement of pH in water is one of the basic requirements because the hydrogen ion is one of the important variables in the reactions related to all water quality, but the pH values in the waters of the Euphrates River did not witness clear spatial differences between the measurement sites, as the annual rates varied between (7.7-7.6-7.6) in the sites of Ramadi, Habbaniyah and Fallujah, respectively [6]

3.1.4 Total dissolved solids (TDS):

The increase in dissolved solids in the water of the Euphrates River in the study area within the lands of the sedimentary plain when allowed within the river water causes an increase in the growth of algae, which works to deplete the dissolved oxygen in the water, as well as the presence of solids in these waters affects the use of water for various human purposes.

3.1.5 Electrical conductivity (EC):

There is a spatial variation of the values of electrical conductivity in the sediments of the Euphrates River, as the lowest rate of conductivity at the site of the Al Mohammadi area was 6.5 De / m, while the highest values of electrical conductivity at the site of Amriyat Al-Fallujah at a value of 9.7 De Mans / m as it represents the last course of the Euphrates River within the study area The values of electrical conductivity in the sediments of the Euphrates River are located between the low-brine to medium salinity sediments, where it is noted that the location of the Mohammadi area was characterized by a lack of types of sediments because it represents the beginning of the entry of the

Euphrates River into the study area and the water of the Euphrates River is not affected by human pollutants, while the values of electrical conductivity recorded an increase in these values as a result of the presence of pollutants, which resulted in the sediment values of electrical conductivity.

3.1.6. Translucence

The amount of transparency in the Euphrates River varies according to the depth of the water and the amount of turbidity and sediment, if the turbidity is high, the transparency ranges between 5-10 cm, while in pure water it reaches 10-20 meters, and the rate of transparency in the Euphrates River is within a meter and is considered a low value as a result of the high turbidity resulting from carrying mud and silt particles in the river water column

3.1.7 Chloride ion (CL1-)

Chloride is the ion responsible for the salty taste, especially when the positive sodium ion, which forms sodium chloride salts, is table salt, and the greater the concentration of these ions in the water, the greater the intensity and salinity of the water, which can be distinguished by tasting the water, and the lands of the sedimentary plain affect the increase in water salinity as a result of the generation of the chloride ion Na Table No (1,2)

3.1.8. sulfate (SO4):

The concentration of sulfate ions in the waters of the Euphrates River increases within the lands of the sedimentary plain in Anbar province and the concentration of sulfate ions increases in the waters of the Euphrates River as a result of the drainage of trocar water scattered in the lands of the sedimentary plain, which drains without any treatment to the water of the Euphrates River and these sulfates contribute to the formation of permanent hardness in the water, especially those in the form of calcium and magnesium sulfates Table No (1,2)

3.1.9. Calcium (Ca):

Calcium is characterized by the speed of its interaction with water, as it consists of the reaction calcium oxide and its union with bicarbonate, forming calcium bicarbonate, which causes the formation of water hardness, and the values of calcium ions in the water of the Euphrates River are less than 200 mg / liter depending on the values of the Iraqi determinants of the quality of water suitable for the aquatic environment of rivers in the study area.

3.1.10. Magnesium (Mg):

The concentration of magnesium ions in the water of the Euphrates River within the study area is within the environmentally permissible limits of the concentration ratio, as the concentration is high during the autumn and summer seasons, while we find low concentrations during the winter and spring seasons. Table No (1,2)

3.1.11. Carbonate and bicarbonate (Co3):

Carbonate and bicarbonate ions are essential ions in most natural waters and are the result of weathering processes of metals (CO 2) and through the reaction of H2Co3 silicate and carbon gas by the action of carbonic acid

The values and rates of bicarbonate concentration in the waters of the Euphrates River vary according to seasons and locations within the lands of the sedimentary plain in Anbar province. Table No (1)

3.1.12. Nitrates (Hco3):

The concentration of nitrates in the waters of the Euphrates River did not exceed the environmental limits in all seasons, but the nature of the study area contributed to raising the concentrations, while it is noted that there are more pronounced temporal variations, especially during the summer and winter. Table No (1,2)

3.1.13. Dissolved Oxygen (DO):

The values and rates of oxygen concentration in the waters of the Euphrates River are change according to the seasons of the year and the sampling sites in different locations within the study area, as the average oxygen concentration reached 6.2 mg / liter, which is within the permissible environmental limits for its concentration, as the value of these specifications is 4 mg / l as a minimum for concentration in the Iraqi aquatic environmental specifications. Table No (1,2)

3.1.14. Silica (SIO2):

The role of silica in the waters of the Euphrates River is highlighted in being an element of nutrients and necessary for organisms that live in the waters of the river, and increasing the concentration of silica is undesirable, especially when using when using this water for industrial purposes for fear that silicate scales crystallize inside the equipment that are difficult to remove and the rate of silica concentration appears

Table No (1) The validity of the Euphrates River water for drinking purposes

According to the World Health Organization (WHO) and Iraqi specifications

N0	variants	units	The general rate of the Euphrates River water	WHO specifications	Iraqi standard specifications
1	Temperature	m°	24.243	35	35
2	Turbidity (Tur)	NTU	17.52	5	5
3	Electrical Conductivity (Ec)	decimens/m	0.9367	1.5	1.5
4	Total Dissolved Salts (TDS)	mg/l	476.06	1500	1000
5	Percent Hydrogen (pH)	1 - 14	7.6	9	6.5 -8 .5
6	Total Hardness(TH)	mg/l	358.27	500	500
7	Sodium(Na)	mg/l	55.7	200	200
8	calcium Ca	mg/l	92.32	200	50
9	Magnesium (Mg)	mg/l	39.75	150	50
10	Potassium(K)	mg/l	3.7	10	-
11	Chloride ion (CL1-)	mg/l	135.11	600	250
12	Sulphate (SO4)	mg/l	238	400	250
13	Nitrates(NO3)	mg/l	2.85	50	50
14	Phosphates(PO4)	mg/l	0.34	3	3
15	Dissolved Oxygen (DO)	mg/l	7.10	Not less than 4	-

Source*:* [6]

Table No (2) Natural limits and concentration rates of major elements (mg/L) in surface water

Elements	Natural limits	The global average river water
Sodium(Na)	450- <1	6.3
calcium Ca	100 > - < 15	15
Magnesium (Mg)	50-1	4.1
Potassium(K)	51-<1	2.3
Chloride ion (CL1-)	40-2	7.8
Sulphate (SO4)	80-2	11.2
Sulphate (SO4)	400-25	58.4
Nitrates(NO3)	450- <1	1

Source :[7], [8], [9], and [10]

3.2 Pollution from reservoir lakes

The study of pollution resulting from the water of reservoir lakes and the statement of its role in changing the chemical and physical properties of the water of the Euphrates River and the storage of water that enters the lakes and then the problem begins after this water stored in the lakes drains again towards the rivers, as in the case of the Euphrates River within the lands of the sedimentary plain, as the waters of the Habbaniyah and Tharthar lakes with plateau sites go to it, as Lake Habbaniyah is located in the western plateau, while Lake Tharthar is located in the plateau of the island and the two drainage lakes descend towards The low floodplain of the Euphrates River and their waters mix with the waters of the Euphrates River within the lands of the sedimentary plain. The storage process in the lakes of Habbaniyah and Tharthar has many negative effects, especially on the quality and characteristics of the water of the Euphrates River, as it leads to an increase in total dissolved salts, as well as other elements that go to those waters, so they work to change their properties, as it was found that there is a significant impact of the characteristics of the two lakes on the waters of the Euphrates River through the analyzes that were conducted for the water of the Euphrates River after the mouth of the Tharthar - Euphrates channel in the Euphrates River in the Habbaniyah area and the mouth of the Habbaniya-Euphrates channel in Sin al-Dhaban area of Habbaniyah District [11]

picture No (*2*) Pollution resulting from drainage lakes and household fluids to the Euphrates River

Field study on 21 – 7 – 2022

4 - Conclusions

In the light of the study and analysis of the pollution of the Euphrates River in the sedimentary plain area of Anbar province, the following was found:

1- The pollution levels of the Euphrates River water in the sedimentary plain area vary within the river water from one area to another of the course of the Euphrates River within Anbar province through qualitative indicators (chemical and physical), they are generally suitable for agricultural purposes (irrigation), but they can only be used for drinking after treatment in the sedimentary plain area.

