Secondary Clarifier

Secondary clarifier are used to remove the settlable suspended solids created in biological treatment processes such as the activated sludge and trickling filter process

Advanced Waste Water Treatment Methods

The effluent from a typical secondary treatment plant still contains 20-40 mg/L BOD which may be objectionable in some streams. Suspended solids, in addition to contributing to BOD, may settle on the stream bed and inhibit certain forms of aquatic life.

The BOD if discharged into a stream with low flow, can cause damage to aquatic life by reducing the dissolved oxygen content. In addition the secondary effluent contains significant amounts of plant nutrients and dissolved solids. If the waste water is of industrial origin, it may also contain traces of organic chemicals, heavy metals and other contaminants.

Different methods are used in advanced waste treatment to satisfy any of the several specific goals, which include the removal of

1- Suspended Solids

2-BOD

3-Plant nutrients

4-Dissolved solids

5-Toxic substances

These methods may be introduced at any stage of the total treatment process as in the case of industrial waterways or may be used for complete removal of pollutants after secondary treatment.

1-Removal of suspended solids:

This treatment implies the removal of those materials that have been carried over from a secondary treatment settler. Many methods were proposed of which two methods were commonly used.

The two methods are micro staining and chemical coagulation followed by settling and mixed media filtration:

Micro staining:

It is a special type of filtration process which makes use of filters oven from stainless steel wires with very fine pores of 60-70 microns size. This filter helps to remove very fine particles. High flow rates and low back pressures are achieved

Coagulation and flocculation:

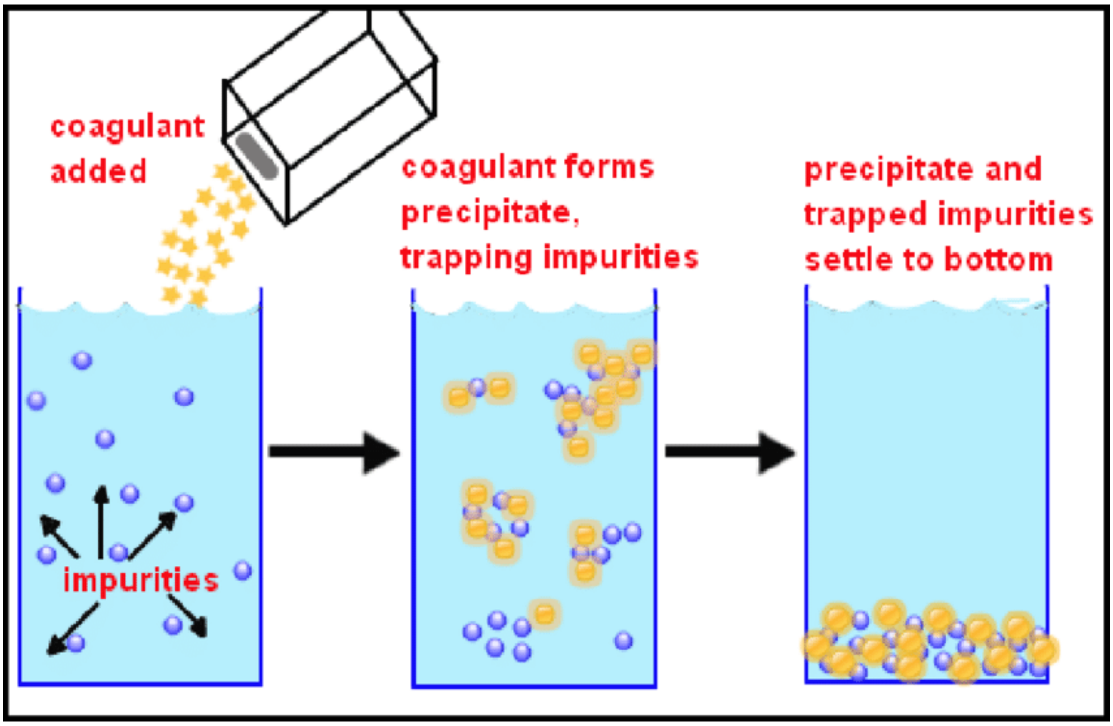
The object of coagulation is to alter these particles in such a way as to allow them to adhere to each other. Most colloids of interest in water treatment remain suspended in solution because they have a net negative surface charge that causes the particles to repel each other. The intended action of the coagulant is to neutralize that charge, allowing the particles to come together to form larger particles that can be more easily removed from the raw water. The usual coagulant is alum [AI2(S04)2‘ 18H20], though FeCI3, FeS04 and other coagulants, such as polyelectrolytes, can be used. Alum when added to water, the aluminium in this salt hydrolyses by reactions that consume alkalinity in the water such as:

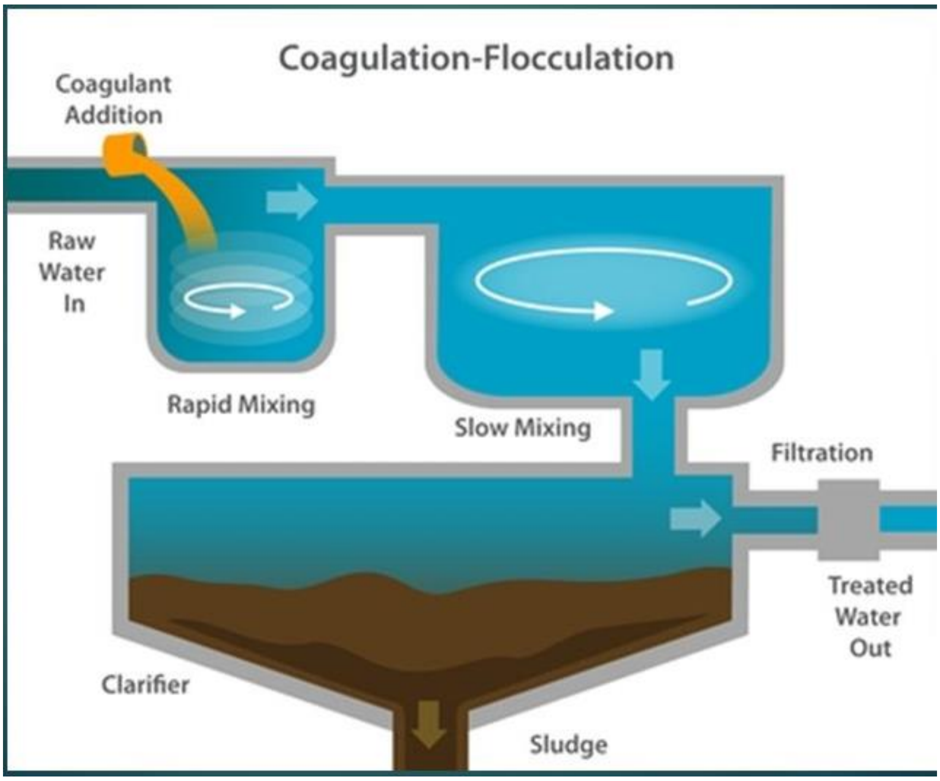
Al (HO)6] + 3 3HC03 — AI(OH)3(s) + 3Co2 + 6H2o …………………….. (1(

