Module – 4

Structure

4.0 Introduction

Waste water characteristics, sampling, significance and techniques, physical, chemical and biological characteristics, flow diagram for municipal waste water treatment, unit operations; screens, grit chambers, skimming tanks, equalization tanks

Suspended growth and fixed film bio process, design of trickling filters, activated sludge process, sequential batch reactors, moving bed bio reactors, sludge digesters.

4.1 Objectives

- Understand and design different unit operations involved in conventional and biological treatment process.

4.2 Difference between Domestic and Industrial wastewater

Domestic sewage consists of liquid waste originating from bathrooms, water closets, kitchen sinks, wash basins etc of residential, commercial or institutions buildings. For example, apartments, hotels, hospitals, shopping mall etc

Industrial wastewater consists of wastes originating from the industrial processes of various industries such as paper manufacture, textile, sugar, brewing, dyeing etc. The quality of industrial wastewater depends largely upon the type of industry & the chemicals used in their process water. Sometimes, they may be very foul & may require extensive treatment before being disposed off in public sewage

Industrial waster as pointed out above, usually contains several chemical pollutants & toxic substances in too large proportions. The characteristics of the produced wastewater will usually vary from industry to industry & also vary from process to process even in the same industry, such industrial waster cannot always be treated easily by the normal methods of treating domestic wastewater & certain specially designed methods are sequence of methods may be necessary. The normal biological treatment methods for sewage are dependent up on the bacterial activity within the sewage, & as the toxic chemicals present in the industrial wastewater may hinder or destroy the bacterial activity. Therefore these normal methods may not be sufficient unless modify &/or supplemented by additional techniques.

Effect of effluent discharge on streams

If the industrial waste water is discharged into streams, it causes depletion of DO of the stream. This is due to the settlement of the suspended substances and subsequent decomposition of the same in anaerobic condition. The alkalinity and toxic substances like sulphides & chromium affects the aquatic life and also interferes with the biological treatment processes. Some of the dyes are also found to be toxic. The color often renders the water unfit for use for side. The presence of sulphides makes the waste corrosive particularly to concrete structures. All treatment plants should be planned giving serious consideration for the reduction of waste volume & strength, through process of chemical substitution, chemical recovery & recycling of water. The pollution load from a textile, mill is dealt with operations like segregation, neutralization, equalization, chemical ppt, chemical oxidation & biological oxidation. Several chemicals are used to reduce the BOD by chemical coagulation such as alum, ferric sulphate, ferrous sulphate& ferric chloride, lime or H_2SO_4 is used to adjust pH in this process. The dye waste may be economically treated by biological methods prior equalization, neutralization &chemical oxidation.

The industrial waste when discharged into sewer not only chokes the sewer due to the deposition of solids but also reduces the cross section of the sewer arising out of the lime encrustation.

Chromium compounds in excess of 10-20mg disrupt the operation of the trickling filter. Sulphides are also toxic to the micro organisms are removed along with the sludge. The sludge is dried over sand drying beds and can be used as good manure. Chemical coagulation (Alum, ferric chloride, and ferrous sulphate) with or without prior neutralization followed by biological treatment is necessary for better quality of effluent.

4.3 Methods of Industrial Waste Water Treatment;

4.3.1 Volume reduction

In general the first step in minimizing the effects of industrial wastes on relieving streams and treatment plants is to reduce the volume of such wastes. This may be accomplished by

1. Classification of wastes
2. Conservation of waste water
3. Change in production to decrease wastes.
4. Re- using both industrial & municipal effluent as raw water supplies.
5. Elimination of Batch or Slug Discharge of Process Wastes

Classification of wastes

If wastes are classified so that manufacturing process waters are separated from cooling waters, the volume of water requiring intensive treatment may be reduced considerably. Sometimes it is possible to classify & separate the process waters themselves, so that only the most polluted once are treated & the relatively uncontaminated are discharge without treatment.

The 3 main classes of wastes are

a) Wastes from manufacturing process

These include waters used in forming paper, discharge from plating solutions in metal fabrication those discharge from washing of milk cans in dairy plants etc.

b) Waters used as cooling agents in industrial process

The volume of these wastes varies from one industry to another. Although cooling water can be become contaminated by small leaks, corrosion products or the effect of heat, these wastes containment little , if any organic matter & are classed as non pollution.

c) Wastes from sanitary uses

The volume depends on many factors including size of the plant, amount of waste produce materials washed from the floors & the degree of cleanliness require & number of workers in the unit.

Unfortunately, in most old plants process, cooling & sanitary waste water are mixed in one pipeline & many industries are paying little attention to segregating wastes to avoid stream pollution.