2- The indiscriminate use of water and the dumping of industrial area waste into the sewage network have contributed significantly to raising the level of pollution in the waters of the Euphrates River within the sedimentary plain area.

3- The flow of the Euphrates River in the sedimentary plain area made it exposed to pollution by solid waste that is constantly dumped on the banks and within the course of the Euphrates River within the study area, especially the cities of Ramadi and Fallujah, as the largest and most densely populated cities and their polluting activities.

4- Wastewater is discharged directly to the riverbed without prior treatment, and this water has a toxic effect on living organisms because it contains large amounts of salts, and heavy metals.

5- Agriculture in the plain lands extending on both sides of the Euphrates River in the study area contributed to supplying large quantities of contaminated water loaded with salts, agricultural pesticides and fertilizer residues, which affected the quality of the river's water, as well as the use of fishermen toxic substances and electric shocks in the fishing process, and this also has a direct impact on the quality of the Euphrates River water.

6- The water of the Euphrates River is exposed to continuous pollution resulting from pollution with the remnants of agricultural residues and the residues of chemical fertilizers, as well as the residues of harmful pesticides, as well as pollution with household waste and heavy sewers, which are thrown directly into the waters of the Euphrates River

7- The water of the Euphrates River in the long term is undrinkable according to the standard of the World Health Organization and acceptable for human use according to the standard of the Iraqi Ministry of Health and Environment

8- The water of the Furra River in the study area is suitable for various human activities, especially agricultural activity, for its suitability for irrigation of various agricultural crops

Recommendations

1- Diverting the water resulting from the agricultural activity in the agricultural lands within the sedimentary plain area, which drains directly into the Euphrates River, into irrigation channels that drain it away from the fresh water of the river.

2- Establishing plants to purify and evaluate industrial wastewater, especially in areas with the most intensive human activity, because of its significant impact on the pollution of the Euphrates River water in the sedimentary plain area.

3- Setting deterrent measures to prevent the residents of the sedimentary plain area from dumping household waste and debris directly on the banks and course of the Euphrates River by raising their awareness of the importance of the Euphrates River water and the extent of its impact on the public health and environment of the population in the region.

4- The need to continue cleaning the course of the Euphrates River from sediments and plants with a polluting effect on the Euphrates River from time to time to preserve the river from the accumulation of mud, especially at the banks of the river in the sedimentary plain area

5- Working to control the multiple sources of pollution in the sedimentary plain area, especially human pollutants, through the treatment and process of waste by various means to reduce its impact on the quality of river water within the study area

6- Treating wastewater that is directly dumped into the river without prior treatment, and benefiting from it after treatment in light of the decreasing water revenue of the river and to ensure that it is not discharged to the stream again, as well as preventing abuses in which the domestic sewer is connected with the rainwater drainage unit.

7- Diverting agricultural drainage water from the agricultural lands discharged by the Euphrates River to the drainage channels away from the fresh water of the river, as it is one of the main and direct sources in raising the concentration of dissolved and salinity substances added to other natural sources and leading to the deterioration of water quality, as well as preventing fishermen from using illegal methods in fishing operations legally.

8- Clean the riverbed of sediment and unwanted vegetation from time to time to keep the river from mud accumulation, especially at the banks of the river.

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Monitoring of Water Quality: Review

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Abstract: Different methods and criteria are used to assess the water quality in the world. In this research, 45 types of research published worldwide were highlighted to determine the best method for assessing water quality worldwide. We classified the methods/tools applied to assess water pollution into five main groups: (GIS, remote sensing, laboratory analysis, traditional method, and artificial neural networks). The results were that the percentage of research for each group (method) applied in 45 articles is: 31% for remote sensing, 29% for GIS, 21% for laboratory analysis, 12% for the traditional method, and 7% for artificial neural networks. Traditional methods are complicated and require time and cost, so we recommend using remote sensing and GIS as quick methods with high-accuracy results. As for parameters, the highest parameters used by the researchers are (Turbidity, Dissolved Oxygen, and chlorophyll-a) with a percentage of 8%, and the lowest parameters used by the researchers were (Potassium, Alkalinity, and Manganese), and the percentage is 2%.

4. Introduction

The water supply of various bodies of water, such as rivers, streams, springs, and lakes, is often referred to as surface water. Due to the presence of pollutants and anthropogenic influences, it is considered a critical issue in several countries [1,2]. The effect of anthropogenic factors, the chemical composition of the river basin, and natural processes such as the interaction of water with a lithogenic structure are some of the factors that have been studied [3,1]. Surface water quality has been degraded to such an extent that it is unsuitable for drinking water, agriculture, and industry [4-6].

The river's water quality is affected by various natural processes and anthropogenic activities, such as the discharge of industrial and agricultural wastes into the river[7]. Industrial and agricultural wastes are the primary sources of pollution affecting the river [8-10]. Since rivers are the main source of freshwater for humans, they must be protected from pollution. Having reliable information about the river's water quality is also essential to manage them effectively. Monitoring and assessing rivers' water quality is also necessary to ensure that they are protected from further degradation [11,10]. The various characteristics of water, such as its physical, chemical, radiological, and aesthetic properties, are known as water quality [12,13].

Due to the increasing vulnerability of developing nations to pollution, and the need to protect freshwater, regular assessments of its quality are essential [14,15]. A water quality index is a quantitative method used to evaluate the water's characteristics. It is derived from a complex process involving the analysis of various water quality parameters [16,17]. Although individual parameters can be used to evaluate the water quality of a river, this method could be more practical due to the high concentration of variables involved [18]. Most countries prefer to use the WQI method to evaluate the water quality of their rivers. It is effortless to understand and is single-valued [19].

Several agencies and authors have also integrated different water quality parameters into their WQIs. This method yields different and varying indices [20-22]. Most of the WQIs currently used by governments are based on a single index developed by the US National Stopping Foundation [23].

In Iraq, rapid development and the river discharge decrease are causing severe water shortages. The increasing prevalence of water contamination and pollution also worsens the country's water problems. Traditional methods of water sampling, which involve in-situ measurements, are very time-consuming and costly. The development of remote sensing techniques has made it possible to perform water quality assessments using RS data. This method allows for establishing a model that can easily follow the water quality parameters. Proper in-situ validation is required to improve the accuracy of the data collected by remote sensing systems [24].

Scientists have also made various labors to improve the models' accuracy in water quality assessments. Four different methods can be used for analyzing and monitoring water quality [25]. One of these is the statistical method, commonly used in the semi-analytical and analytical methods. The data collected by remote sensing systems can then be used to establish a model that can follow the water quality parameters. To perform an inversion algorithm, the relationship between the characteristics and feature bands of the data can be analyzed [26]. Typical empirical methods involve linear regression, band combination, single-band, artificial neural network, and so on.

Although there is a wide variety of methods and criteria used in water quality assessments, little attention has been paid to the effectiveness of these tools in assessing the effects of pollution on the water supply. This study aimed to analyze the data collected from various sources over the past three decades. We collected and analyzed 45 studies published in scientific journals, reports of international organizations, or sources of information obtained from practitioners. The increasing attention paid to the issue of water pollution has prompted the development of new procedures and techniques for assessing it. Introducing new technologies, such as remote sensing systems, geographic information systems (GIS), and computer technology, has led to the development of more accurate and timely methods for monitoring and assessing water pollution. Section 2. summarizes the various criteria and methods used in water quality assessments.