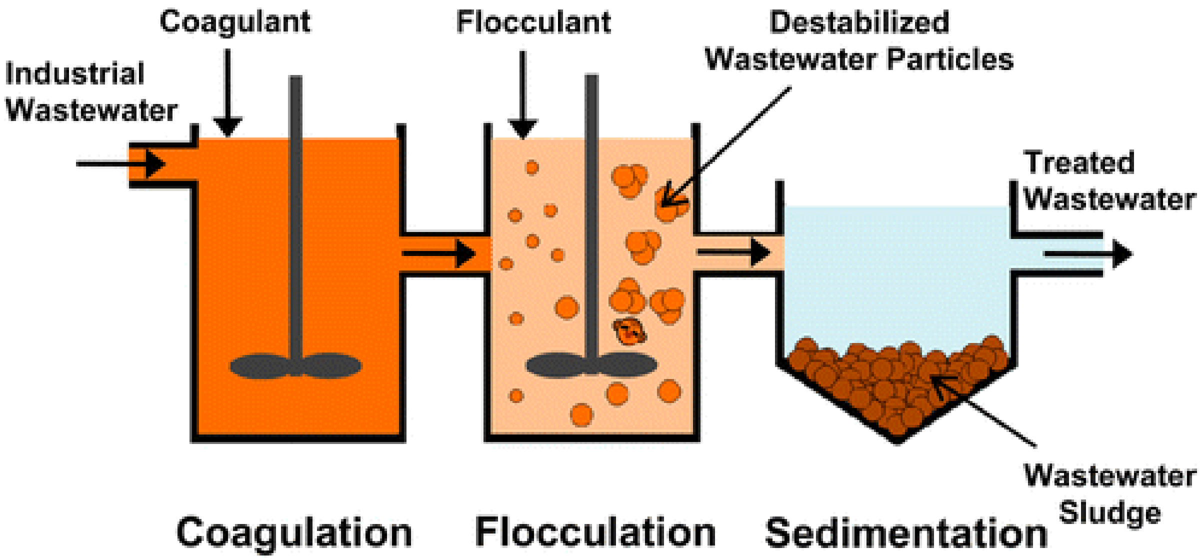
The gelatinous hydroxide thus formed carries suspended material with it as it settles. Metal ions in coagulants also react with virus proteins and destroy upto 99% of the virus in water. Anhydrous ion (III) sulphate can also act as effective coagulant similar to aluminium sulfate. An advantage with iron (III) sulfate it that it works over a wide range of pH.

To separate the dissolved and suspended particles from the water coagulation and flocculation processes are used. Coagulation and flocculation is relatively simple and cost-effective, provided that chemicals are available and dosage is adapted to the water composition. Regardless of the nature of the treated water and the overall applied treatment scheme, coagulation-flocculation is usually included, either as pre-treatment (e.g. before rapid sand filtration) or as post-treatment step after sedimentation (see also centralised water purification plants).

Most solids suspended in water possess a negative charge; they consequently repel each other. This repulsion prevents the particles from agglomerating, causing them to remain in suspension. **Coagulation** and flocculation occur in successive steps intended to overcome the forces stabilizing the suspended particles, allowing particle collision and growth of flocs, which then can be settled and removed (by sedimentation) or filtered out of the water. **Coagulation-Flocculation** is also a common process to treat industrial and domestic wastewater in order to remove suspended particles from the water.







Coagulation principles

Coagulation destabilizes the particles' charges. Coagulants with charges opposite to those of the suspended solids are added to the water to neutralize the negative charges on dispersed non-settable solids such as clay and organic substances.
Once the charge is neutralized, the small-suspended particles are capable of sticking together. The slightly larger particles formed through this

process are called microflocs and are still too small to be visible to the naked eye. A high-energy, rapid-mix to properly disperse the coagulant and promote particle collisions is needed to achieve good coagulation and formation of the microflocs. Over-mixing does not affect coagulation, but insufficient mixing will leave this step incomplete. Proper contact time in the rapid-mix chamber is typically 1 to 3 minutes.

Flocculation

Following coagulation, flocculation, a gentle mixing stage, increases the particle size from submicroscopic microfloc to visible suspended particles.

The microflocs are brought into contact with each other through the process of slow mixing. Collisions of the microfloc particles cause them to bond to produce larger, visible flocs. The floc size continues to build through additional collisions and interaction with inorganic polymers formed by the coagulant or with organic polymers added. Macroflocs are formed. High molecular weight polymers, called coagulant aids, may be added during this step to help bridge, bind, and strengthen the floc, add weight, and increase settling rate. Once the floc has reached its optimum size and strength, the water is ready for the separation process (**sedimentation**, floatation or filtration). Design contact times for flocculation range from 15 or 20 minutes to an hour or more.

Coagulation flocculation separation

In water treatment, coagulation and flocculation are practically always applied subsequently before a physical separation. The **Coagulation-Flocculation** process consists of the following steps:

- **Coagulation**-flocculation: The use of chemical reagents to destabilise and increase the size of the particles; mixing; increasing of flog size,
- A physical separation of the solids from the liquid phase. This separation is usually achieved by sedimentation (decantation), flotation or filtration.

The common reagents are: mineral and/or organic coagulants (typically iron and aluminium salt, organic polymers), flocculation additives (activated silica, talcum, activated carbon…), anionic or cationic flocculants and pH control reagents such as acids or bases. Certain heavy metal chelating agents can also be added during the coagulation step.

Jar test

The jar test is used to identify the most adapted mix of chemical compounds and concentrations for coagulation-flocculation. It is a batch test consisting of using several identical jars containing the same volume and concentration of feed, which are charged simultaneously with six different doses of a potentially effective coagulant. The six jars can be stirred simultaneously at known speeds. The treated feed samples are mixed rapidly and then slowly and then allowed to settle. These three stages are an approximation of the sequences based on the large-scale plants of rapid mix, coagulation flocculation and settling basins. At the end of the settling period, test samples are drawn from the jars and turbidity of supernatant liquid is measured. A plot of turbidity against coagulant dose gives an indication of the optimum dosage (i.e. the minimum amount required to give acceptable clarification). The criteria thus obtained from a bench jar test are the quality of resultant floc and the clarity of the supernatant liquid after settling. The design of the full-scale plant process is then done based on the bench-scale selection of chemicals and their concentrations.

Unfortunately, the jar test suffers from a number of disadvantages, despite its widespread application. It is a batch test, which can be very time-consuming. And the results obtained from a series of jar tests might not correspond to the results obtained on a full-scale plant.

Filtration:

If properly formed, the addition of chemicals for promoting coagulation and flocculation can remove both suspended and colloidal solids. After the floes are formed, the solution is led to a settling tank where the floes are allowed to settle.

While most of the flocculated material is removed in the settling tank, some floe do not settle. These floes are removed by the filtration process, which is usually carried out using beds of porous media such as sand or coal. The current trend is to use a mixed – media filter which consists of fine garnet in the bottom layer, silica sand in the middle layer and coarse coal in the top layer which reduces clogging.

