Version 1.0

WASTE WATER GUIDE
FOR OPERATORS

A holistic approach by
Ahmedabad Municipal Corporation and DNP Foundation

Preface:

This Publication has a goal to give user's practice topics with exam questions that will be helpful in field work, simple methods of waste treatment with reducing cost and complexity of treatment without sacrificing the requirement of pollution control has been elaborated with unified approach.

This book is in part the result of field work as a Municipal Corporation expert.

The topics test the skill and knowledge required of an engineer and operator working in waste water treatment plant.

This book contains new developments and changes that have been occurred in the field of waste water engineering with respect to :

1. *Characteristics of the consequences found in the waste water.*
2. *Greater fundamental understanding of bio logical waste water treatment.*
3. *Application of advance treatment for removal of specific constitutes.*

The topic included in this book have been chosen to sample as many different aspect of wastewater treatment job responsibility as possible ,however because of the tremendous variety in equipment's, processes, conditions and duties all of the topics may not be useful in all of the application but, it will be prove pathway for achieving goal.

References :

Wastewater Engineering (Treatment and Reuse) Metcalf & Eddy

The STP Guide (Design Opertion and Maintenance) by Ananth S. Kodavasal, Ph.D. Published by of Karnatak State Pollution Control Board .

CONTENTS

CHAPTER-1

INTRODUCTION TO WASTEWATER TREATMENT

WHAT IS DOMESTIC WASTEWATER?

- Waste water produced due to human activities in households and offices is called domestic waste water i.e. waste water from the kitchen, washbasin, toilet, shower and laundry is called domestic waste water.

DEFINITION OF DIFFERENT TYPES OF DOMESTIC WASTEWATER

- Yellow Water : Human Urine
- Brown Water : Human Faeces with flux water (Included Toilet Paper)
- Black Water : Human Faeces (Brown Water) mixed with urine water(Yellow Water) i.e. Wastewater from toilet
- Grey Water: water used in kitchen, bathroom including sinks, baths, showers and laundry i.e. Water then be used at house except water from toilet

COMPONENTS PRESENT IN DOMESTIC WASTE WATER

Component	Of special interest	Environmental effect
Microorganisms	Pathogenic bacteria, virus and worms eggs	Risk when bathing and eating shellfish
Biodegradable organic materials	Oxygen depletion in rivers and lakes	Fish death, odours
Other organic materials	Detergents, pesticides, fat, oil and grease, colouring, solvents, phenols, cyanide	Toxic effect, aesthetic inconveniences, bioaccumulation in the food chain
Nutrients	Nitrogen, phosphorus, ammonium	Eutrophication , oxygen depletion, toxic, effect
Metals	Hg, Pb , Cd , Cr, Cu, Ni	Toxic effect, bioaccumulation
Other inorganic materials	Acids, for example hydrogen sulphide, bases	Corrosion, toxic effect
Thermal effects	Hot water	Changing living conditions for flora and fauna
Odour (and taste)	Hydrogen sulphide	Aesthetic inconveniences, toxic effect
Radioactivity	Radon	Highly toxic, cancerous

Table : 1.1 Components present in Domestic Waste Water

CHARACTERISTICS OF DOMESTIC WASTE WATER

- Bacteria, fungi, protozoa, and algae. Plants include ferns, mosses, seed plants and liverworts. Physically, domestic wastewater is usually characterized by a grey colour, musty odor and has a solids content of about 0.1%. The solid material is a mixture of faeces, food particles, toilet paper, grease, oil, soap, salts, metals, detergents, sand and grit. The solids can be suspended (about 30%) as well as dissolved (about 70%).
- Chemically, wastewater is composed of organic (70%) and inorganic (30%) compounds as well as various gases. Organic compounds consist primarily of carbohydrates (25 %), proteins (65 %) and fats (10 %), which reflects the diet of the people. Inorganic components may consist of heavy metals, nitrogen, phosphorus, pH, sulphur, chlorides, alkalinity, toxic compounds, etc. However, since wastewater contains a higher portion of dissolved solids than suspended, about 85 to 90% of the total inorganic component is dissolved and about 55 to 60% of the total organic component is dissolved. Gases commonly dissolved in wastewater are hydrogen sulphide, methane, ammonia, oxygen, carbon dioxide and nitrogen. The first three gases result from the decomposition of organic matter present in the wastewater.
- Biologically, wastewater contains various microorganisms but the ones that are of concern are those classified as protista, plants, and animals.