2. Materials and Methods

5. Different methods can be utilized for water pollution assessment. The number of research for each type, such as Remote Sensing (RS) (22), Geographic Information System(GIS) (20), Traditional method (8), Laboratory analysis (15), and Artificial Neural Networks (ANNs) (5). We have classified the methods for water pollution assessment into five main groups: 1) Remote Sensing (RS) (e.g., [27-34] Geographic Information System(GIS) (e.g. [35- 40]) 3) Traditional method (e.g. [41- 44]) 4) Laboratory analysis (e.g. [45]) and 5) Artificial Neural Networks (ANNs)(e.g. [46]). As shown in figure 1, the percentage of each method utilized by the 45 articles was: 31% for group remote sensing, 29% for set GIS, 21% laboratory analysis, 12% traditional method, and 7% ANNs. The following sections include a description of each method individually, data and systems requirements, applicability and limitations, and Examples of studies that have used these methods in evaluating water pollution.

2.1 Remote Sensing (RS)

6. RS stands for remote sensing, the measurement and observation of objects that are not touched [27]. RS also refers to the acquisition of data about a thing that is not directly connected. This is done using sensors without direct contact with the body [28]. According to Bachiller Jareno, RS is regarded as the art and science of collecting data about surface phenomena that are not contact with the body [29]. Through sensors, remote sensing systems can collect data about surface phenomena that emit or reflect energy. This information can then be used to develop new and valuable applications [30,31].

Remote sensing systems use aerial platforms and satellites to collect images of the Earth. Using different image processing techniques, they can also distinguish the other features of the planet's surface. In addition to monitoring the water levels in small dams, remote sensing can also be utilized to analyze the quantity of water stored in them [32]. Through remote sensing, one can now gain valuable information on soil characteristics on different spatial scales [33]. In Iraq, remote sensing techniques have allowed authorities to address the country's water scarcity. This method can also help farmers and commercial entities meet their water needs [34].

2.2 Geographic Information System(GIS)

7. In 1963, Roger Tomlinson created the Geographic Information System, a computer-based device. This device usually stores and visualizes geographic information [35-37]. A GIS is a computer system that manages, analyzes, and visualizes geographic information [38]. A spatial data set comprises the coordinates of various points in a geographic area. This information can be used to develop new and useful applications related to urban planning, agriculture, and water management.

8. According to a recent study, the use of geographic information systems (GIS) for analyzing water supply projects has allowed authorities to make informed decisions and improve the efficiency of their operations [39]. Modern technology can help address the data shortage related to water resources management. It will allow authorities to develop a more accurate runoff estimate [40].

2.3 Traditional method

9. Traditional field methods for monitoring various environmental parameters, such as water quality, were time-consuming and expensive. They required a lot of specialized equipment and personnel, and they did not provide a comprehensive view of the water quality in a region [41]. Due to the complexity of the task and the time involved in monitoring water quality, traditional field methods could not provide a complete view of the condition of the water [42-44].

2.4 Laboratory analysis

10. A broad description of the various procedures involved in analyzing water quality is provided in Water Quality Testing. These procedures are performed to ensure that the water is safe to drink [45].
11. Besides testing for drinking water, water testing also involves monitoring other environmental parameters, such as industrial effluents, groundwater, and domestic wastewater.

2.5 ANNs

12. One of the most essential advantages of using a neural network method for analyzing water quality is its ability to retrieve various parameters simultaneously without requiring prior knowledge about the relationships between them. This is very important to minimize the uncertainties caused by the different background factors affecting water quality. The main advantage of using a neural network technique is that it can process information in a similar manner to that of the human brain. This type of system was developed using inspiration from how our nervous system works [46].

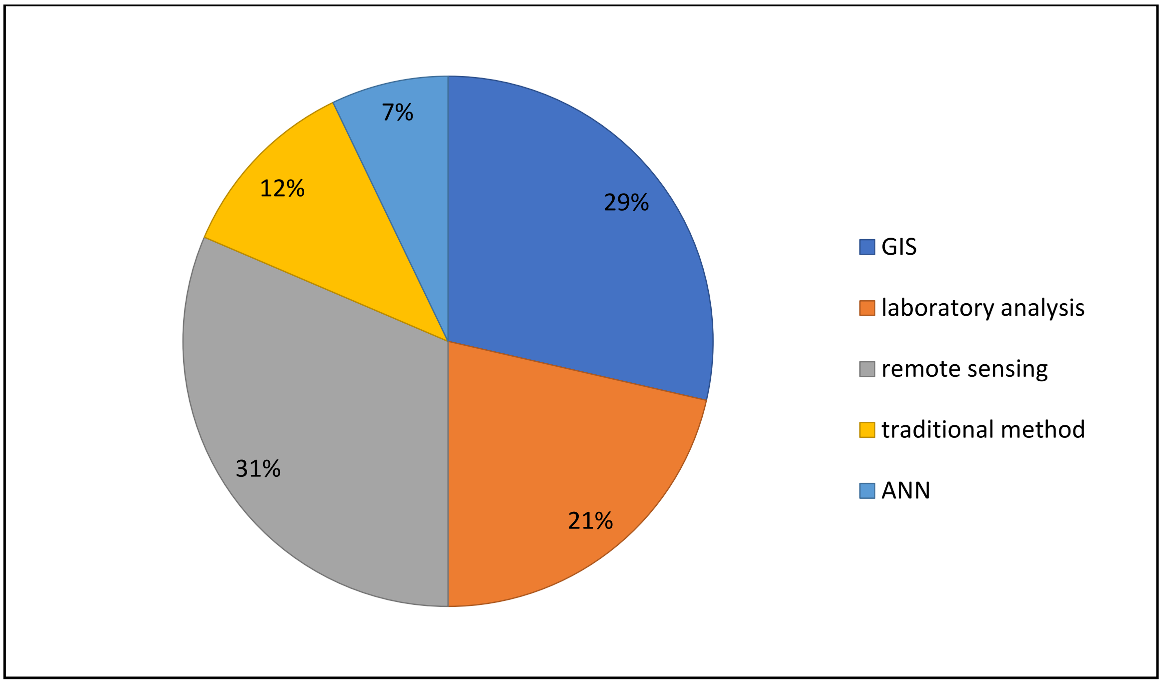

Figure 1. The percentage of methods.

3.Results and Discussion

The assessment of water pollution depends on several parameters. Several studies in the world used different parameters with various methods. The most communal parameters used in water pollution assessment were applied as a percentage of the article reviewed: turbidity (8%), Total Suspended Solids (TSS) (5%), Total Dissolved Solids (TDS) (6%), Dissolved Oxygen (DO) (8%), Water temperature (7%), Biochemical Oxygen Demand (BOD) (5%), Chemical oxygen demand (COD) (5%), Chlorophyll-a (Chl-a) (8%), PH (7%), Conductivity (6%), Nitrate (NO 3) (6%), Total phosphorus (TP) (6%), Alkalinity (2%), Chlorides (5%), Hardness (3%), Manganese (2%), Magnesium (3%), Calcium (4%), Potassium (2%), Sodium (3%) (Show in the figure 2). A description of each parameter individually that has been used in evaluating water pollution is in the following sections.

12.1. *Turbidity*

The term turbidity refers to the cloudiness or haziness of a fluid. This is a vital parameter that determines the quality of water. The scattering of particles or light absorption can cause it [47]. (8%) of the reviewed article adopted the Turbidity factors e.g. [47].

3.2 Total Suspended Solids (TSS)

The amount of suspended particles in a sample is called the dry weight. This is determined by a filter that can be used to analyze the water [47]. (5%) of the reviewed article adopted the Turbidity factors e.g. [47].