Ultra Filtration:

a. Selectively filters only molecules of a specified size and weight.

b. Removes e.g. various viruses.

c. Used for sterilization, clarification, wastewater treatment.

d. Membrane size 1 _ – 0.01 µm. is used

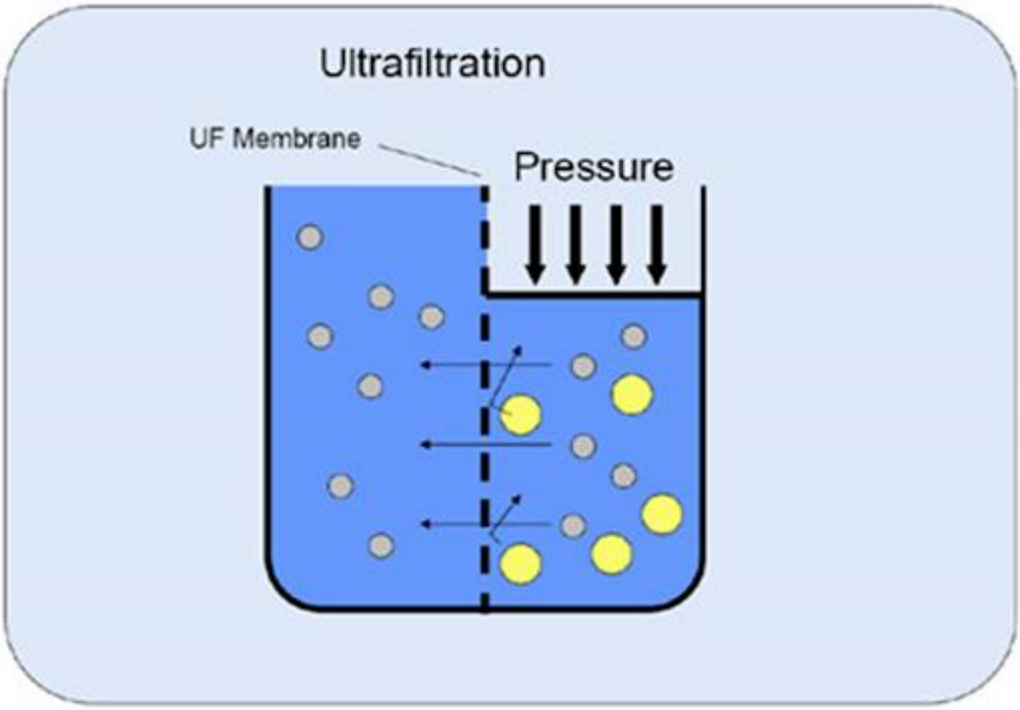
This is a dynamic filtering process with a predominance of physical (mechanical) phenomena in which chemical phenomena are also involved. The membranes used, polymeric or mineral, allow dissolved salts to pass while they reject high molecular weights selectively.

The selectivity depends on the membrane structure and is defined as the cut-off of molecular weight, which the membrane can separate with an efficiency of 90 % (although this definition may not be rigorous depending on the molecular shape)

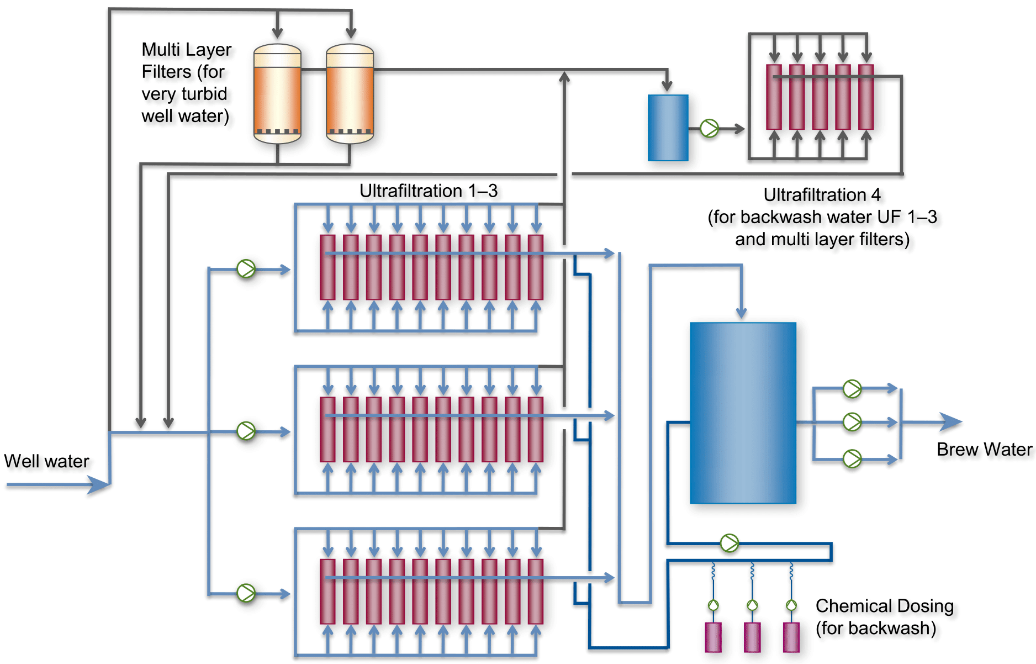
Commercial membranes applied in ultra filtering can separate substances with a molecular weight between 1.000 and 10.000. Ultra filtering systems generally work in a pressure range between 1.5 and 7 bar With industrial discharge waters the fluxes of permeate generally fluctuate between 0.5 and 1 – 5 m3 / h / m2 surface, depending on the concentration of the substances to be separated, with energy consumptions varying between 2 and 20 KWh per m3 of permeate. The single pass ultra filtering process is the simplest and most commonly used process for water treatment because it allows the recovery of high percentages of permeate (approximately 90-95 %).

There has been a relatively recent application of this technique in the metal finishing sector for the recovery of degreasing baths (the first cleaning bath in metal-finishing processes, for pieces which are still dirty with lubricating substances).

The solution to be treated is passed through the membrane at a certain speed and under hydrostatic pressure, obtaining a concentrated fraction of oils and grease for disposal, while the filtrate is recovered and reused to prepare new baths.