Conservation of waste water

Water conserve is water saved. Conservation begins when an industry changes from an open to a closed system. For example, a paper mill which recycles while water (water passing through a wire screen upon which paper is formed) & thus reduces the volume of waste waters it uses, is practicing water conservation.

Concentrated recycled wastewater is often treated at the end of their period of usefulness, since usually it is impractical & uneconomical to treat the waste waters as a complete each cycle. The savings are twofold i.e., both water cost & waste treatment cost are lowered.

One large textile mill reduced its water consumption by 50 % during a municipal water shortage, without any drop in production. It was observed that despite the savings to the mill, water usage returned to its original level one the shortage was over. This further illustrates the cheapness of water in the public mind.

Steel mills reuse cooling water to quench & coal processors reuse water to remove dirt & other non combustible materials from coal.

Introduction of conservation practices requires a complete engineering survey of existing water views & an inventory of all plant operations using water & producing wastes, so as to develop an accurate balance for peak & average operating conditions.

Change in production to decrease wastes

This is an effective method of controlling the volume of wastes but at the same time it is very hard to persuade the industry to change their operations just to eliminate wastes as this may involve additional costs. However, the engineer can point out that reduction in the amount of Sodium sulphites used in dyeing, sodium cyanide used in plating and other chemical used directly in production has resulted in both reduction of wastes & saving of money.

Several other measures that can be used to reduce wastes include improved process control, improved equipment design, use of different or better quality raw materials, good housekeeping & preventive maintenance.

Reusing both industrial & municipal effluents as raw water supplies

Practiced mainly in areas where water is scarce and/or expensive, this is proving a popular and economical method of conservation: of all the sources of water available to Industry, Sewage plant effluent is the most reliable at all seasons of the year and the only one that is actually increasing in quantity and improving in quality.

Many industries and cities hesitate to reuse effluents for raw water supply. Certain technical problems such as hardness, color and aesthetic reluctance to accept the effluents as a potential source of water for any purpose. Also treatment plants are subject to shutdown and sudden discharges, both of which may make the supply undependable or of variable quality. However, as the cost of importing a raw water supply increase, it would seem logical to re-use Waste- treatment plant effluents to increase the present water supply by replenishing the ground water. The ever-available treatment plant effluent can produce a low cost steady water source through ground water recharge. Re-use of sewage effluent will reduce the quantity of pollution discharged by the municipality

Elimination of Batch or Slug Discharge of Process Wastes

If the waste is discharged in a short period of time, it is usually referred to as a slug discharge. This type of waste, because of its concentrated contaminants and/or surge in volume, can be troublesome to both treatment plants and receiving streams.

There are at least two methods of reducing the effects of these discharges:

1. The-manufacturing firm alters its practice so as to increase the frequency and lessen the magnitude of Batch discharges.
2. Slug Wastes are retained in holding basins from which they are allowed to Flow continuously and uniformly over an extended (usually 24-hour) period.

4.3.2 Strength Reduction

Waste Strength reduction is the second major objective for an industrial plant concerned with waste treatment. The strength of wastes may be reduced by

1. Process Changes
2. Equipment Modifications
3. Segregation of Wastes
4. Equalization of Wastes
5. By-Product Recovery
6. Proportioning of Waste sand
7. Monitoring Waste Streams

Process Changes

In reducing the strength of wastes through process changes, the sanitary engineer is concerned with wastes that are most troublesome from a pollution standpoint.

Equipment Modification

Changes in equipment can effect a reduction in the strength of the waste, usually by reducing the amounts of contaminants entering the waste stream. An outstanding example of waste strength reduction occurred in the dairy industry. The new cans were constructed with smooth necks so that they could be drained faster and more completely. This prevented a large amount of milk waste from entering streams and sewage plants.

Segregation of Wastes

Segregation of Wastes reduces the strength and/or the difficulty of treating the final waste from industrial plant. It usually results in two wastes: one strong and small in volume and the other weaker with almost the same volume as the original unsegregated waste. The small-volume strong waste can then be handled with methods specific to the problem it presents. In terms of volume reduction alone, segregation of cooling waters and storm waters from process waste will mean a saving in the size of the final treatment plant.

Equalization of Wastes

Plants, which have many products, from a diversity of processes, prefer to equalize their wastes. This requires holding wastes for a certain period of time, depending on the time taken for the repetitive process in the plant. For example, if a manufactured item requires a series of operations that take eight hours, the plant needs an equalization basin designed to hold the wastes for that eight hours period. The effluent from an equalization basin is much more consistent in its characteristics than each separate influent to that same basin.