3.3 Total Dissolved Solids (TDS)

The total dissolved solid measures a liquid's organic and inorganic substances. It can be measured by comparing the total dissolved solids in a sample with the total dissolved content in a liquid [47]. (6%) of the reviewed article adopted the Turbidity factors e.g. [47].

3.4 Dissolved Oxygen (DO)

The level of free oxygen present in a water sample is known as dissolved oxygen. This is a vital parameter that can be used to determine the water quality because it can affect the organisms that live in the water [47]. (8%) of the reviewed article adopted the Turbidity factors e.g. [47].

3.5 Water temperature

Temperature is a vital factor affecting water's various biochemical, physical, and chemical processes [48]. (7%) of the reviewed article adopted the Turbidity factors e.g. [48].

3.6 Biochemical Oxygen Demand (BOD)

The BOD or Biochemical Oxygen Demand is a measure of the level of oxygen that water-borne bacteria require to survive and thrive in conditions that are favorable to their growth. Some food sources these organisms can rely on are organic waste from septic systems and industrial facilities [48]. (5%) of the reviewed article adopted the Turbidity factors e.g. [48].

3.7 Chemical oxygen demand (COD)

The chemical oxygen demand or COD is a measure of the quantity of matter that's required to be oxidized in water. In the case of chemical oxygen demand, there is no difference between inert and biological materials. The total amount of oxygen required to break down all organic materials into water and carbon dioxide [48]. (5%) of the reviewed article adopted the Turbidity factors e.g. [48].

3.8 Chlorophyll-a (Chl-a)

The Chl-a form of chlorophyll is a proxy for phytoplankton concentration in surface waters [49,50]. In coastal and open oceans, chlorophyll-a's presence can be considered an important optical active variable [51]. (8%) of the reviewed article adopted the Turbidity factors e.g.([49],[50],[51]).

3.9 pH

The pH level is a vital factor that can affect the properties of a liquid. For instance, a low pH can make certain elements, such as metals and minerals, more available to the body. On the other hand, a high pH can make heavy metals less toxic. In addition, a low pH can negatively affect certain applications of water [52]. (7%) of the reviewed article adopted the Turbidity factors e.g. [52].

3.10 Conductivity

The Conductivity of a liquid is a measure of how it can pass an electrical current. When a sample's level of dissolved salts increases, this can result in higher Conductivity. Conductivity can also be affected by temperature. For instance, if the water's temperature is higher, this can lead to a higher conductivity [53]. (6%) of the reviewed article adopted the Turbidity factors e.g. [53].

3.11 Nitrate (NO_3)

In addition to being present in our diet, nitrate is also found in nature. It can naturally occur and be made by humans. Nitrate can be found in various bodies of water, such as rivers, lakes, and groundwater [54]. (6%) of the reviewed article adopted the Turbidity factors e.g. [54].

3.12 Total phosphorus (TP)

When it comes to monitoring the health of a waterway, total phosphorus or TP is a measure of the amount of phosphorus found in a sample. This is commonly used in wastewater treatment. In addition to being present in our diet, phosphates can also be found in various compounds. One of these is the phosphate ion, which can be found in soil, water, and sediments [55]. (6%) of the reviewed article adopted the Turbidity factors e.g. [55].

3.13 Alkalinity

A measure of the water's ability to neutralize various chemicals is known as its alkalinization. It can be determined by comparing the level of these chemicals with the amount of acid in the water. A water body's ability to maintain a low pH level is referred to as its buffering capacity [56]. (2%) of the reviewed article adopted the Turbidity factors e.g. [56].

3.14 Chlorides

One of the most common water pollutants is chlorides. An overabundance of these chemicals in ocean water can lead to their non-applicability to drinking water. Due to the development of desalination techniques, this hurdle has been reduced significantly. The accumulation of salt in nearby areas and the dissolution of industrial wastes are some factors that can cause the presence of chlorides in surface waters. They can also contribute to the formation of well water pollution. Although chlorides have a mild effect on living organisms, excessive consumption can lead to severe poisoning or damage [57]. (5%) of the reviewed article adopted the Turbidity factors e.g. [57].

3.15 Hardness

The presence of two non-toxic chemicals in drinking water, magnesium, and calcium, can cause hardness. The water is considered hard if these chemicals are present in large amounts. This is because washing your hands or making a soap-like product can be hard. Water with little magnesium or calcium is referred to as soft [58]. (3%) of the reviewed article adopted the Turbidity factors e.g. [58].

3.16 Manganese

Minerals, soil, and rocks can also contain manganese, which is a common element. Although manganese is naturally found in groundwater, its levels can increase due to mining and steel production activities. In Wisconsin, manganese can cause the water to turn brown or rust color. It can also cause staining of various surfaces, such as faucets and sinks. Varying levels of manganese can be found in the state's groundwater [59]. (2%) of the reviewed article adopted the Turbidity factors e.g. [59].

3.17 Magnesium

The presence of alkali earth metals, such as magnesium, can also cause water hardness. Water with significant amounts of these minerals is called hard water. On the other hand, water that has low amounts of these minerals is called soft water [60]. (3%) of the reviewed article adopted the Turbidity factors e.g. [60].

3.18 Calcium

It is also helpful to determine the calcium content of water. This can help one decide if the water is soft or hard [61]. (4%) of the reviewed article adopted the Turbidity factors e.g. [61].

3.19 Potassium

The presence of potassium can also be used as an indicator of potential contamination. It can be attributed to the activities of industrial and agricultural facilities [62]. (2%) of the reviewed article adopted the Turbidity factors e.g. [62].

3.20 Sodium

The presence of sodium compounds in water is usually caused by the salt found in rocks and soils. Not only oceans but also bodies of water such as lakes and rivers contain large amounts of this chemical [63]. (3%) of the reviewed article adopted the Turbidity factors e.g. [63].