CHARACTERISTICS OF WASTEWATER

Solids :

- Other than gases, all contaminants of water contribute to the solids content, which is composed of floating matter, settleable matter, colloidal matter and matter in solution.
- Solids typically include inorganic matter such as silt, sand, gravel, and clay, and organic matter such as plant fibres and microorganisms from natural and man-made sources.
- Other important physical characteristics include particle size distribution, turbidity, color, transmittance, temperature, conductivity, density, specific gravity and specific weight.
- Odor, sometimes considered to be a physical factor. In regards to size, solids in wastewater can be classified as suspended, settleable, colloidal, or dissolved.
- They are also characterized as being volatile or non-volatile

Test	Description
Total soilds(TS) TS= (M1-M2)/V M1= mass of crucible dish after drying at 105 ^{o}C M2=mass of initial crucible dish V=volume of sample	The residuals remaining after a waste water sample has been evaporated and dried at a specified temperature (103-105 ^{o}C)
Total Volatile solids (TVS) VS=(M1-M3)/V M1=mass of crucible dish after drying at 105 ^{o}C M3=mass of crucible dish after ignition at 550 ^{o}C V=volume of sample	Those solids that can be volatilized and burned off when the TS are ignited (500 ±50 ^{o}C)
Total fixed solids (TFS)	The residues that remains after TS are ignited (500 ±50 ^{o}C)
Total suspended solids (TSS) SS=(M4-M5)V M4=mass of filter after drying at 105 ^{o}C M5=mass of initial filter V=volume of sample	Portion of the TS retained on a filter with a specified pore size, measured after being dried at a specified temperature (105 ^{o}C).
VSS=(M4-M6)/V M4=mass of filter after drying at 105 ^{o}C M6=mass of filter after ignition at 550 ^{o}C V=volume of sample	Those solids that can be volatized and burned off when the TSS are ignited (500 ±50 ^{o}C)
Fixed suspended solids (FSS)	The residue that remain after TSS are ignited (500 ±50 ^{o}C)
Total dissolved solids (TDS)	Those solids that pass through the filter, and are than evaporated and dried at specified temperature. It should be noted that what is measured as TDS is comprised of colloidal and dissolved solids. Colloids are typically in size range from 0.001-1 µm.
Total volatile dissolved solids (VDS)	Those solids that can be volatilized and burned off when the TDS are ignited (500 ±50 ^{o}C)
Fixed dissolved solids (FDS)	The residue that remain after TDS are ignited (500 ±50 ^{o}C)
Settleable solids	Suspended solids, expressed as milliliters per litter that will settle out of suspension within a specified period of time.