Stabilization of pH and B.O.D and settling of Solids and Heavy Metals are among the objectives of equalization. Stable effluents are treated more easily and efficiently, than unstable ones by industrial and municipal treatment plants.

By-Product Recovery

All wastes contain by products, the exhausted materials used in the process. Since some wastes are very difficult to treat at low cost, it is advisable for the Industrial Management concerned to consider the possibility of building a recovery plant which will produce a Marketable By-Product and at the same time solve a troublesome wastes problem.

Proportioning Wastes

By Proportioning its discharge of concentrated wastes into the main sewer a plant can often reduce the strength of its total waste to the point where it will need a minimum of final treatment or will cause the least damage to the stream or treatment plant.

It may prove less costly to proportion one small but concentrated waste into the main flow. According to the rate of the main flow, than to equalize the entire waste of the plant in order to reduce the strength

Monitoring Waste Streams

Accidental spills are often the sole cause of stream pollution or malfunctioning of treatment plants and these can be controlled, and often eliminated completely, if all significant sources of wastes are monitored.

4.3.3 Neutralization

Excessively acidic or alkaline wastes should not be discharged without treatment into a receiving stream. A stream is adversely affected by low or high pH values. This adverse condition is even more critical when sudden sludge of acids or alkalis are imposed upon the stream.

Acceptable Methods of Neutralization

1. Mixing wastes so that the net effect is a neutral pH.

2. Passing acid wastes through beds of limestone.
3. Mixing acid wastes with lime slurries.
4. Adding the proper proportions of concentrated solutions of caustic soda (NaOH) or soda ash (Na_2CO_3) to acid wastes.
5. Adding compressed CO_2 to alkaline wastes.
6. Adding sulphuric acid to alkaline wastes.

The material and method used should be selected on the basis of the overall cost, since material costs vary widely and equipment for utilizing various agents will differ with the method selected. The volume, kind and quality of acid or alkali to be neutralized are also factors in deciding which neutralizing agent to use.

4.3.4 Equalization

Equalization is a method of retaining wastes in a basin so that the effluent discharged is fairly uniform in its characteristics (pH, color, turbidity, alkalinity, B.O.D etc). A secondary but significant effect is that of lowering the concentration of effluent contaminants. A retention pond serves to level out the effects of peak loadings on the plant while substantially lowering the BOD and suspended solids load to the aeration unit. Air is sometimes injected into these basins to provide:

1. Better mixing
2. Chemical oxidation of reduced compounds
3. Some degree of biological oxidation
4. Agitation to prevent suspended solids from settling.

The size and shape of the basins vary with the quantity of waste and the pattern of its discharge from the industry. The capacity should be adequate to hold and render homogeneous, all the wastes from the plant. Almost all industrial plants operate on a cycle basis; thus if the cycle operations is repeated for every two hours, an equalization tank which can hold a two -hour flow will usually be sufficient.

The mere holding of waste, however is not sufficient to equalizing it. Each unit volume of waste discharged must be adequately mixed with other unit volumes of waste discharged many hours previously.

This mixing may be brought about in the following ways:

1. Proper distribution and baffling: Proper distribution and baffling is the most economical, though usually least efficient method of mixing. Still this method is sufficient for many plants. Horizontal distribution of the waste is achieved by using either several inlet pipes, spaced at regular intervals across the width of the tank. Over and under baffles are advisable when the tank is wide because they provide more efficient horizontal and vertical distribution
2. Mechanical agitation: Mechanical agitation eliminates most of the need for baffles and generally provides better mixing than baffle alone. This type of equipment is good not only for equalisation but also for dilution, oxidation, reduction or any other function in which one wants chemical compounds discharged to react with compounds discharged before or after them to produce a desired effect.
3. Aeration: Aeration of equalizing basins is the most efficient way to mix types of

waste, but it is also the most expensive. Aeration facilitates mixing and equalization of waste prevents or decreases accumulation of settled material in the tank and provides preliminary chemical oxidation of reduced compounds such as sulphur compounds. It is of special benefit in situations in which wastes have varying character and quantity excess of reduced compounds and some settleable suspended solids.

4. Combination of all three.

4.3.5 Proportioning

Proportioning means the discharge of industrial wastes in proportion to the flow of municipal sewage in the sewers or to the stream flow in the receiving river. In most case sit is possible to combine equalization and proportion in the same basin. The effluent from the equalization basin is metered into the sewer or stream according to a predetermined schedule. The objective of proportioning in sewers is to keep constant the percentage of industrial wastes to domestic sewage flow entering the municipal sewage plant.