Ultrafiltration with Backwash Water Recycling



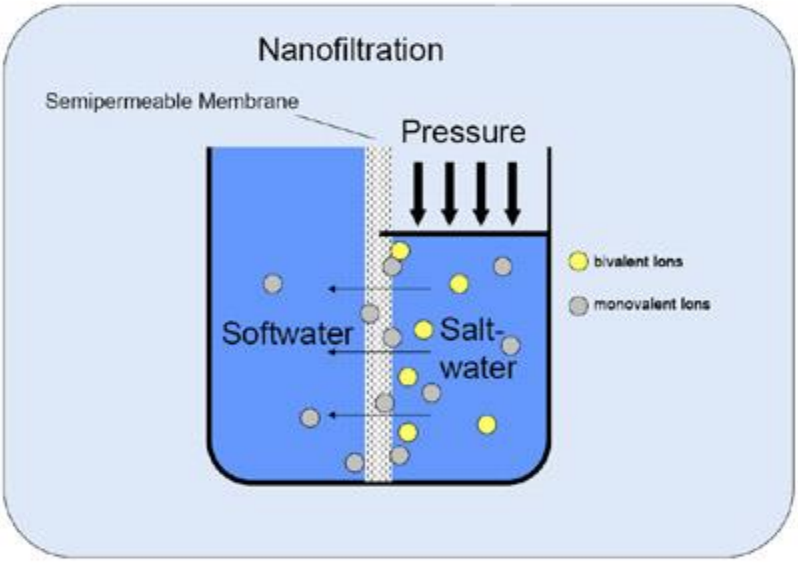
Nano Filtration:

The Nano filtration technique is mainly used for the removal of two valued ions and the larger mono valued ions such as heavy metals. This technique can be seen as a coarse RO (reversed osmosis) membrane. Because Nano filtration uses less fine membranes, the feed pressure of the NF system is generally lower compared to RO systems. Also the fouling rate is lower compared to Ro systems.

2. Removal of Dissolved Solids:

The dissolved solids are of both organic and inorganic types. A number of methods have been investigated for the removal of inorganic constituents from waste water.

Three methods which are finding wide application in advanced waste treatment are ion-exchange, electro dialysis and reverse osmosis. For the removal of soluble organics from waste water the most commonly used method is adsorption on activated carbon. Solvent extraction is also used to recover certain organic chemicals like phenol an d amines from industrial waste waters.



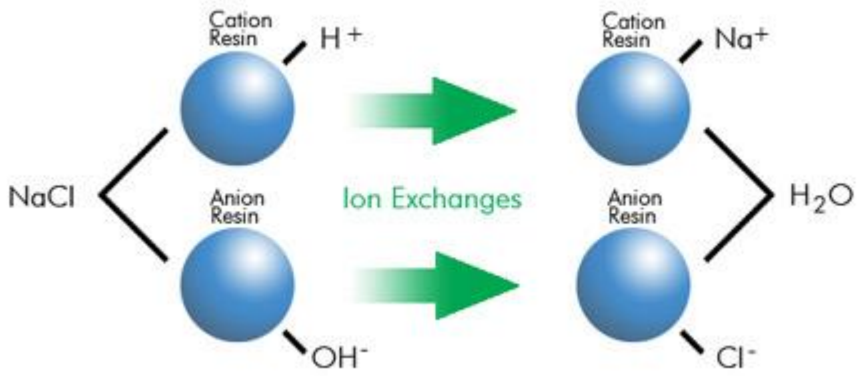
Ion exchange:

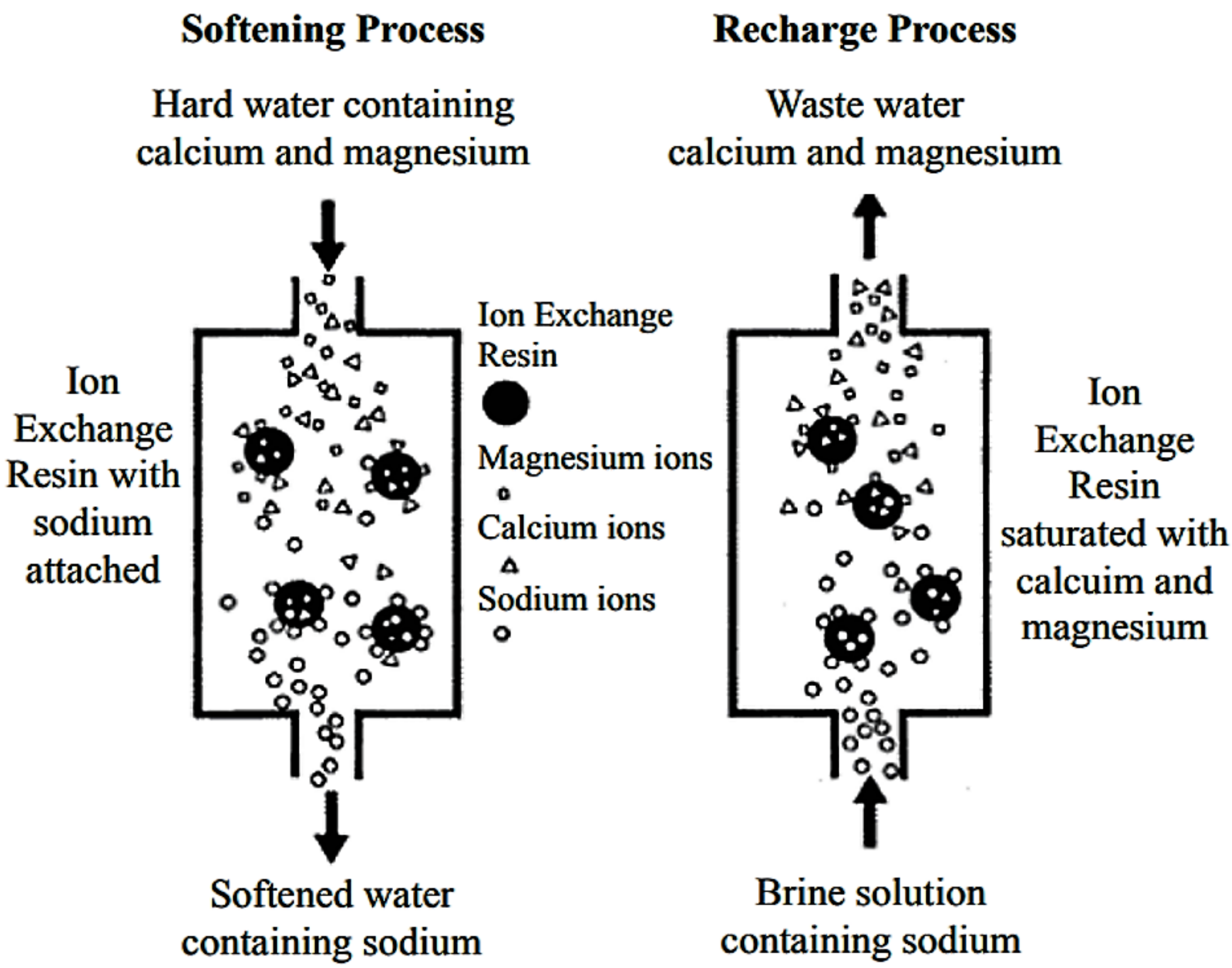
This technique has been used extensively to remove hardness, and iron and manganese salts in drinking water supplies. It has also been used selectively to remove specific impurities and to recover valuable trace metals like chromium, nickel, copper, lead and cadmium from industrial waste discharges. The process takes advantage of the ability of certain natural and synthetic materials to exchange one of their ions.

A number of naturally occurring minerals have ion exchange properties. Among them the notable ones are aluminium silicate minerals, which are called zeolites. Synthetic zeolites have been prepared using solutions of sodium silicate and sodium aluminate.