Table : 1.2 Characteristics of Wastewater

INTERRELATIONSHIPS OF SOLIDS FOUND IN WATER AND WASTEWATER

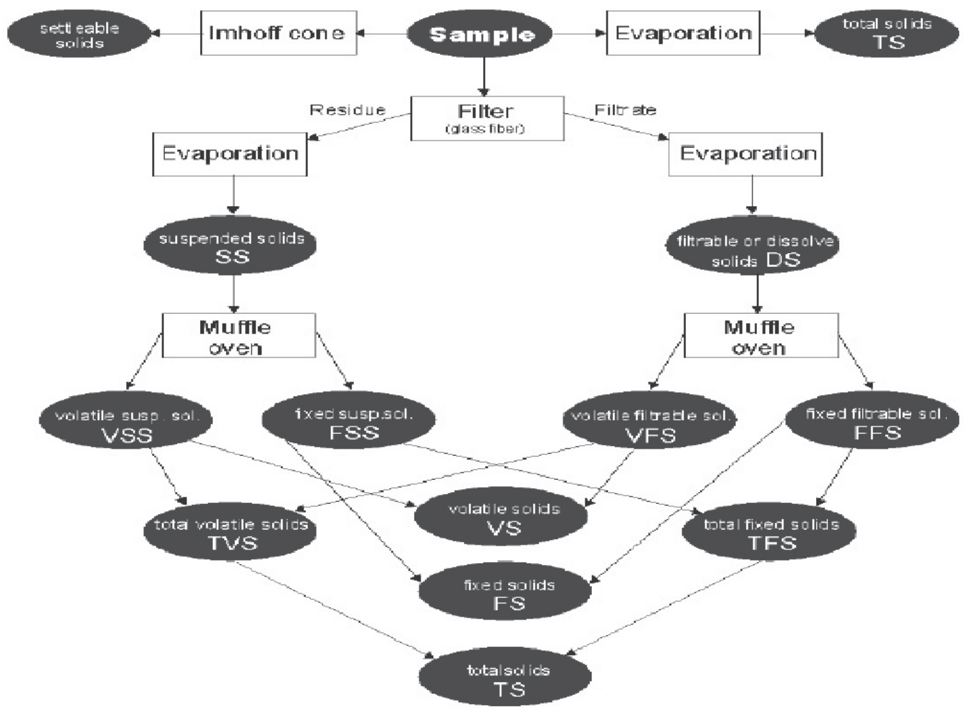

Fig : 1.1 Interrelationships of solids found in water and wastewater

Gases :

- Gases commonly found in untreated wastewater include nitrogen (N_2), oxygen(O_2), carbon dioxide (CO_2), hydrogen sulfide(H_2S), ammonia (NH_3), and methane (CH_4).
- The first three are common gases of the atmosphere and will be found in all waters exposed to air.
- The latter three are derived from the decomposition of the organic matter present in waste water and dangerous to worker's health and safety.
- Although not found in untreated waste water, other gases with which the environmental engineer must be familiar include chlorine (Cl_2), ozone (O_3) and the oxides of sulfur and nitrogen.

Solubility of gases in water :

- The actual quantity of a gas that can be present in solution is governed by (1) the solubility of the gas as defined by henry's law, (2) the partial pressure of the gas in the atmosphere, (3) the temperature, (4) the concentration of the impurities in the water.

  Henry's law:

  $p=k_hC$

  k_h=henry's constant

  C=concentration of solute in solution

  p= partial pressure of solute in the solutiona

CHAPTER-2

WATER AND WASTEWATER PARAMETERS

PHYSICAL PARAMETERS

Turbidity :

- Turbidity, a measure of the light-transmitting properties of water.
- The measurement of turbidity is based on comparison of the intensity of light scattered by a sample to the light scattered by a reference suspension under the same condition.
- Turbidity measurement are reported as nephelometric turbidity unit (NTU).
- If ultraviolet radiation (UV) is used for disinfection of treated wastewater, turbidity measurement will be important because for UV to be effective in disinfecting wastewater effluent, UV light must be able to penetrate the stream flow.
- There is no relationship between turbidity and the concentration of total suspended solids in untreated wastewater. Both the size and surface characteristics of the suspended material influence absorption and scattering.
- One of the problems with the measurement of turbidity (especially in low filtered effluent) is the high degree of variability observed, depending on the light source (incandescent light versus light-emitting diodes) and method of the measurement (reflected versus transmitted light).

Color :

- In wastewater treatment, colour is not necessarily a problem, but instead is a indicator of the condition of the wastewater.
- fresh wastewater is usually a light brownish-gray colour The colour of wastewater changes sequentially from grey to dark grey and ultimately to black as the travel time in collection system increases (flow becomes increasingly more septic) and more anaerobic conditions develop..
- If the colour of waste water is black, the waste water is septic.
- Some industrial waste water may also add colour to domestic water.
- Gray, dark gray, and black colour of the waste water is due to the formation of metallic sulfides.
- Sulfide is produced under anaerobic conditions reacts with the metals in the waste water.