This procedure has several purposes:

1. To protect municipal sewage treatment using chemicals from being impaired by a sudden overdose of chemicals contained in the industrial waste.
2. To protect biological treatment devices from strong loads of industrial wastes which may inactivate the bacteria
3. To minimize fluctuations of sanitary standards in the treated effluent
4. The rate of flow of industrial waste varies from instant to instant, as does the flow of domestic sewage system. Therefore the industrial waste must be equalized and retained, then proportioned to the sewer or stream according to the volume of domestic sewage or stream flow

There are two general methods of discharging industrial waste in proportion to the flow of domestic sewage municipal plant.

Manual control: manual control is lower in initial cost but less accurate. It involves determining the flow pattern of domestic sewage for each day of the week over a period of months.

Automatic control by electronics: Automatic control of waste discharge to sewage according to sewage flow involves placing a metering device that registers the amount of flow at the most convenient main sewer connection. This device translates the rate of flow in the sewer to a recorder located near the plants holding tank. The pen on the recorder actuates either a mechanical or a pneumatic control system for opening or closing the diaphragm of the pump. There are many variations of automatic flow control systems. Although their initial cost is higher than manual control, they will usually return the investment many times by the savings in labour costs.

4.4 Removal of organic solids

The removal of dissolved organic matter from waste waters is one of the most important tasks of an engineer. These solids are usually oxidized rapidly by microorganisms in the receiving stream, resulting in loss of dissolved oxygen and the accompanying the ill effects of deoxygenated water. They are difficult to remove because of the extensive detention time required in biological process and often expensive equipment required for other methods. In general, biological methods have proved more effective since the microbes including bacteria and protozoa, consume the organic pollutants as food. They metabolize the biodegradable organics, converting them into carbon dioxide, water and energy for their growth and reproduction. To keep the microbe healthy and productive in their task of wastewater treatment, they must be provided with enough oxygen, adequate contact with the organic material in the effluent suitable temperatures and other favorable conditions. The design and operation of a biological treatment plant is accomplished with these factors in mind.

There are many varieties of biological treatments, each adopted to certain types of wastewaters and local environmental conditions such as temperature and soil type. Some specific processes for treating organic matter are

(i) Lagoonin gin oxidation ponds.
(ii) Trickling filter.
(iii) Activated – sludge treatment
(iv) Modification of the activated sludge process
(v) Anaerobic digestion.
(vi) High-Rate aerobic treatment
(vii) Wet combustion
(viii) Spray irrigation

Lagooning: Lagooning in oxidation ponds is a common means of both removing and oxidizing organic matter and wastewaters as well. The most commons type of lagoon used for treating wastewaters is facultative pond. In a facultative pond, which is generally about 2m (6ft) deep, both aerobic and anaerobic biochemical reactions take place

Raw wastewater enters the pond eliminating the need for primary treatment. Organic solids that settle to the bottom decompose anaerobically, producing such substances as methane, organic acids, ammonia, carbon dioxide and hydrogen sulfide. In the liquid above the sludge zone of the pond, incoming organics and the products of anaerobic microorganisms are stabilized by facultative bacteria as well as by aerobic microorganisms. Facultative bacteria can grow in either aerobic or anaerobic environments. The average sewage detention time in a facultative pond may be 60 days or more. Oxygen is added to the wastewater in the pond by wind action and mixing at the surface and from the day light metabolism of algae taking place. This oxygen supports the aerobic reactions. The mutually dependent relationship between the algae and bacteria in a stabilization pond is very important. Using energy from sunlight, the algae grow and multiply by consuming the carbon dioxide and other inorganic compounds released by the bacteria. The bacteria use both the oxygen released by the algae and the organics from the wastewater. Although the algae play an important role in the purification process in a lagoon, they can also cause a problem. When, they die, they impose a secondary organic loading on the pond. Another disadvantage is seasonal one algae are less effective in winter. Beside this, lagoons are used with increasing frequency in areas where land is readily available. The low construction, operational and maintenance cost and negligible energy costs offer distinct advantages for this natural purification system.

Trickling filters: The trickling filter is a type of fixed growth system. The microbes remain fixed or attached to a surface, while the wastewater flows over the surface to provide contact with the organics. Thus the trickling filter may be defined as a process by which biological units are coated with slime growths from the bacteria in the wastes. These growths adsorb and oxidize dissolved and colloidal organic matter from the wastes applied to them.

A trickling filter consists basically of a layer or bed of crushed rock about 2 m deep. It is usually circular in shape and may be built as large as 60 m in diameter. Crushed stones may be of granite and limestone or sometime other materials, such as plastic rings, may also be used, because plastic media are light weight, chemical resistant.