Alternatively synthetic ion-exchange resins composed of organic polymer with attached functional groups such as (strongly acidic cation exchange resins), or – COO – 3 -SO H+~ H+ (weakly acidic cation exchange resins or -N+(CH3)3OH~ (strongly basic anion exchange resins) can be used.

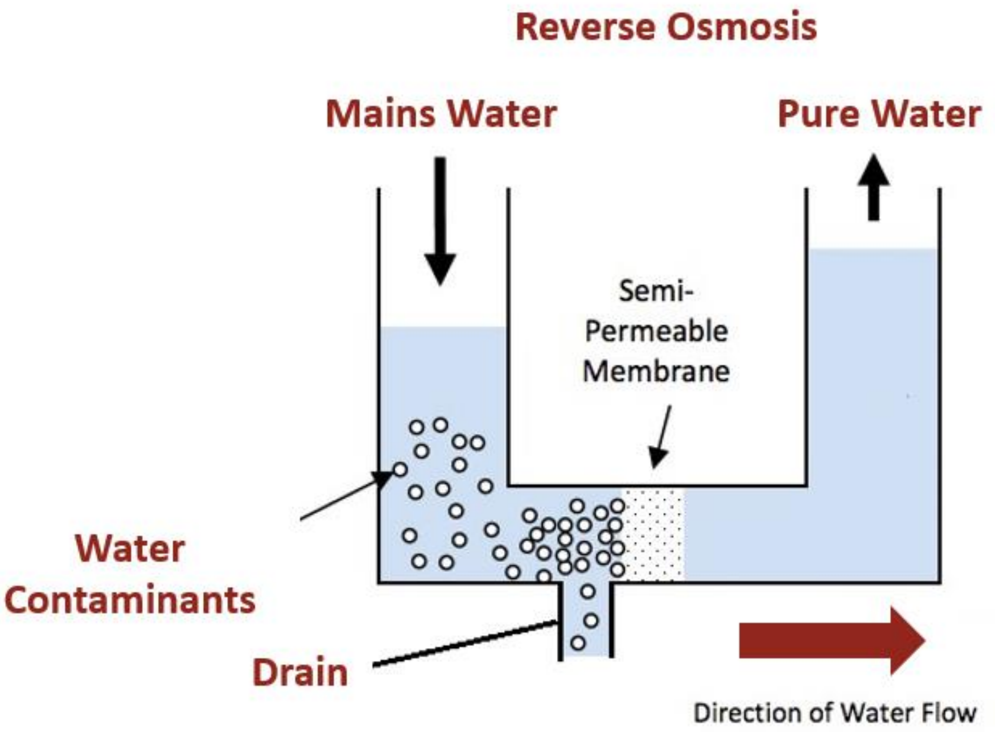
In the water softening process, the hardness producing elements such as calcium and magnesium are replaced by sodium ions. A cation exchange resin in sodium form is normally used. The water-softening capability of cation exchange can be seen when sodium ion in the resin is exchanged for calcium ion in solution



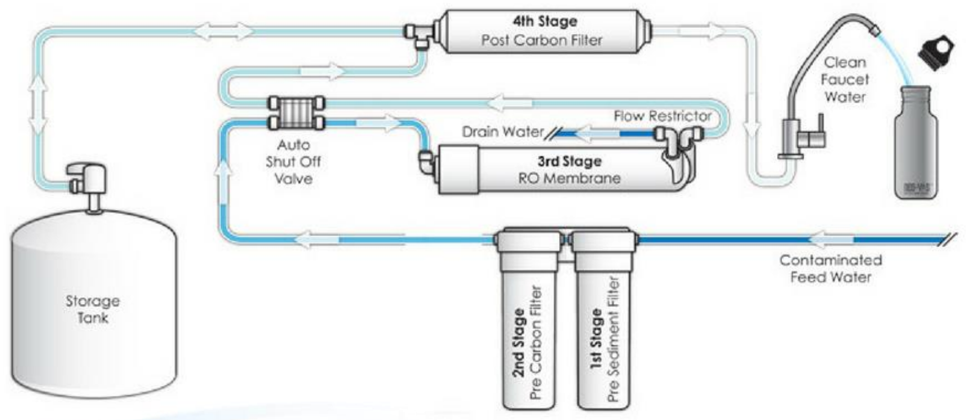


Reverse osmosis:

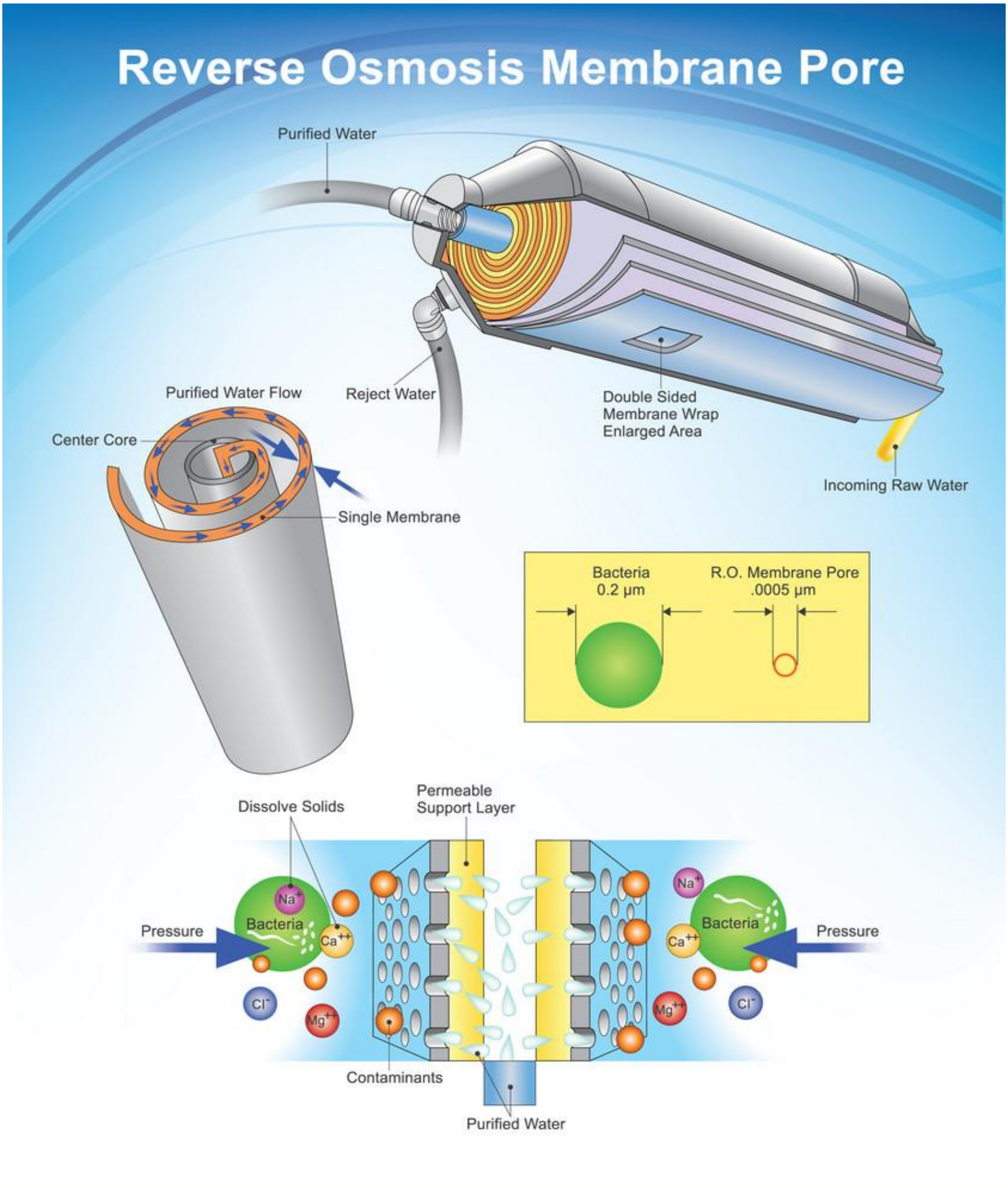
In the reverse osmosis process, de-mineralization water is produced by forcing water through semi permeable membranes at high pressure. In ordinary osmosis, if a vessel is divided by a semi permeable membrane (one that is permeable to water but not the dissolved material), and one compartment is filled with water and other with concentrated salt solution, water diffused through the membrane towards the compartment containing salt solution until the difference in water levels on the two sides of the membrane creates a sufficient pressure to counteract the original water flow. The difference in levels represents the osmotic pressure of the solution.