Temperature :

- Temperature is very important parameter because of its effect on chemical reactions on reaction rates, aquatic life, and the solubility of essential gases such as oxygen in water.
- The temperature of waste water is commonly higher than that of the local water supply.
- It is due to addition of warm water from household and industrial activities.

Effects of temperature :

- Oxygen is less soluble in warm water than in cold water
- A sudden change in temperature can result in a high rate of mortality of aquatic life.

Odour :

- In wastewater, odours are of major concern, especially to those who reside in close proximity to a wastewater treatment plant. These odours are generated by gases produced by decomposition of organic matter or by substances added to the wastewater. Odour from fresh wastewater is less objectionable than the odour from wastewater that has undergone anaerobic decomposition.
- The most characteristic odour of stale or septic wastewater is that of hydrogen sulphide (H_2S), which is produced by anaerobic microorganisms that reduce sulphate to sulphide. The malodorous compounds responsible for producing objectionable odours in water can be detected by diluting a sample with odour free water until the least detectable odour level is achieved. This is recorded as TON (Threshold Odour Number).
- The concentration of malodorous gases such as hydrogen sulphide, ammonia, mercaptans etc. emitted into the air from wastewater can be measured by any commercially available gas monitor.

Conductivity :

- Electrical conductivity of a water is used to determine the suitability of a water for irrigation.
- SI units of electrical conductivity : Millisiemens per meter (mS/m) and in US : Micromhos per centimeter (µmho/cm).

Density, Specific Gravity and Specific Weight :

- The density of waste water ρ is defined as its mass per unit volume expressed as g/L or kg/m^3 in SI units.
- Density of waste water forms density currents in sedimentation tank, chlorine contact tank, and other treatment units.
- Both the density and specific gravity of waste water are temperature- depended.
- Vary with the concentration of total solids in the waste water .

CHEMICAL PROPERTIES

- The chemical constituents of waste water: inorganic, organic matter.
- Organic matter in waste water classified as aggregate and individual.
- Inorganic nonmetallic and metallic constituents in waste water derived from:
- Background level in the water supply
- Additional resulting from domestic use,
- Additions of highly mineralized water from private wells and ground water,
- Industrial use.
- Inorganic nonmetallic constituents includes : pH, nitrogen, phosphorus, alkaline, chloride, sulfur, gases and odour.

pH :

- pH is defined as the negative logarithm of hydrogen ion concentration.
- Expressing hydrogen ion concentration.
- $pH=-log_{10}[H^+]$
- The concentration range suitable for the exitenence of most biological life is quite narrow and critical.
- Allowable pH range of effluent usually varies from 6.5-8.5 to protect organisms.
- pOH is defined as the negative logarithm of the hydroxyl-ion concentration.
- pH + pOH = 14

Chlorides :

- Domestic wastewater is a rich source of chlorides, because human excreta, mainly urine, is rich in chloride. It does not present a major pollution threat. But, Chloride ion concentration is an important factor to be considered if treated effluent is used for irrigation. High chloride concentration disturbs the osmotic balance between the plants and the soil, which affects the growth of the plants.
- In waste water can impact the final reuse application's of treated waste water. Chlorides in natural water result from the leaching of chloride-containing rocks and soils with which the water comes in contact in costal area.
- Agricultural, industrial and domestic waste waters discharged to surface waters are a source of chlorides.

Alkalinity :

- Alkalinity is the capacity of water to neutralise acids.
- Alkalinity in waste water results from the presence of hydroxides $[OH^-]$, carbonates$[CO_3^-]$, and bicarbonates $[HCO_3^-]$ of elements such as calcium, magnesium, sodium,potassium or ammonia.
- Calcium and magnesium bicarbonates are most alkaline.
- For most practical purposes alkalinity can be defined in terms of molar quantities.
- Alkalinity plays an important role in the treatment of wastewater, as it indicates the buffer capacity of water. This affects the growth and activity of microbes present in activated sludge, which are responsible for the treatment of wastewater. It is also an essential parameter to be estimated to design and implement the corrosion and odourcontrol processes.