As the primary effluent trickles downward through the beds of stones, a biological slime of microbes develops on the surfaces of the rocks. The continuing flow of the wastewater over these fixed biological growths provides the needed contact between the microbes and the organics. The microbes in the thin slime layer adsorb the dissolved organics, thus removing oxygen – demanding substances from the wastewater. Air circulating through the void spaces in the bed of stones provides the needed oxygen for stabilization of the organics by the microbes.

Activated sludge treatment

The activated sludge process is probably versatile and effective of all wastewater treatment processes. It is quite effective in the treatment of domestic sewage, as well as a few industrial wastes from large plants. The basic component of an activated sludge sewage treatment system includes an aeration tank and a secondary settling basin or clarifier. Primary effluent is mixed with settled solids that are recycled from the secondary clarifier and then introduced into the aeration tank. Compressed air is injected continuously into the mixture through porous diffusers located at the bottom of the tank along one side

In the aeration tank, microorganisms consume the dissolved organic pollutants as food and convert organic materials in wastewater to microbial biomass and CO_2 by using O_2 provided in the air compressor. The organic nitrogen is converted to ammonium ion or nitrate.

The aerobic microorganisms in the tank grow and multiply, forming an active suspension of biological solids called activated sludge. The combination of the activated sludge and wastewater in the aeration tank is called the *mixed liquor*. In basic or conventional activated sludge treatment system, a tank detention time of about 6h is required for through stabilization of most of the organics in the mixed liquor. After about 6h of aeration, the mixed liquor flows to the secondary or final clarifier, in which the activated sludge solids settle out by gravity.

Modification of the activated sludge process: Several modification of the conventional activated sludge process has been developed. The objective is to supply the maximum of air to the sludge when it is in optimum condition to oxidize adsorbed organic matter. In step aeration process, the sewage is introduced along the length of aeration tank in several steps; while the return sludge is introduced at the head. Such an arrangement results in the uniform air requirement along the entire length of tank. The process enables a large reduction in the size of aeration tank. There are two important distinctions between step aeration system and a conventional system. First, screened sewage is directed into the step aeration tank without any primary setting. Second, the detention time or aeration period is about 30 h, whereas the conventional system's detention time to about6h.

Anaerobic digestion: It is a process for oxidizing organic matter in closed vessels in the absence of air. The process has been highly successful in conditioning sewage sludge for final disposal. It is also effective in reducing the BOD of soluble organic liquid wastes such as yeast, slaughterhouse, dairy, and paper mill waste. Generally anaerobic processes are less effective than aerobic processes, mainly because of the small amount of energy that results when anaerobic bacteria oxidize organic matter. Anaerobic processes are therefore slow and require low daily loading and long detention periods. However, since little or no power need be added, operating cost is very low. Where liquid wastes volumes are small and contain no toxic matter and there are high percentages of readily oxidized dissolved organic matter, this process has definite advantages over aerobic system. The pH in the digester must be controlled to near the neutral point

High-Rate aerobic treatment: This process consists of communication of the waste, long period (1-3 days), final settling of the sludge and return of the settled sludge to the aeration tank. There is no need for sludge digestion but the aeration system must be large enough to provide the required aeration period. The total oxidation process is particularly useful in small installations because it does not require a great deal of supervision.

Wet combustion: Wet combustion is the process of pumping organics laden waste water and air into a reactor vessel at elevated pressure. The organic functions undergo rapid oxidation, even though they are dissolved or suspended in the waste. This rapid oxidation gives off heat to the water by direct conviction and the water flashes into a stream. Inorganic chemicals which are present in many industrial wastes can be recovered from the steam in a separate chamber.

Spray irrigation: Spray irrigation is an adaption of the familiar method of watering agricultural crops by portable sprinkling irrigation system. Wastes are pumped through portable pipes to self actuated sprinkler heads. Light weight aluminium or galvanised piping, equipped with quick assembly pipe joints can be easily moved to areas to be irrigated and quickly assembled. Wastes are applied as a rain to the surface of the soil with the objective of applying the maximum amount that can be absorbed without surface runoff or damage to the cover crops.

4.5 Removal inorganic dissolved solids

Little attention has been given to the removal of dissolved minerals from waste waters by waste treatment engineers, because minerals have been considered less polluting than organic matter and suspended solids. However, regarding the causes and effects of pollution, it is important to reduce the quantity of certain types of inorganic matter. Chloride, phosphates, nitrate and certain metals are examples of the significant inorganic dissolved solids. The various methods employed for removing inorganic matter are

(i) Evaporation

(ii) Electro dialysis
(iii) Ion exchange
(iv) Algae
(v) Reverse osmosis
(vi) Miscellaneous

Evaporation: This is a process of bringing wastewater to its boiling point and vaporizing pure water. The vapor is either used for power production, or condensed and used for heating, or simply wasted to the surrounding atmosphere. The minerals solids concentrate in the residue is reused either in production cycle or to be disposed of easily. Chrome, nickel, and copper plating wastes may be reclaimed from the rinse tank by evaporation in glass-lined equipment or other suitable evaporators, and the concentrated solution returned to the plating system. Efficiency of evaporation is directly related to heat-transfer rate expressed in British thermal units per hour (Btu/hr)-through the heating surface.