The Cross Flow Filtration Of Reverse Osmosis System




RO Membrane
CTO Filter
PP Filter
CAUTION
NOTICE
PRO – 3.2

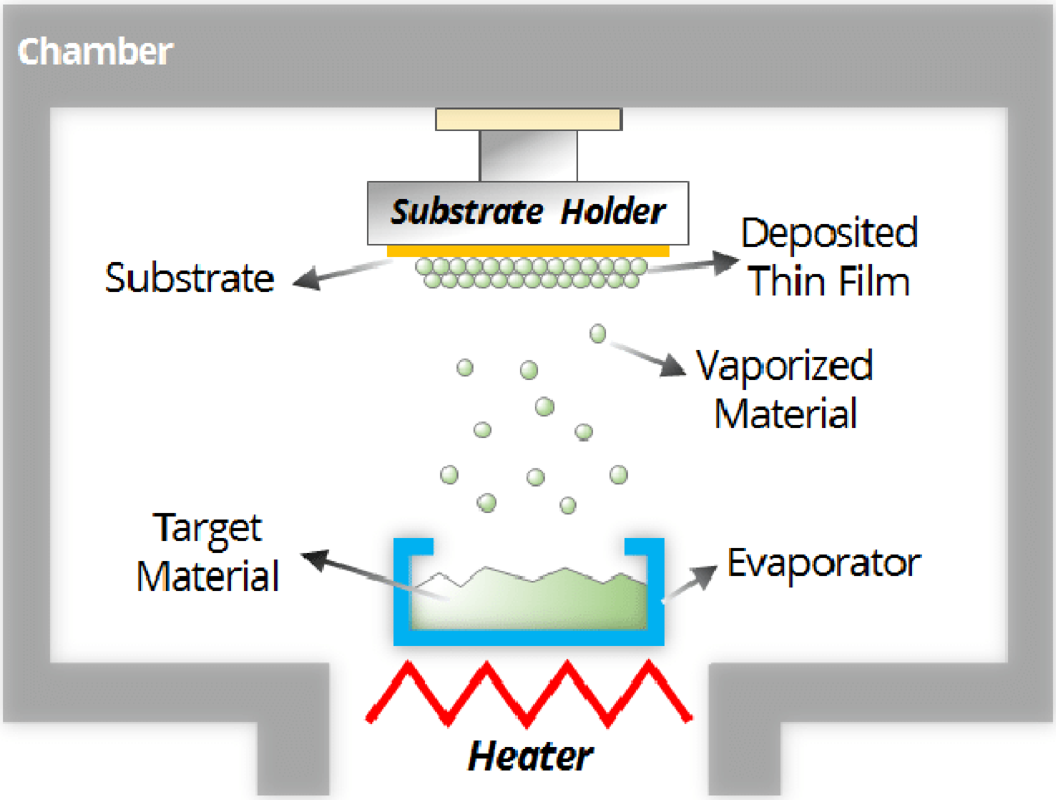

Reverse Osmosis Membrane Pore
Purified Water
Purified Water Flow
Reject Water
Double Sided
Membrane Wrap
Enlarged Area
Center Core
Single Membrane
Incoming Raw Water
Bacteria
0.2 µm
R.O. Membrane Pore
.0005 µm
Dissolve Solids
Permeable
Support Layer
Pressure
Bacteria
Na+
Ca++
Cl-
Mg++
Contaminants
Purified Water

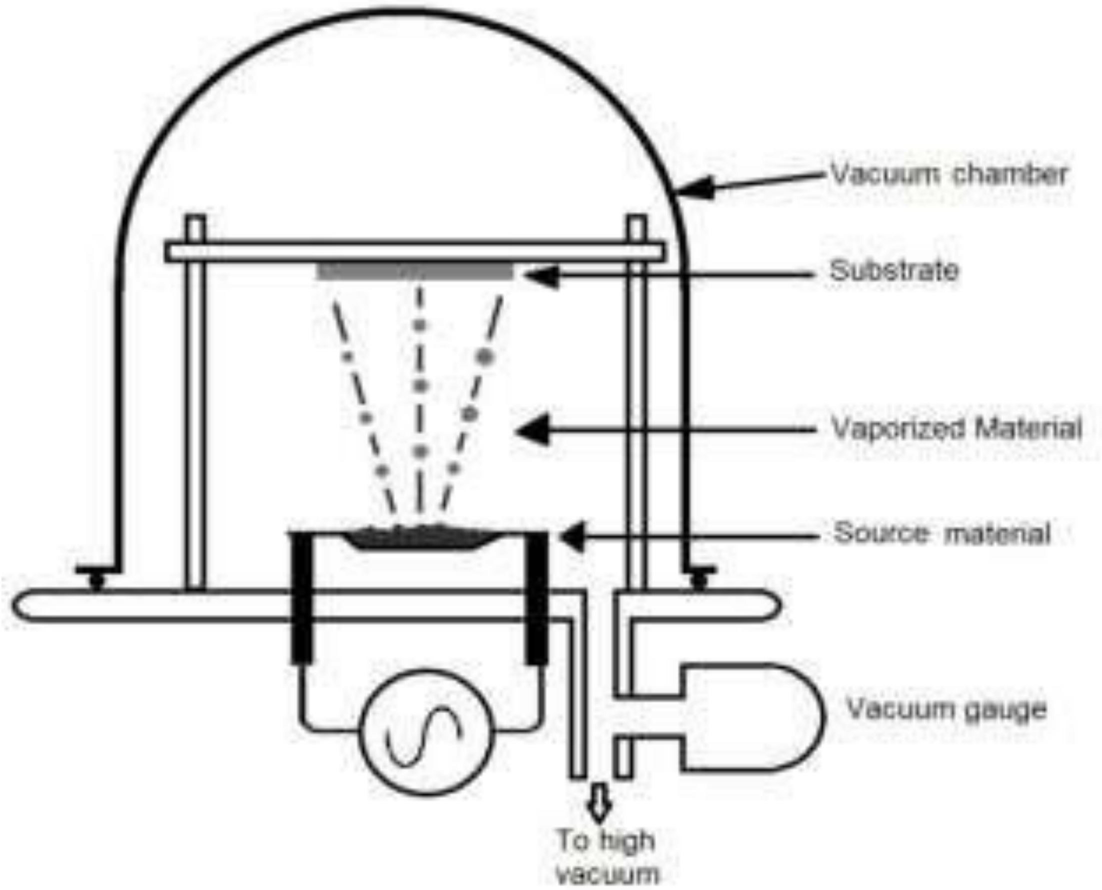
3. Thermal Evaporation:

Evaporation can take the form of vacuum distillation, atmospheric evaporation, and thermal evaporation. Vacuum distillation is accomplished by drawing a vacuum on a chamber and evaporating water at reduced temperatures, typically in the range of 90-150 degrees Fahrenheit. This technology is characterized by low energy cost, moderate to high manpower requirements, and very high capital cost.

Atmospheric evaporation involves spraying the wastewater across a high surface area medium and blowing large volumes of air across the medium. This type of evaporation is characterized by moderate energy cost, moderate capital cost, high manpower requirements due to the tendency for fouling and reduced throughputs caused by changes in atmospheric conditions.

Thermal evaporation/distillation is accomplished by heating the wastewater to a boiling temperature and evaporating the waste stream at various rates based on the amount of energy (BTU's) input into the system. This type of evaporation is characterized by moderate to high energy cost, low manpower requirements, moderate capital cost, high flexibility and high reliability. This system has the ability to exhaust water as clean water vapor or recover water as distilled water.


Chamber
Substrate Holder
Substrate
Deposited Thin Film
Vaporized Material
Target Material
Evaporator
Heater


Vacuum chamber
Substrate
Vaporized Material
Source material
Vacuum gauge
To high vacuum

The advantages of Thermal Evaporation over Chemical Treatment are as follows:

Zero Discharge:

Evaporation completely eliminates your discharge effluent. This eliminates accountability to your pollution control Board as well as the hassle and expense associated with potential discharge violations.

Total Solution:

Chemical treatment does not completely address parameters such as emulsified oils, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), or dissolved solids in the discharge wastewater. This becomes more important each year as Pollution control discharge limits become increasingly strict

Lower Disposal Cost:

Due to the addition of chemistry, the sludge volume being generated will be greater for chemical treatment compared to evaporation which typically does not require the addition of chemistry. This translates to lower disposal liability and cost for evaporation.

4. Removal of Dissolved Organic Compounds:

One of the most commonly used techniques for removing organics involves the process of adsorption, which is the physical adhesion of chemicals on to the surface of the solid. The effectiveness of the adsorbent is directly related to the amount of surface area available to attract the particles of contaminant.

The most commonly used adsorbent is a very porous matrix of granular activated carbon, which has an enormous surface area (~ 1000 m2/g).

Adsorption on activated carbon is perhaps the most economical and technically attractive method available for removing soluble organics such as phenols, chlorinated hydrocarbons, surfactants, and colour and odour producing substances from waste water.

Granular activated carbon treatment systems consist of a series of large vessels partially filled with adsorbent. Contaminated water enters the top of each vessel, trickles down through granulated activated carbon, and is released at the bottom.

After a period of time, the carbon filter becomes clogged with adsorbed contaminants and must be either replaced or regenerated. Regeneration of the carbon is accomplished by heating it to 950 °C in a steam air atmosphere. This process oxidizes surface, with an approximately 10% loss of carbon Activated carbon is commonly used to adsorb natural organic compounds, taste and odor compounds, and synthetic organic chemicals in drinking water treatment. Adsorption is both the physical and chemical process of accumulating a substance at the interface between liquid and solids phases. Activated carbon is an effective adsorbent because it is a highly porous material and provides a large surface area to which contaminants may adsorb. The two main types of activated carbon used in water treatment applications are granular activated carbon (GAC) and powdered activated carbon (PAC).

GAC is made from organic materials with high carbon contents such as wood, lignite and coal. The primary characteristic that differentiates GAC to PAC is its particle size. GAC typically has a diameter ranging between 1.2 to 1.6 mm and an apparent density ranging between 25 and 31 lb/ft^3), depending on the material used and manufacturing process..

Remove nutrients

1-Nitrogen control: ammonia in waste water effluent can be toxic to aquatic life in certain instances by providing additional biological treatment beyond the secondary stage nitrifying bacteria present in wastewater can biologically convert ammonia to the nontoxic nitrate through process known as nitrification the nitrification process is normally sufficient to remove the toxicity associated with ammonia in the effluent since nitrate is nutrient excess amounts can contribute to eutrophication in the receiving waters in situations where nitrogen must be completely removed from effluent an additional biological process can be added to the system to convert the nitrate to nitrogen gas the conversion of nitrate to nitrogen gas is accomplished by bacteria in a process known as denitrification effluent with nitrogen in the form of nitrate is placed into a tank devoid of oxygen where carbon containing chemicals such as methanol are added in this oxygen free environment bacteria use the oxygen attached to the nitrogen in the nitrate form releasing nitrogen gas because nitrogen comprises almost 80% of the air in the earth atmosphere the release of nitrogen into the atmosphere does not cause any environmental harm

2-phosphour control: like nitrogen phosphorus is a necessary nutrient for the growth of algae phosphorus reduction is often needed to prevent eutrophication before discharging effluent into likes reservoirs and estuaries phosphorus can be removed biologically in a process called enhanced biological phosphorus removal in this process specific bacteria called polyphosphate accumulating organism PAOS accumulating large quantities of phosphorus within their cells up to 20% of their mass when the biomass enriched in these bacteria is separated from the treated water these bio solids have a high fertilizer value phosphorus removal can also be achieved by chemical precipitation usually with salts or iron alum or lime this may lead to excessive sludge production as hydroxides precipitates and the added chemicals can be expensive despite this chemical phosphorus removal requires a significantly smaller equipment than biological removal is easier to operate and is often more reliable than biological phosphour removal

Fog removal

Fatty organic materials from animals, vegetables, and petroleum also are not quickly broken down by bacteria and can cause pollution in receiving environments. When large amounts of oils and greases are discharged to receiving waters from community systems, they increase BOD and they may float to the surface and harden, causing aesthetically unpleasing conditions. They also can trap trash, plants, and other materials, causing foul odors, attracting flies and mosquitoes and other disease vectors. In some cases, too much oil and grease causes septic conditions in ponds and lakes by preventing oxygen from the atmosphere from reaching the water. The removal of oil and grease depends on the condition of the oil water mixture the type of the equipment must be carefully selected the type of oil water mixture may be classified as oil and grease present as septic free oil dispersed oil, emulsified oil or dissolved oil the API separator is to separate free oil from waste water such gravity separators will not separate oil drop lets smaller than the size of free oil nor will it break down emulsion the dissolved air flotation DAF devices utilize the gravity separation concept for the removal of oil and grease from wastewater but tend to be more effective than API separators in removing the dispersed oil mixture because the bouncy differential is increased by induced small air bubbles