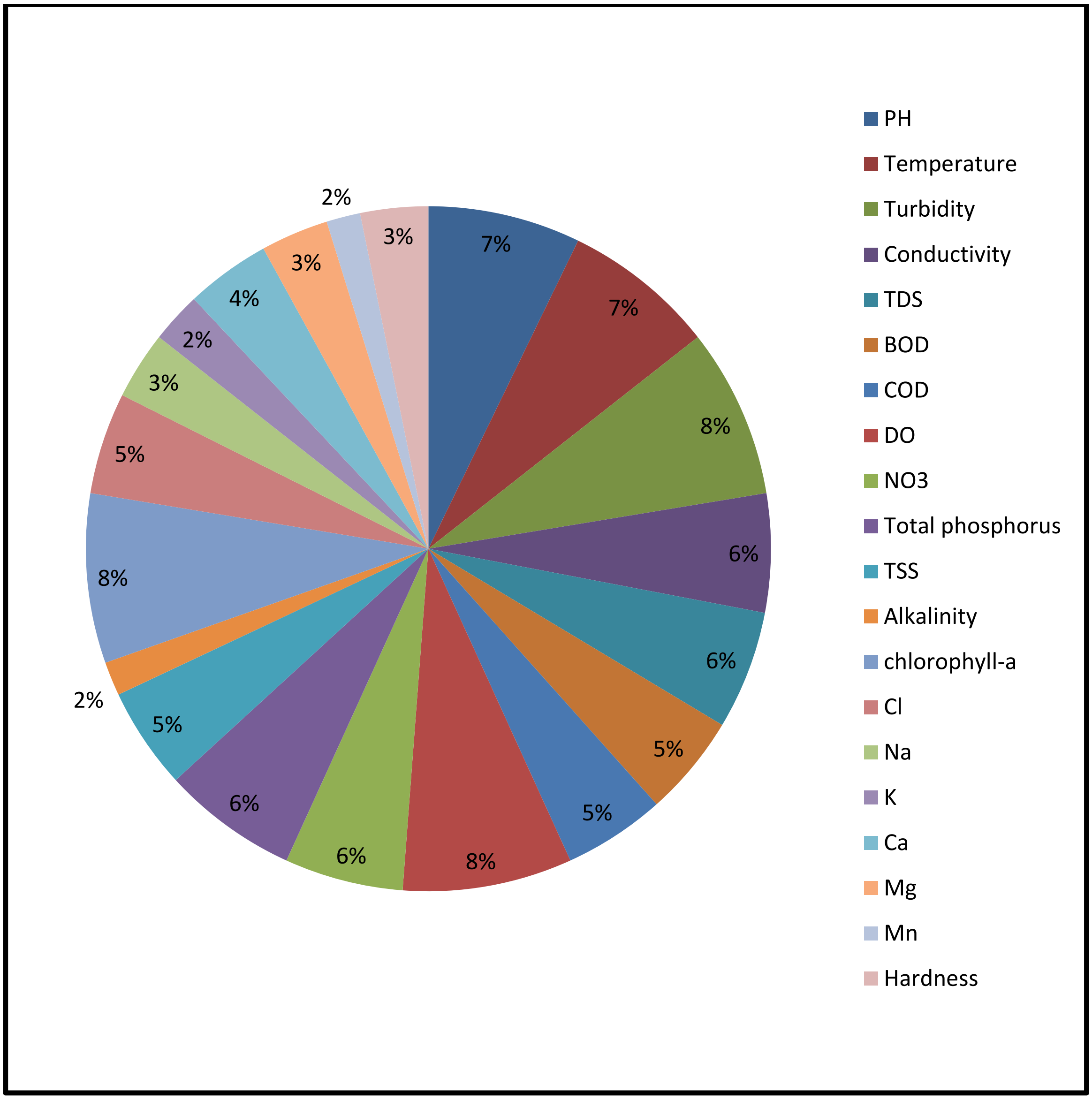

Figure 2. The percentage of parameters.

4.Conclusion

The main objective of this study is to define general methods and criteria used to assess the water quality in the world throughout the last three decades. This study concluded: Various techniques were included in water quality assessment, such as laboratory analysis, traditional methods, remote sensing, laboratory analysis, and artificial neural networks , Using GIS with modern technologies can help improve water quality management's efficiency and cost-effectiveness. It is not feasible to implement the traditional technology due to the time and expense involved in data collection, This research suggested using artificial neural networks for water quality assessment because they can work with inadequate data. The artificial neural network can still produce outputs even if the collected information is incomplete. This is why the country's scientists and engineers must be trained in using these new tools.

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Multivariate statistical methods used in determining the hydrogeochemical surfaces of groundwater in Yusufiya district

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Abstract: For the importance of groundwater and being the second natural source of water after surface water, it is necessary to know the quality, features and hydrological surfaces of this water. For this reason, 15 wells were chosen in the Al Yusufiyah sub-district to study the quality of groundwater based on multivariate statistical methods as well as the Piper chart. These methods proved successful in characterizing the study of groundwater chemistry and can be relied upon for ground and surface water in other regions. The quality of the groundwater in Al Yousifiyah, according to Piper's scheme, the alkalinity increases with the presence of sulfate and chloride, depending on the type of soil. From the analysis of the correlation matrix, the totals were found to be Ca, Mg, and Cl. , Ca, Mg, Cl, and SO4, as well as Ca, Na, Mg, Cl, SO4, and HCO3. From the mass analysis, the first K, second Na, third Ca, fourth Mg, SO4 and fifth Cl, HCO3 were obtained. Finally, from the main component analysis, hydrogeochemical facies were found: Cl, SO4, Ca, HCO3, Mg, and Na, Respectively.

Key word: Groundwater, Hydrogeochemical, Statistical methods, Water quality, Yusufiya district,

1- INTRODUCTION

Water is considered the artery that supports life on the globe. Water sources are either surface or groundwater, which is water formed in a permeable underground formation called an aquifer, used for all areas of life, Especially for areas where surface water is not available (**Deoli, et al. 2017**; **CGWB 2015**; **Chakrapani 2005**). As a result of the increase in population, urbanization and factories increase, groundwater has become necessary and supportive of surface water, and sometimes it become the main water source. Therefore, the preservation of groundwater quality is necessary for the continuity of life and its well-being (**Mattas 2014**: **UN, 2022**). Municipal sewage and industrial waste are the main source of groundwater pollution, in addition to leachate resulting from solid waste and irrigation of agricultural lands (**Matta and Kumar, 2015**), most of the pollutants are sulfates, chlorides, nitrates, viruses and bacteria, in addition to fertilizers and pesticides polluted from agricultural lands (**Matta and Kumar, 2015**), groundwater quaility varies from One region to another according to the type of soil and the nature of the aquifer (**Rahul, 2019**). This water has been subjected to deterioration as a result of random withdrawals as a result of the lack of access to safe drinking water , also due to lack of sewage networks, the population has been forced to use sewage basins, which affects the rise pollutants of groundwater such as salts, organic and inorganic substances.

The Piper chart relies on the concentrations of major ions such as calcium, sodium, magnesium, potassium, bicarbonates, chlorides and sulfates in interpreting the hydrogeochemical characteristics, thus neglecting the actual concentration of dissolved solids [**G. van, 1989**]. This is considered a serious drawback on the Piper chart. [**G. van, 1989**].

Multivariate statistical methods were used in many fields, as in groundwater, to interpret the hydrogeochemical aspects. There are several methods of factor analysis such as graphical methods [**M. G. Dalton, 1978**]. Multivariate statistical methods have been used in groundwater to evaluate the hydrogeochemical features in many countries such as South Africa [**M. D. Molekoa, 2019**] USA [**B. D. Newman, 2016**] China [**C. Su, 2020**], and others. It has been used in Iraq to evaluate groundwater in the Zuber area South of Iraq **[Hussain et al., 2021]**, Erbil [**H. M. Issa, 2018**], Baghdad [**A. H. Ismail, 2015**], and others. Most research focused on climate change factors and water management, but few used multivariate statistical methods with hydrogeochemical characteristics. The aim of this study is to use multivariate statistical methods to evaluate the hydrogeochemical characteristics of groundwater in the city of Yousifiya district.

2- Materials and Methods

2.1 study area

Yusufiyah district is an Iraqi sub-district of Al-Mahmudiyah. It is distinguished by its geographical location middle of Iraq, at a distance of 25 km in the southwest side of the capital, Baghdad, side of Al Karkh, between longitudes and latitudes 44 ° 08 ′ 52 "-44 ° 08 ′ 28" and 33 ° 13 ′ 58 "- 33 ° 01 ′ 15" respectively. It is characterized by the fertile agricultural character for passage Al Yusufiya River branching from the Euphrates River, addition to a commercial and economic location, which is the food provider for the Baghdad city . It is also characterized with livestock, poultry and fisheries. For these reasons, 15 wells were chosen in the study area as a case study, as shown in Figure (1) and (2).