Electro dialysis: It is the separation of solute by means of their unequal diffusion through membranes. It is most useful in recovering pure solutions for reuse in manufacturing processes for e.g. caustic soda in textile industry. Electro dialysis work on the simple principle of passing a concentrated, impure caustic solution upward, counter current to a downstream water supply, from which it is separated by a semi-permeable membrane. The caustic soda permeates the membranes and goes into water more rapidly than the other impurities contained in the water. The quantity of NaOH diffusing through the membrane diaphragm depends upon the time, the area of the dialyzing surface, the mean concentration difference and the temperature.

Electro dialysis is an operation requiring very little operator attention and although its main role is to conserve raw materials and to reduce plant waste, at the same time it aids in waste treatment. With the introduction of acid resistant membranes, Electro dialysis has been used successfully in the recovery of sulphuric acid in the copper, stainless steel and other industries. Some operation can recover as much as the 70 to 75% of the acid, but recovery as little as 20% may be justifying the process. In Electro dialysis, the driving force of separation is natural diffusion because of concentration gradient. Electro dialysis is another form of dialysis in which the natural driving force is enhanced by the application of electrical energy. Electro-dialysis can achieve as much as 44 percent reduction in concentration of dissolved solids in industrial effluents.

Algae: The use of algae for removing minerals from waste water has been investigated. Although sedimentation and filtration do not remove any phosphorus, the algae actively growing in the ponds caused a reduction of about 42% of the phosphate content. Chlorella and Scenedesmus are most active algae in stabilized ponds; because they are very hardy.

Reverse osmosis: It is process for separating relatively pure water or some other solvent from a less pure solution. The solution is passed over the surface of a specific semi-permeable membrane at a pressure in excess of the effective osmotic pressure of the feed solution. The permeating liquid is collected as the product and the concentrated feed solution is generally discarded. The membrane must be (1) highly permeable to water (2) highly impermeable to solutes (3) capable of withstanding the applied pressure without failure, (4) chemically inert, mechanically strong.

Reverse osmosis is an advanced unit operation in water treatment. Reverse osmosis membranes are capable of removing at least 90 percent of the dissolved solids in water as well as organics, bacteria and others impurities.

Ion exchange: Ion exchange is basically a process of exchanging certain undesirable cations and anions of the wastewater for sodium, hydrogen or other ions in resinous materials. The resins, both natural and artificial are commonly referred to as Zeolites.

Miscellaneous methods:

Chemical precipitation or coagulation has been used to remove some inorganic matter from wastewater.

Chemical oxidation consists of addition of chemicals like chlorine and ozone to reduce the BOD loading on the subsequent biological process or to reduce the substances like ammonia, cyanide etc.

Thermal reduction involves the burning and thereby oxidation of some refractory and toxic substances.

Removal of colloidal solids

A colloids particle is extremely small size (1-200 mill microns). These particles do not settle out on standing and cannot be removed by conventional physical treatment processes. Colloids are often responsible for a relatively high percentage of the color, turbidity, and BOD of certain industrial wastes. Thus it is important to remove colloids from wastewater before they can reach into streams.

Colloids exhibit Brownian movement that is the continuous, random movement of tiny solid particles in liquids or gases. This is caused by the impact of moving liquid or gas molecules pushing at the solid particles from all the side. They are essentially non-settleable because of their charge, small size and low particle weight. They are dialyzable through semi permeable membrane. Colloidal particle are generally electrical charged with respect to their surroundings. An electric current passing through a colloidal system causes the positive charges to migrate to the cathode and the negative one to the anode. Colloids exhibit Tyndall effect; that is the scattering of light from very small particles, as seen when a beam of sunlight passes through a dirty atmosphere. This gives bluish light. True solution shows no Tyndall effect, where as colloidal solutions do.