Dissolved Oxygen (DO) :

- Dissolved oxygen is the amount of molecular oxygen dissolved in water. It is required for the respiration of aerobic microorganisms. However, oxygen is only slightly soluble in water. The actual quantity of oxygen (other gases too) that can be present in solution is governed by:
- The solubility of gas
- The partial pressure of the gas in the atmosphere
- The temperature
- The concentration of the impurities in the water (e.g., Salinity, suspended solids, etc.) The amount of do decreases with increasing water temperature. So a cool or cold water can contain much more do than the warm water. As a result, aquatic life in streams and lakes is placed under more oxygen stress during summer months than during the other seasons.

Nitrogen :

- The elements nitrogen and phosphorous is essential to the growth of microorganisms, plants and animals.
- known as nutrients or biostimulants.
- Trace quantities of other elements such as iron, are also needed for biological growth but nitrogen and phosphorous, are the major nutrients.
- Nitrogen is an essential building block in the synthesis of protein.
- Nitrogen data will be required to evaluate the treatability of waste water by biological processes.
- Insufficient nitrogen can necessitate the addition of nitrogen to make the waste treatable.

Source of Nitrogen :

(1) the nitrogenous compounds of plant and animals origin

(2) Sodium nitrate and

(3) Atmospheric nitrogen

- Nitrogen compounds with environmental relevance frequently analyzed in wastewater are ammonia, nitrite, nitrate, and Kjeldahl nitrogen. Ammonia discharged to surface water can be nitrified in the aqueous environment if nitrifying microorganisms are present. The nitrifying bacteria consume dissolved oxygen for this process, thus depleting the oxygen content of the surface water with the consequence of massive dying of fish. Moreover, if the pH of the surface water is in the alkaline range, NH_3 is formed which is toxic towards fish.
- The nitrate ion represents a nutrient leading to eutrophication of surface water, and nitrite is toxic and can react with amines (formed e.g. from amino acids of proteins) to yield N-nitosoamines which represent powerful carcinogens. Kjeldahl nitrogen is a sum parameter of compounds containing the nitrogen atom with an oxidation number of -3 (ammonia, amines and many other organic nitrogen compounds). It thus comprises organic nitrogen compounds besides ammonia nitrogen. This is also an important nitrogen parameter, because organic nitrogen compounds can be metabolized to ammonia (this conversion can also take place in surface water).

Nitrogen Pathways in Nature :

- The nitrogen present in fresh wastewater is primarily combined in proteinaceous matter and urea.
- Decomposition by bacteria readily changes the organic form to ammonia.
- The age of wastewater is indicated by the relative amount of ammonia that is present.
- In an aerobic environment, bacteria can oxidize the ammonia nitrogen to nitrites and nitrates.

Phosphorus :

- Phosphorus is essential to the growth of algae and other biological organisms. Municipal wastewater may contain 4 to 16 mg/l of phosphorus as.
- The usual forms of phosphorus include the orthophosphate, polyphosphate and organic phosphate.
- The amount of phosphorus compounds present in wastewater discharge has to be controlled in order to avoid noxious algal blooms occurred in surface water.
- The sum of all three phosphorus species is designated as total phosphorus.