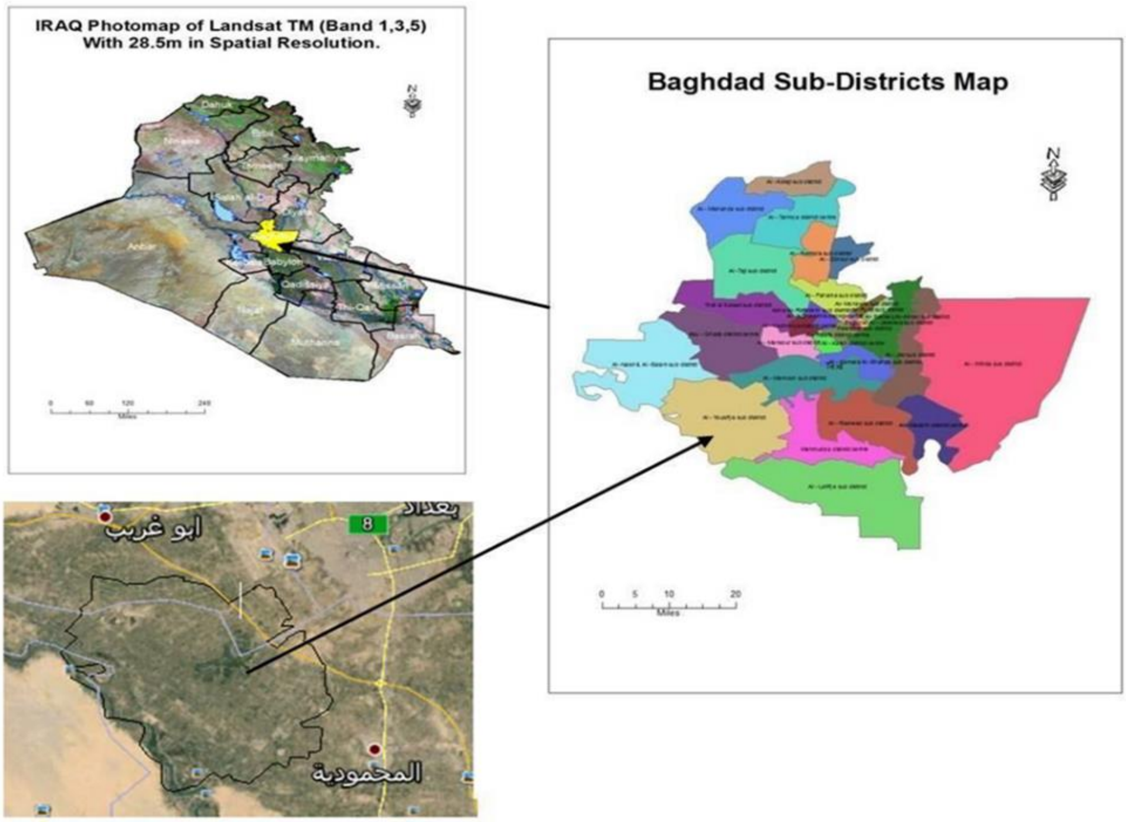

Figure (1): Al Yusufiya district location

2.2 Collection and Analysis Sampling

fifteen wells in Al Yusufiya district area were selected to collect Groundwater samples during October 2020. Plastic bottles of 500mm capacity were used for this purpose. All samples were tested for the variables (pH, EC, TDS, TH, Ca, Mg, Na, k, HCO3, Cl, SO4, NO3. According to the specifications mentioned in the Standard Method, (**APHA, 2012**).

2.3 Statistical analysis of data result from Al Yusufiya groundwater wells.

This study relied on statistical methods to analyze the results, where the correlation matrix, cluster analysis (CA) and principal components analysis (PCA) were used to analyze the main components of groundwater in Yusufiyah district. By using the academic statistics software package STATISTICA - version 13.3 for Windows.

2.3.1- Correlation Matrix Analysis

is a statistical method for evaluating variables linearly. The accuracy of the correlation depends on parameters and other variables [**Mukaka, 2012**]. Also named as effective factor analysis for

multiplied variables that biased on chemical parameters they depend on their sources (**Li et al., 2013**). Interpreted of coefficient of correlation as in Table (1).

Table (1): interpreted of coefficient of correlation (**Pam et al., 2011**)

coefficient of correlation	results	interpretation
coefficient of correlation	Cf > 0.7	strong correlation
coefficient of correlation	Cf = 0.5-0.7	moderate correlation
coefficient of correlation	Cf < 0.5	low correlation

2.3.2- Cluster Analysis (CA)

The CA process is implemented before conducting data analysis, in order to remove the difficulties resulting from the process of collecting it. In this way, the data is collected in groups or nodulate data, and each cluster has an homogeneity internal interdependence and a large external heterogeneity [**K. McGarigal,2013**].The data is then divided into groups, The analysis of the clusters is done one after the other until it becomes one group [**J. McKenna, 2003**].

2.3.3- *Principle Component Analysis (PCA)*

It is an evaluation of observations which is expressed as a data matrix that depends on many dependent variables and is associated with each other [**Adeyi, and Torto,2014**]. The main purpose of this analysis is to obtain information that was previously inferred, used with the basic components, as well as on factors, eigenvectors, and shipments. Values for each variable are estimated according to the basic component **[Eman et al, 2021].**

3. Results and Discussion

3.1- The results obtained by laboratory examination and shown in Table (2) were used in studying the effectiveness of multivariate statistics in knowing the interpretation of the hydrogeochemical surfaces of the groundwater of the Al Yusufiyah region.Figure (2) shows the places where samples were taken.

Table 2: Concentrations of anions and cations of groundwater in Al Yusufiyah district

No.	pH	EC (µs/cm)	TDS (ppm)	TH (ppm)	K (pm	Na (ppm)	Mg (ppm)	Ca (ppm)	Cl (ppm)	SO4 (ppm)	HCO3 (ppm)	CO3 (ppm)	NO3 (ppm)
1	7.2	2800	2000	325.5	12.1	424	36	71	362	510	270	0	9.4
2	7.26	2250	1850	947.8	3.8	214	112	195	471	420	393	0	10.46
3	7.42	1268	950	537.8	10	88	70	100	190	300	50	0	5.6
4	7.31	1268	950	٥٤٨.8	5	88	68	108	182	379	51	0	4.06
5	7.11	1227	930	426.4	4.1	132	54	82	254	245	64	0	14.02
6	7.39	1570	1093	272.4	1.4	153	31	58	208	242	72	0	8.6
7	7.09	1570	1093	272.4	1.4	153	31	58	208	242	72	0	6.2
8	7.7	2190	1511	179.5	8.5	245	20	39	159	306	193	0	4.5
9	7.33	1457	1274	666.3	9.4	94	83	130	154	582	62	0	1.05
10	7.6٢	2310	1947	929.3	1.54	254	116	181	570	519	164	0	2.8
11	7.16	3860	2480	1357.3	2.48	248	166	270	445	1035	265	0	25.18
12	7.12	2840	1830	325.1	4.28	428	36	71	362	510	270	0	63.5
13	7.15	2800	2000	343.3	1.5	424	38	75	300	550	170	0	1
14	7.2	4530	3800	1223.7	5.36	332	157	232	716	1296	509	0	6.4
15	7.22	2250	1850	947.8	2.14	214	112	195	471	420	393	0	28.8
S.S*	6.5-8.5	1000-2000 µm/cm	500-1000 mg/L	120 to 170 mg/L	1.5 mg/l	200 mg/l	150 mg/l	200 mg/l	250-400 mg/l	200-400 mg/l	---.---	---.---	15 mg/l

* SS Standard Specification limit for drinking water (WHO, 2011)