Chemical Coagulation

This is a process of destabilizing colloids, aggregating them and binding them together for sedimentation. It involves the formation of chemical floes that absorb, entrap, or otherwise bring together, suspended matter that is so finally divided as to be colloidal. The chemicals most commonly used are: alum, copperas, Ferric Sulfate, Ferric Chloride. Ferric Chloride and chlorinated copper as a mixture of ferric sulfate and chloride. Aluminum sulfate appears to be more effective in coagulating carbonaceous wastes, while iron sulfates are more effective when a considerable quantity of proteins is present in the wastes

Coagulation by Neutralization of the Electrical Charges This can be performed by:

- Lowering of the zeta potential of the colloids. Zeta potential is the difference in electrical charge existing between the stable colloid and the dispersing medium
- Neutralizing the colloidal charge by flooding the medium with an excess of oppositively charged ions usually hydrous oxide colloids formed by reaction of the coagulant with ions in the water.

In this process, the coagulant colloids also become destabilized by the reaction with oppositely charged colloids and produce hydrous oxide, which is a floc-forming material.

From the stand point of electrical charges, there are two predominant types of colloid in wastewaters

- ✓ Colloids naturally present, including several proteins, starch, hemicelluloses, polypeptides and other substances, all posses negative charge.
- ✓ Colloids artificially produced by coagulants usually the hydroxides of iron and aluminium are mainly positively charged ions.

Combined treatment methods:

Merits:

- ✓ Here the responsibility is placed with one owner, while at the same time, the cooperative spirit between industry & municipality increases, particularly if the division of costs is mutually satisfactory.
- ✓ Only one chief operator is required, whose sole obligation is the management of the treatment plant i.e he is not burden by the miscellaneous duties often given to the industrial employee in charge of waste disposal & the chances of mismanagement and neglect which may result if industrial production men operate waste treatment plants, are eliminated.
- ✓ Since the operator of such a large treatment plant usually receives higher pay than separate domestic plant operators, better trained people are available.
- ✓ Even if identical equipment is required construction costs are less for a single plant than for 2 or more. Furthermore, municipalities can apply for state & or federal aid for plant construction, which private industry is not eligible to receive.
- ✓ The land required for plant construction & for disposal of waste products is obtained more easily by the municipality.
- ✓ Operating costs are lower, since more waste is treated at a lower rate per unit of volume.
- ✓ Possible cost advantages resulting from lower municipal financing cost & federal grants.
- ✓ Some wastes may add valuable nutrient for biological activity to counter act other industrial wastes that are nutrient deficient. Thus bacteria in the sewage are added to organic industrial wastes as seeding material. These micro organisms are vital to biological treatment. Also, acids from one industry may help to neutralization alkaline wastes from another industry.
- ✓ The treatment of all waste water generated in the community in a municipal plant, enables the municipality to assure a uniform level of treatment to all the users of the

river & even to increase the degree of treatment given to all waste water to the maximum level obtainable with technological advance.

Demerits:

- ✓ If an industrial waste water stream is discharged to municipal waste treatment system which has to been designed to handle it, the discharge may cause serious problem. It could disrupt the treatment processes affecting the performance and hence the treated effluent characteristics.
- ✓ The seriousness of the effect will depend on the characteristics of industrial waste streams, the size and design of municipal waste treatment system and standards for discharge recycle or reuse.
- ✓ Waste characteristics such as temperature, pH, organic content, toxicity and flow must be evaluated to determine the acceptability to municipal waste treatment system otherwise it will cause serious problems.
- ✓ Among many problems arising from combined treatment the most important is the character of the industrial waste water reaching the disposal plant.
- ✓ Because most sewage plants use some form of biological treatment, it is essential for satisfactory operation
    - As homogenous in composition and uniform in flow rate as possible and free from sudden dumping of the more deleterious industrial wastes
    - Not highly loaded with suspended matter
    - Free of excessive acidity or alkalinity and not high in content of chemicals that precipitate on neutralization or oxidation
    - Practically free of antiseptic materials and toxic trace metals
    - Low in potential sources of high BOD, such as carbohydrates, sugar, starch and cellulose
    - Low in oil and grease content.

Feasibility study for combined treatment:

Some of the important scientific factors associated with industrial waste treatment include the following.

Type of municipal sewage treatment: A secondary biological treatment plant if adequately sized can be utilized to treat a readily decomposable organic laden industrial waste. Typical examples include dairies, canneries, slaughterhouses and tanneries. However each of these wastes as well as other typical organic wastes, contain contaminants which can interfere with effective treatment when combined with domestic sewage. For example dairy wastes often turn acid extremely fast and lowered pH can affect biological oxidation, while tannery wastes contain chromium, sulfides and lime which are not compatible with normal sewage treatment. Proper pretreatment and plant operation however can remedy these problems. In some cases it has been shown that trickling filters can handle industrial waste with less upsets than activated sludge system.