Sulfur :

- The sulfate ion occurs naturally in most water supplies and in wastewater as well.
- Sulfur is required in the synthesis of proteins and it is released in their degradation.
- Sulfate is reduced biologically under anaerobic conditions to sulfide which, can combine with hydrogen to form hydrogen sulfide (H_2S).
- Hydrogen sulfide gas, which will diffuse into the headspace above the wastewater in sewers that are not flowing full, tends to collect at the crown of the pipe.
- The accumulated H_2S can be oxidized biologically to sulfuric acid, which is corrosive to concrete sewer pipes.
- This corrosive effect, known as "crown rot", can seriously threaten the structural integrity of the sewer pipe.
- Sulfates are reduced to sulfides in sludge digesters and may upset the biological process if the sulfide concentration exceeds 200mg/l.
- The H_2S gas, which is evolved and mixed with the wastewater gas (CH_4 + CO_2), is corrosive to the gas piping and, if burned in gas engines, the products of combustion can damage the engine and severely corrode exhaust gas heat recovery equipment, especially if allowed to cool below the dewpoint.

Oil and Grease :

- The term oil and grease, includes the fats, oils, waxes, and other related constituents found in waste water.
- It causes scum in aeration basins of activated sludge plants, which interferes with the biological oxidation of wastes and produces a low quality settling sludge.
- Oil and grease are chemically similar they are compounds of alcohol or glycerol with fatty acids.
- The glyceride of fatty acids that are liquid are called oil and those are solids are called grease.
- Adsorbable organic halides (AOX) is an organic sum parameter comprising such organics that contain chlorine, bromine or iodine (not fluorine!) atoms and are adsorbable to activated carbon.

Metallic Constituents :

- Trace quantities of many metals, such as cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), and zinc (Zn) are important constituents of waste waters.
- Many of this metals are also classified as priority pollutants.

Source of Metals:

The source of trace metals in waste water include :

- discharges from residential dwellings,
- ground water infiltration.
- commercial and industrial discharges.
- Cadmium, chromates, lead, and mercury are often present in industrial wastes.
- Fluoride, a toxic anion is found commonly in waste water from electronics manufacturing facilities.

CHAPTER-3

WASTEWATER ORGANIC & BIOLOGICAL CONSTITUENTS

AGGREGATE ORGANIC CONSTITUENTS

- Over the years a number of different analysis have been developed to determine organic content of wastewater.
- In general, the analysis may be classified into : Organic matter comprising, a number of organic constituents with similar characteristics.
- And those analysis used to quantify individual organic compounds.

Measurement of Organic Content :

- Laboratory methods commonly used today to measure gross amounts of organic matter waste water include :-
  (1) biochemical oxygen demand (BOD)
  (2) chemical oxygen demand (COD)
  (3) total organic carbon (TOC)
- Biochemical Oxygen Demand is a sum parameter and the amount of oxygen required to oxidise organic matter present in the water biochemically. So BOD is an indirect measure of the concentration of organic contamination in water.

1) BOD (Biochemical Oxygen Demand) :

- BOD is the most widely used parameter of organic pollution applied to wastewater and is used:-
- to determine the approximate quantity of oxygen that will be required to biologically stabilize the organic matter present,
- to determine the size of wastewater treatment facilities,
- to measure the efficiency of some treatment processes;
- to determine compliance with wastewater discharge permits.

Basis for BOD Test :

- If sufficient oxygen is available, the aerobic biological decomposition of an organic waste will continue until all of the waste is consumed.
- Three more or less distinct activities occur.
- A portion of a waste is oxidized to end products to obtain energy for cell maintenance and the synthesis of new cell tissue.
- Some of the waste is converted into new cell tissue using part of the energy released during oxidation.
- When the organic matter is used up, the new cell begin to consume their own cell tissue to obtain energy for cell maintenance. This third process is called endogenous respiration.

2) COD (Carbonaceous Biochemical Oxygen Demand) :

- When nitrification occurs, measured BOD value will be higher than true value due to oxidation of carbonaceous material. If a given percentage of carbonaceous biochemical oxygen demand (CBOD) removal must be achieved to meet regulatory permit limits, early nitrification can pose a serious problem.
- The effect of nitrification can be overcome either by using various chemical to suppress the nitrification reaction, or by treating the sample to eliminate the nitrifying organisms.
- The equivalent amount of oxygen required to oxidise organic matter present in a water sample by means of a strong chemical oxidising agent is called chemical oxygen demand (COD). COD is also a sum parameter and is used to measure the content of organic matter of wastewater. The COD values include the oxygen demand created by biodegradable as well as non-biodegradable substances. As a result, COD values are greater than BOD
- Once the correlation has been established, COD measurements can be used to good advantage for treatment-plant control and operation.