Coagulant aids such as polyelectrolytes are commonly used to promote agglomeration of the oil bearing matter into large flocs which are more easily removed the DAF device is reported effective in producing an effluent with 1 to 20 mg/l of oil and grease carbon adsorption or membrane filtration using reverse osmosis treatment is very effective to remove dissolved and emulsified oils biologically treatment is generally effective in degrading dissolved oils and other types of stabilized emulsions which cannot be destabilized by chemical coagulants however a biological system is only effective on highly dilute oil contaminated wastewater because mineral based oils are adsorbed by the microorganisms faster than they can be metabolized in activated sludge systems the adsorbed oil tends to damage sluge settling characteristics and cause system failure it has been reported that biological organism are efficient in oxidizing dispersed or emulsified oil but large amounts of free oil must be avoided

In these reservoirs wastewater is stored for long periods of time

The purpose of the storage is twofold

To obtain highly quality effluents wastewater treatment wastewater irrigation projects must match the almost homogenous sewage flow coming from the city to the discontinuous water demand for irrigation wastewater storage reservoirs add flexibility to the operation system optimize the reuse of the reclaimed water increase the area which can be irrigated and release effluents of a good and reliable quality these waste water storage and treatment reservoirs can be also applied to other situations

Coastal areas wastewater is stored during the summer in order to avoid the contamination of beaches during the summer in order to avoid the contamination of beaches during the tourism season by the end of summer when the last tourist has gone wastewater will be released from the reservoirs into the sea meanwhile these effluents will reach excellent quality due to long residence time within the reservoirs during the summer months

River stream recovery 1wastewater is stored during the dry season when the river runs at minimum flow wastewater of high quality will be released from the reservoirs to the river when river flow is at maximum thus obtaining maximum dilution and minimum negative ecological impact

River stream recovery 2 wastewater is stored when river flow is at maximum wastewater of very high quality is then released from the reservoirs to the river during the dry period as a substitute for freshwater in order to avoid total drying of the river and ecosystem destruction

High quality effluents are required wastewater contains not only organic matter but also significant concentrations of pathogens heavy metals hard detergents pesticides organic micro pollutants and other pollutants which are not removed by classic sewage treatment plants stabilization reservoirs are able to remove most of them

Cooling water wastewater is more and more used as cooling water in power stations and other installations wastewater storage reservoirs can supply cooling towers with wastewater of proper quality and temperature in due time

Besides, stabilization reservoirs are green

Processes occurring within the reservoirs are natural they utilize solar energy (mechanical plants use electricity) algae within the reservoirs produce most of the oxygen required by the processes mechanical plants take oxygen from the atmosphere with high energy consumption

Aquatic birds find the reservoirs a good refuge this is important in areas where the natural habitat of the birds have been invaded by urban tourism or agriculture development

Disinfection

Disinfection Methods Disinfection of wastewater is achieved using a variety of methods in Victoria, including: • chemical (for example, chlorination, ozonation); • physical (for example, ultraviolet radiation, microfiltration); and • biological (for example, detention lagoons). Chemical Chlorination Chlorine is used to disinfect wastewater in either gaseous form (Cl_2), or as hypochlorite salts. Disinfection by ozonation is achieved using the formation of free radicals as oxidizing*- agents. Ozonation is more effective against viruses and bacteria than chlorination, yet problems with effective bactericidal action occur when conditions are not ideal. The low solubility of ozone in water is the main factor that greatly reduces its disinfection capacity, and any ozone residual produced rapidly dissipates as a consequence of its reactive nature. The absence of a lasting residual may also be seen as a disadvantage as this may allow possible microbial DISINFECTION OF TREATED WASTEWATER EPA Victoria 8 re-growth and make it difficult to measure the efficiency of the disinfection process. Physical Ultraviolet radiation The disinfection of treated wastewater via ultraviolet (UV) radiation is a physical process that principally involves passing a film of wastewater within close proximity of a UV source (lamp). The efficiency of UV disinfection depends on the physical and chemical water quality characteristics of the wastewater prior to disinfection. With a better quality of wastewater comes a more efficient UV disinfection process. The advantage of the UV disinfection process is that it is rapid and does not add to the toxicity of the wastewater. There have been no reports of byproducts produced from UV disinfection that adversely impact on the receiving environment. UV disinfection does not

result in a lasting residual in the wastewater. This is a disadvantage when wastewater must be piped or stored over significant distances and time (particularly relevant to reuse schemes) as re-growth of the microbial population is considered a risk. Membrane filtration Membrane technologies disinfect treated wastewater by physically filtering out microorganisms. This disinfection process does not require the addition of reactive chemicals and as such, no toxic disinfection by-products are produced. Key membrane technologies include: • reverse osmosis; • ultrafiltration; • nanofiltration; and • microfiltration. Microfiltration is the most commercially viable technology for the disinfection of treated wastewater. The wastewater passes through membrane fibres, hollow cylinders permeated with millions of microscopic pores. These pores allow wastewater to flow through the same fibres that act as a physical barrier to particles and microorganisms. Microfiltration efficiently reduces particulates, bacteria, and a range of viruses, algae and protozoans. Protozoa are generally larger than 0.2 micron and are removed effectively by microfiltration, giving this method an advantage over other technologies. Viruses larger than 0.2 micron (which includes most enteric viruses) are also reduced effectively. The main disadvantages associated with microfiltration include the potentially high capital costs, the resultant concentrated backwash with significant microbial contamination, and the handling and management of contaminated chemicals produced by periodic cleaning of the membranes. Biological Lagoons The storage of secondary treated wastewater in pondage systems (nominally 30 days) allows natural disinfection to take place before discharging or reusing the treated wastewater. Natural disinfection can occur via sunlight and/or natural microbial dieoff. Natural disinfection processes can be affected by a number of factors such as the: DISINFECTION OF TREATED WASTEWATER Guidelines for Environmental Management 9 • turbidity of the wastewater, as it affects sunlight penetration; • amount of suspended matter in the water, as viruses and bacteria may be shielded from the rays of the sun by being absorbed into surface pores; and • ineffectiveness of sunlight in seawater compared with freshwater. Temperature, pH, adsorption and sedimentation further influence the natural disinfection and inactivation processes occurring in wastewater stored in lagoons. The ability of ponds to remove or reduce the number of pathogens depends on such factors as the load of incoming solids and microorganisms, temperature, sunlight and pond design related to detention time. Re-infection of ponds by bird populations can also pose a problem for operators. Algal blooms in the ponds over summer will also reduce the efficiency of the natural disinfection process. Systems using only detention do not typically result in a Class A effluent and are unsuitable as the sole means of pathogen reduction for high contact uses.