Characteristics of industrial waste: When considering the treatment of the wastes from tissue paper mill, industry needs a municipal plant which concentrates its equipment units on the removal of the finely divided suspended solids area of waste treatment. It is of little benefit to the tissue paper mill if the municipal plant possesses only a high rate trickling filter primarily designed for BOD removal.

The engineer must carry out a complete analysis of the industrial waste to ascertain its compatibility for treatment by varied possible method. Some analysis often overlooked by the sanitary engineer include the waste deoxygenation rate, ultimate oxygen demand, toxic chemicals & metals, temperature, grease content, refractory organic matter, phosphate & nitrates and other algae nutrients etc. These and other important characteristics of certain industrial wastes should signal the key to their eventual successful matter.

Receiving stream water quality: It is a foregone conclusion that a stream which must be maintained in a high water quality state requires the maximum offshore waste treatment. Generally this means a minimum of the equivalent to secondary treatment. Often the conventional biological treatment system will not adequately remove sufficient amounts of the contaminants. Sometimes specific treatment such as chemical precipitation followed by adsorption on activated carbon may remove more industrial contaminants than a secondary type trickling filter plant. Industry has inherited the moral if not the legal, obligation of treating its waste in a manner so as to maintain the highest possible quality water level in the receiving stream.

Volume ratio of industrial to municipal waste: A relatively small volume of industrial waste can usually be assimilated in a municipal sewage treatment system regardless of its contaminants. This fact does not always depend upon rational reasoning but is often bases on results of the very fact that an attempt to handle the wastes is made. In other words municipal plant operators generally react optimistically towards small volumes of industrial wastes agree to try to treat them and end up accepting them with or without certain preconditions. When ratios are high industry usually builds its own treatment plant despite the potentially favorable economics or the potential compatibility for joint treatment.

Economics of alternatives: Industry tends to select the least costly alternative especially when other conditions are equal. Usually industry prefers to compare alternative system costs on the basis of total capital expenditures; the least expensive capital outlay is often preferred.

Discharge of raw, partially treated and completely treated wastes to streams

The effect of waste water on the water environment may be physical, chemical and biological effect.

Physical effect includes increase in turbidity and suspended solids, addition of color, taste and odor producing substances, and formation of sludge banks on the beds and sides of the water bodies. Industrial wastes such as cooling waters from power stations, dyeing and printing wastes from textile industry, spent wash from alcohol distilleries etc raise the temperature of water in the receiving body and reduce the DO content in it. These conditions impart an aesthetically unacceptable appearance to the water, create an environment unsuitable for aquatic creatures such as fish, render it difficult to treat, and initiate the chain of chemical and biological effects.

Chemical effects include a drastic change in the pH value of the receiving water due to a discharge of acidic wastes such as mine drainages or alkaline wastes such as textile wastes. High chlorides renders the water unacceptable as a source of drinking water, high sulphates, under favorable circumstances tend to form hydrogen sulphide and produce malodorous condition, nitrates and phosphates encourage algal and other aquatic growths, toxic and inhibitory substances either wipe out the aquatic life or severely limit its growth and reduce the available DO in the water. The DO may even become zero in the presence of a slag of oxygen-demanding wastewater.

Biological effects due to industrial wastes alone are not very serious because many of them do not contain pathogenic organisms that are present in domestic sewage. When industrial wastes are discharged in combination with domestic sewage, biological effects become significant although a large number of micro-organisms in the sewage are killed by unfavorable environmental conditions in the industrial waste. The physical and chemical effects have an adverse effect on the aquatic life, turbidity and suspended solids, along with color, cut-off penetration of sunlight into the water and reduce photosynthetic activity. Suspended solids can choke the gills of fish and kill them. Organic suspended solids settle to the bottom of the receiving body of water and in the presence of micro-organisms, decompose anaerobically. The products of anaerobic decomposition gradually diffuse to the upper layers of water and add to the total oxygen demand. Anions such as chlorides, sulphates add to the total dissolved solids content of the water and interfere with the metabolic process of micro-organisms. Nitrates and phosphates encourage enormous algal growth in the water.

4.8 Recommended Questions:

1. Explain how volume is reduced in industrial waste water treatment.
2. Explain how strength is reduced in industrial waste water treatment.
3. Write the merits and demerits of combined treatment method.
4. Explain the methods of removal of organics solids
5. Explain the methods of removal of inorganic solids

4.9 Outcomes

1. Identify waste streams and design the industrial waste water treatment plant.
2. Manage sewage and industrial effluent issues.

4.10 Further Reading

1. https://www.sciencedirect.com/science/article/pii/B9780123724939500430
2. http://www.rtu.ac.in/RTU/wp-content/uploads/2015/06/ppt_industrial_treatment.pdf