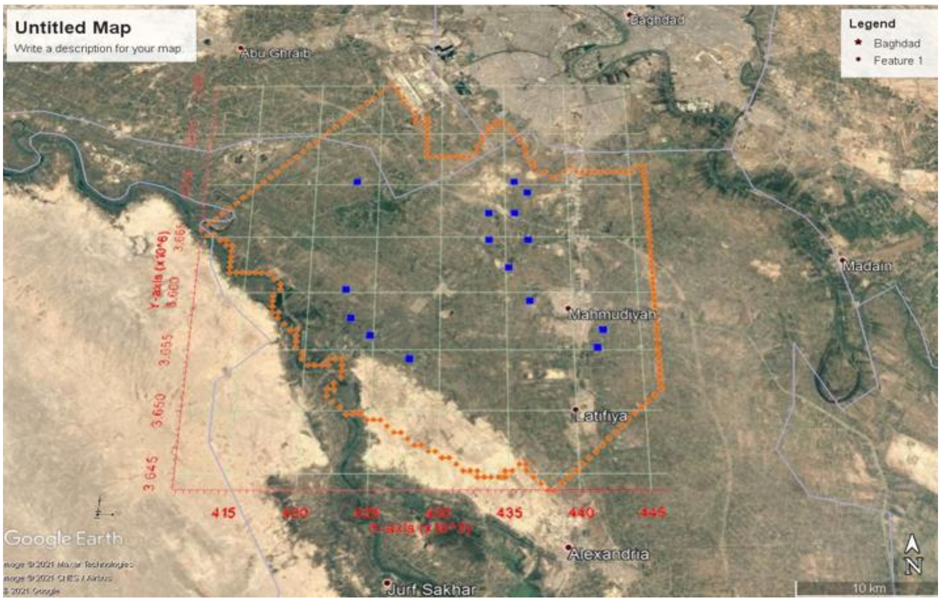

Figure (2): selected wells in study area

3.2- *Piper's classification*

To describe the hydrochemical plains of groundwater samples in Yusufiyah, Piper charts were used, Rock Works software was used to build the Piper diagram and represent the different concentrations of the ions. which is a representative chart showing the type of groundwater. The Piper chart divides water into seven forms shown in Figure (3) and table (3). The results shown in Figure (4). The anions that appear are bicarbonate, carbonate, sulfate and chloride, the cations are calcium, magnesium or sodium and potassium cations. It was found that the wells in Yusufiyah fall within (class e) and (class g) hydrochemical destinations, which indicates the hydrochemical plains is alkaline ground water associated with sulfates, chlorides

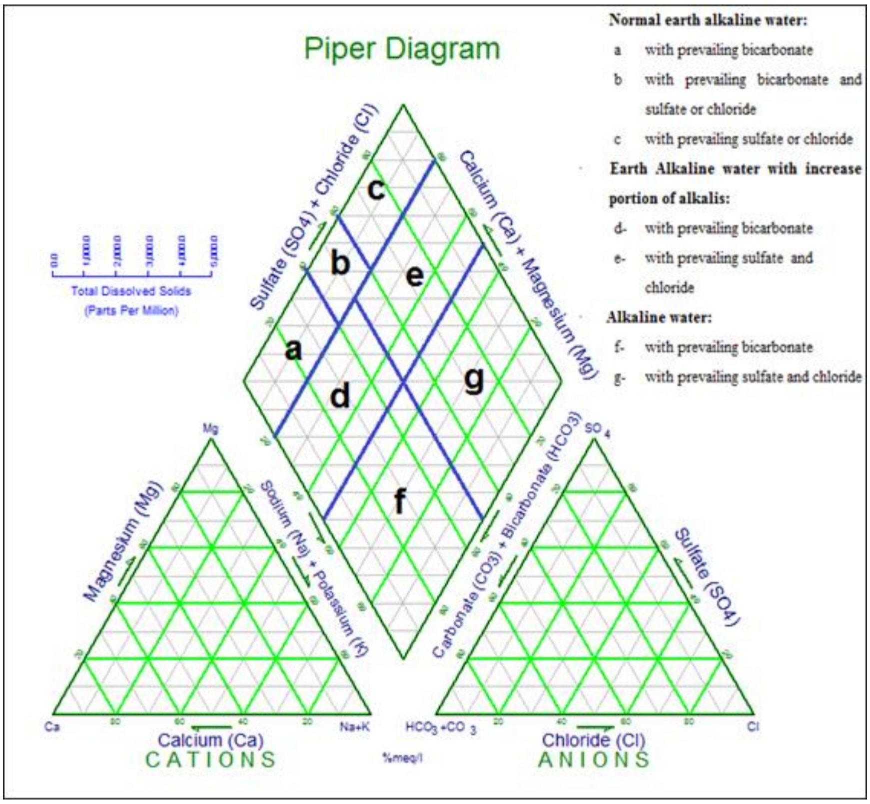

Figure (3): standard Piper diagram **Langguth (1966)**

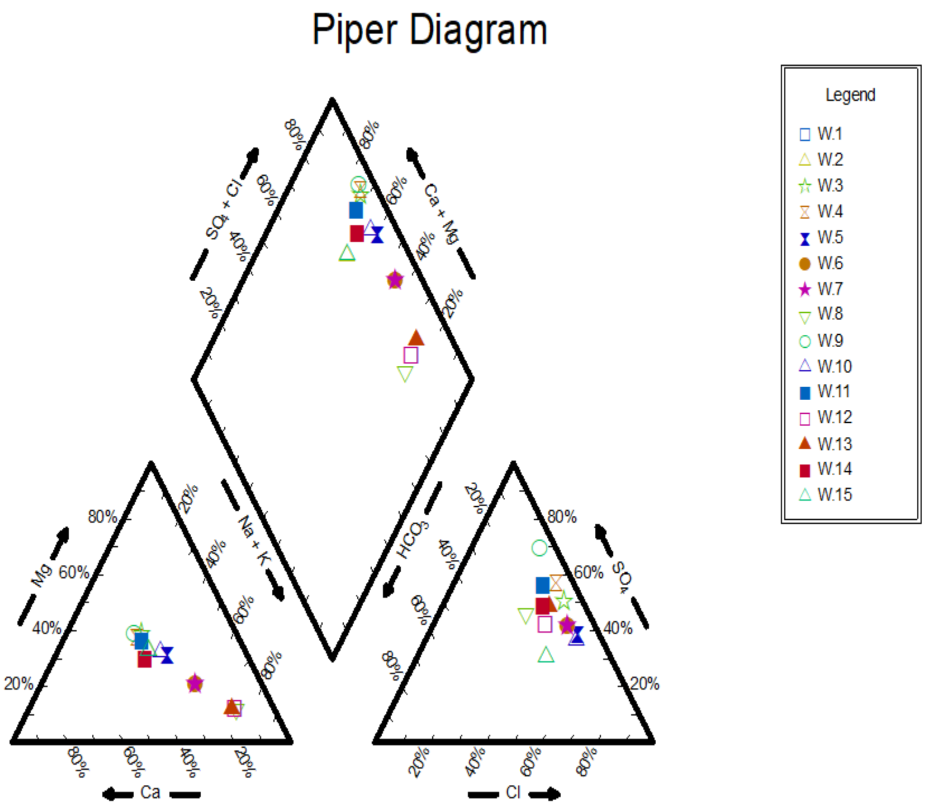

Figure (4): Piper diagram of Al Yusufiyah groundwater tests

Table 3: Classification of the Al Yusufiyah groundwater samples according to the Piper trilineadiagram

Primary title	**Secondary title**	**Class**
Normal earth alkaline water	With prevailing bicarbonate	a
	With prevailing bicarbonate and sulphate or chloride	b
	With prevailing sulphate or chloride	c
Earth alkaline water with increase portion of alkali	With prevailing bicarbonate	d
	With prevailing sulphate and chloride	e
Alkaline water	With prevailing bicarbonate	f
	With prevailing sulphate and chloride	g

3.3 *Correlation Matrix Analysis*

The relationship between two or more variables is measured statically by matrix correlation analysis, while the linear relationship between two variables is represented by the correlation coefficient in order to evaluate the correlation, which is known as the size and strength of the relationship at the level of importance, which shows the reliability of the correlation. The obtained results (correlation coefficient) were compared with the level of significance (p 0.05)**(Li et al., 2011)(I. C. Nnorom, 2019**). For example, the correlation coefficient (r) between sulfate, sodium, calcium, magnesium, total hardness, and bicarbonate was found to be 0.05 level (2-tailed). The other differences are a correlation coefficient of 0.01 level (2-tailed). These differences are considered insignificant and have no effect on the strength of the correlation. Comparing the results, it turns out that the highest correlation coefficient between the two variables is 0.998, which indicates the close correlation between total hardness and magnesium. According to the parameters in Table 1. depend on the main ions (cations - anions) Ca2+, Mg2+, Na+, K+, HCO3-, SO42-, and Cl in meq/l. It turns out that the highest correlation coefficient for calcium is 991.

