Advanced Waste Water Treatment Methods | Waste Management

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.

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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 woven 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 [$AI_2(S0_4)_2$‘ $18H_20$], though $FeCI_3$, $FeS0_4$ 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 ($H_2O)_6$] + 3 $3HC0_3$ — $AI(OH)_3(s)$ + $3Co_2$ + $6H_2o$ …………………….. (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.

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.

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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)

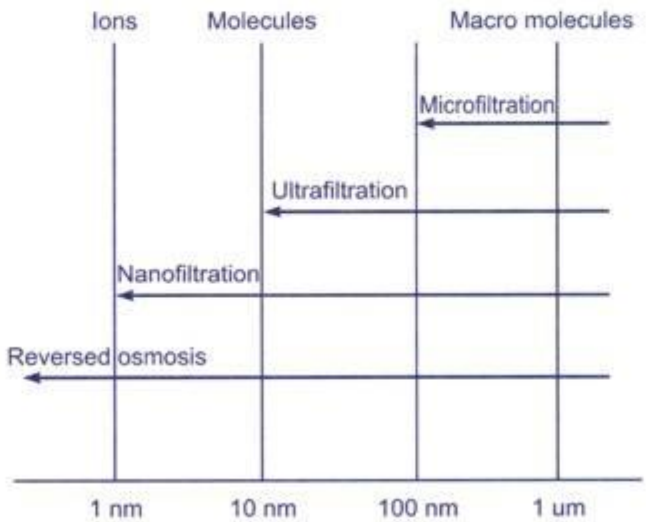
Commercial membranes applied in ultra filtering can separate substances with a molecular weight between 1.000 and 10.000. Ultra filtering systems generally work in a pressure range between 1.5 and 7 bar With industrial discharge waters the fluxes of permeate generally fluctuate between 0.5 and 1 – 5 m^3 / h / m^2 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.

Nano Filteration:

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.

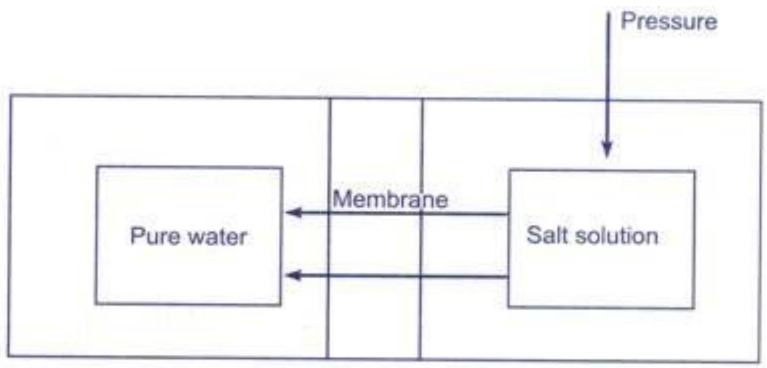
A number of naturally occurring minerals have ion exchange properties. Among them the notable ones are aluminium silicate minerals, which are called zeolites. Synthetic zeolites have been prepared using solutions of sodium silicate and sodium aluminate.

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 -$N^+(CH_3)_3OH$~ (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.



Industrial effluent treatment, using reverse osmosis, can be applied in the following main sectors:

a. Treatment of outflows containing colorings with their possible recovery.

b. Treatment of outflows containing oily emulsions, latex and electro phoretic paints.

c. Treatment of outflows from the metal-finishing industry with recovery of concentrated solutions of metal salts and reuse of the water in cleaning

d. Treatment of waste water from organic chemical, in organic chemical and pharmaceutical industries

The application of reverse osmosis for wastewater treatment is significantly different from general process water purification. This is primarily due to the fact that wastewater generally contains higher levels and a more diverse range of contaminants. In addition, industrial wastewaters have a high degree of variability. Wastewaters vary from industry to industry and can change with hour to hour operation at any individual plant.

The most important factor in treating industrial wastewater with RO is the against organic fouling, mineral scaling and chemical degradation. Before RO should even be considered, a complete cation/anion balance is required and possible flocculants must be identified.

Potential inorganic foul-ants and sealants of RO membranes include calcium, iron, aluminium, and other insoluble heavy metals. Possible organic foulants include surfactants, color bodies, flocculants, and bacteria. High BOD and COD levels can also contribute to membrane fouling.

A wide range of pretreatment technologies is available. Specifically in the metal finishing, printed circuit board and microelectronics industries, rinse-waters from fabrication operations are normally treated to remove heavy metals and are then discharged to the sewer.

The effluent discharged to the sewer typically contains between 200 to 10,000 parts per million (ppm) total dissolved solids (TDS). With the proper pretreatment technology followed by RO, this effluent can be treated and recycled. Ion exchange treatment of the RO product water can further polish the water and make it suitable for all rinses.

To design a successful and cost-effective system, it is necessary to evaluates each individual application because the pH, oxidizing potential and concentration of soluble salts of the wastewater effluents often exceed the operating limits of RO systems. After the detailed evaluation of the wastewater is complete, one need to determine the optimum preconditioning chemistry and selects the best pretreatment technology for the application.

Reverse Osmosis process generates high TDS waste stream reject. Approximately 25-40% of waste reject with high TDS concentration will be generated from feed water. This waste needs to be evaporated in forced evaporation systems to concentrate and remove the in organic impurities from it.

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.

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 m^2/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 oxidises surface, with an approximately 10% loss of carbon (Table 9.3).

Table 9.3 Water-quality based decisions

Agriculture	Forestry
Animal waste management	Ground cover maintenance
Conservation tillage	Limiting disturbed areas
Contour farming	Log removal techniques
Strip-coping	Pesticide and herbicide management
Cover crops	Proper management of roads
Crop rotation	Removal of debris
Fertilizer management	Riparian zone management
Integrated pest management	**Mining**
Rang and pasture management	Underdrains
Terraces	Walter division
Construction	**Multicategory**
Limiting disturbed areas	Buffer vegetated strips
Non-vegetative soil stabilization	Detention and sedimentation basins
Runoff detention and retention	Devices to encourage infiltration
Urban	Vegetated waterways
Blood storage	Interception and diversion of runoff
Porous pavements	Sediment traps
Runoff detention and retention	Streamside management zones
Street cleaning	Vegetative stabilization and mulching

Synthetic organic polymers such as Amberlite XAD-4 have hydrophobic surfaces and are quite useful in removing relatively insoluble organic compounds such as chlorinated pesticides. These absorbents are readily regenerated by solvents such as isopropanol and acetone.