The results show that the positive correlation of cations and anions indicates a strong and medium bond, while the negative correlation indicates a weak bond. From here, the hydrogeochemical characteristics of the Yusufiyah region are shown in terms of cations and anions, depending on the correlation, as follows: (1)Ca, Mg, and Cl. (2) Ca, Mg , Cl, and SO4 and (3) Ca, Na, Mg , Cl, SO4 and HCO3 as in Table 4, These positive relationships that have been reached indicate the existence of more than one common origin as the source (**Eman, 2021).**

Table 4: Correlation matrix analysis for Al Yusufiyah groundwater

	pH	EC	TDS	TH	Ca	Mg	Na	K	Cl	SO4	HCO3	NO3
pH	1											
EC	-.230	1										
TDS	-.167	.961**	1									
TH	-.091	.570*	.647**	1								
Ca	-.110	.579*	.648**	.997**	1							
Mg	-.074	.560*	.644**	.998**	.991**	1						
Na	-.243	.714**	.629*	-.025	.003	-.050	1					
K	.237	-.096	-.078	-.218	-.241	-.196	-.013	1				
Cl	-.141	.770**	.860**	.750**	.755**	.743**	.479	-.283	1			
SO4	-.223	.887**	.905**	.742**	.730**	.750**	.403	-.009	.708**	1		
HCO3	-.200	.794**	.847**	.589*	.612*	.565*	.567*	-.069	.831**	.637*	1	
NO3	-.395	.262	.128	.045	.073	.019	.386	-.175	.192	.085	.324	1
**. Correlation is significant at the 0.01 level (2-tailed).												
*. Correlation is significant at the 0.05 level (2-tailed).												

3.4- *Cluster Analysis*

Variables are classified into homogeneous groups by cluster analysis, using Ward's method on samples tested for Hierarchical Cluster Analysis (HCA). As shown in Figure (5) the hierarchical diagram of ions (cations and anions).

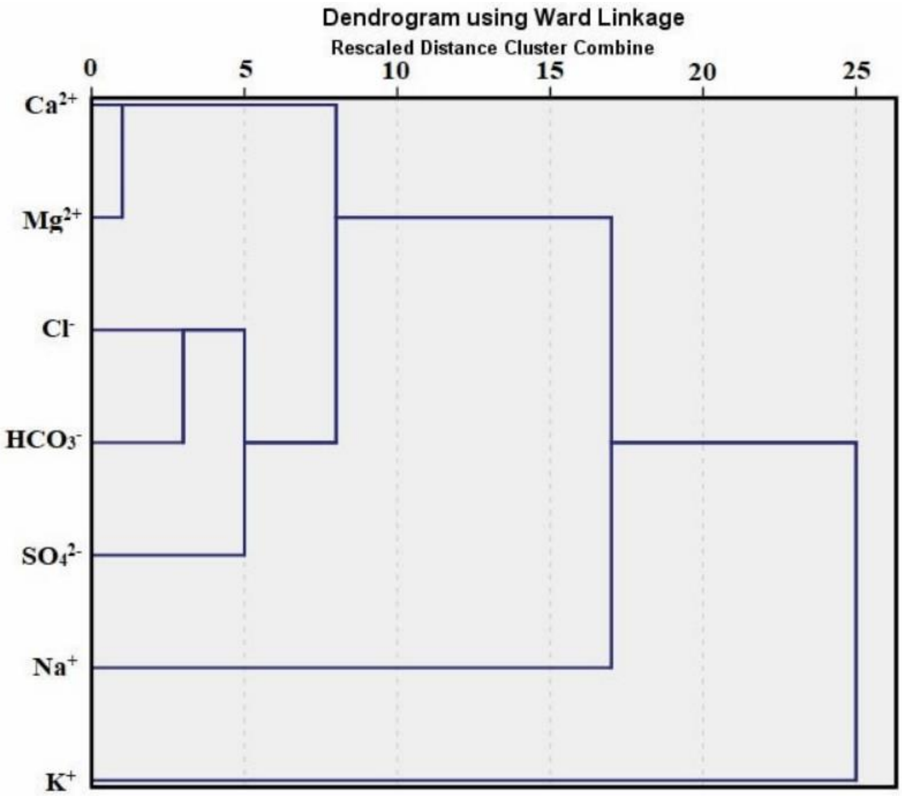

Figure (5): Dendrogram of the cluster analysis of Al Yusufiyah groundwater

The results showed the presence of compatible and overlapping groups between the dendrogram of ions (cations and anions), the results indicated that there are two compatible groups, the potassium group (K), the second group is includes two groups, the first one is single group (Na), while the second consists of two compatible groups, the first includes to calcium (Ca) and magnesium (Mg), while the second group includes two groups, the first one is sulfate (SO4-), and the second includes to chloride (Cl) and bicarbonates (HCO3-), these indicate to presence of positive relationships and indicate to the presence of only one source to groundwater, from this analysis it turns out that the hydrogeochemical characteristics of the Yusufiyah area consist of potassium, sodium, calcium, magnesium, bicarbonate, chlorides and sulfates.

3.5- *Principle Component Analysis (PCA)*

To determine the hydrogeochemical strain of groundwater in Yusufiyah, PCA was used by combining Varimax circulation with the Kaiser application. Table 5 shows the PCA results.From the results, it is clear that there are 3 extracted components, according to (**S. Liu et al.2022**), the positive load has a value between (0.75-1.0), the moderate one is between (0.5-0.75), and the weak one (0.3-0.5).

From the results show that the positive load of ions (cations and anions) are Cl, SO4, Ca, HCO3, Mg, while the positive load in the second group is Na, and the third group lacks a positive group. Also, all aggregates lack medium loads. The ions may be cations and anions in the Youssifiya groundwater of two origins, according to PCA classification, either from Cl, SO4, Ca, HCO3, Mg or from Na.

Table 5: varimax rotation (Factor loadings) of ion (anions and cations) in Al Yusufiyah groundwater

Component Matrix[a]

	Component		
	1	2	3
pH	-.242	-.405	.587
EC	**.897**	.316	.186
TDS	**.934**	.182	.244
TH	**.848**	-.493	-.125
Ca	**.855**	-.465	-.150
Mg	**.839**	-.516	-.101
Na	.467	**.799**	.212
K	-.206	.049	.738
Cl	**.916**	.016	-.011
SO4	**.894**	-.021	.184
HCO3	**.850**	.242	.094
NO3	.235	.560	-.488

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

In Table 6 were shown a summary of the results of the correlation matrix analysis, the cluster analysis, and the basic compounds analysis of the Al Youssoufia groundwater samples, which show its hydrogeochemical surface.

Table 6: According to the multivariate statistics, hydrogeochemical faces of Al Youssoufia groundwater samples

4.

Hydrogeochemical Facies			
Class	**Correlation Analysis**	**Cluster Analysis**	**Principle Component Analysis**
1	Ca, Mg, Cl.	K	Cl, SO4, Ca, HCO3, Mg,
2	Ca, Mg , Cl, and SO4	Na,	Na,
3	Ca, Na, Mg , Cl, SO4, HCO3	Ca, Mg	
4		SO4	
5		Cl, HCO3	

Conclusion

The multivariate statistical method proved as hydraulic features in describing the quality of groundwater, especially in Yusufiyah, from the Piper chart showing that the alkalinity increases with the prevailing sulfate and chloride. This is due to the quality of the soil. Three hydrogeochemical facies were classified from the correlation matrix analysis, namely Ca, Mg, and Cl. and Ca, Mg, Cl, and SO4, as well as Ca, Na, Mg, Cl, SO4, and HCO3. It was concluded that (CA), the five surfaces were found, the first K, second Na, third Ca, Mg fourth SO4 and Fifth Cl, HCO3 . Also, two hydrogeochemical facies were found: Cl, SO4, Ca, HCO3, Mg, and Na,

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