3) TOC (Total Organic Carbon) :

- Wastewater content of carbon bound in organic molecules is the TOC (total organic carbon). Organic carbon comprises nearly all carbon compounds except a few carbon species which are looked at as inorganic (carbon dioxide, hydrogen carbonate, carbonate, cyanide and some further examples which are not commonly found in wastewaters).

BOD-COD-TOC Comparison Ratios :

- Typical value for the ratio of BOD / COD for untreated municipal waste water are in the range from 0.3 to 0.8.
- If the BOD / COD ratio for untreated wastewater is 0.5 or greater, the waste is considered to be easily treated by biological means.
- If the ratio is below 0.3, either the waste may have some toxic components or acclimated microorganisms may be required in its stabilization.
- The corresponding BOD / TOC ratio for untreated wastewater varies from 1.2 to 2.0. In using these ratios it important to remember that they will change significantly with the degree of treatment the waste has undergone, as reported in Table 3.2.

MEASURES OF VARIOUS PARAMETERS

Parameter	Measures to be taken
turbidity	immediate inspection and documentation; analytical quantification should be carried out on the same day
settleable solids	immediate analysis using Imhoff cone
suspended solids	filtration and gravimetric analysis must be performed as soon as possible
colour	immediate inspection and documentation
odor	immediate check and documentation
concentration of dissolved oxygen	analysis with oxygen probe
pH	analysis with pH probe
conductivity	analysis with conductivity probe
nitrite	transport samples as fast as possible to laboratory for analysis; reflectometric analysis at sampling location
temperature	directe determination in the wastewater

Table : 3.1 Measures Of Various Parameters

COMPARISON OF RATIOS OF VARIOUS PARAMETERS USED TO CHARACTERIZE WASTEWATER

Type of wastewater	BOD/COD	BOD/TOC
Untreated	0.3 – 0.8	1.2 - 2.0
After primary settling	0.4 – 0.6	0.8 - 1.2
Final effluent	0.1 – 0.3	0.2 - 0.5

Table : 3.2 Comparison of Ratios of Various Parameters Used To Characterize Wastewater

BIOLOGICAL CHARACTERISTIC

- The biological characteristics of wastewater are important
- In the control of diseases caused by pathogenic organism of human origin
- It is due to the extensive and fundamental role played by bacteria and other microorganisms in the decomposition and stabilization of organic matter.
- Microorganisms found in surface waters and Wastewater include :
- Organisms found in surface water and wastewater include bacteria, fungi, algae, protozoa, plants & animals and viruses,
- Bacteria, fungi, algae, protozoa, and viruses can only be observed microscopically.

General Classification :

- Living single-cell microorganisms that can only be seen with a microscope are responsible for the activity in biological wastewater treatment.

Pathogenic Organisms :

The principal pathogenic organisms found in untreated wastewater are as per table along with the diseases and diseases symptoms associated with each pathogen.

- Bacterial pathogenic organisms of human origin typically cause diseases of the gastrointestinal tract, such as typhoid and paratyphoid fever, dysentery, diarrhea, and cholera.

Analysis Of Wastewater Flow Rate Data :

- Because the hydraulic design of the collection and treatment facilities is affected by variations in waste water flow rates, the flow rate characteristics have to be analyzed carefully from existing records.

Variations In Wastewater Flow Rates :

- Wastewater flow rates vary during the time of the day, day of the week, season of the year, or depending upon the mature of the dischargers to the collection type.
- Minimum flows occur during the early morning hours when water consumption is lowest and when the base flow consists of infiltration and small quantities of sanitary wastewater.

CHAPTER-4

DOMESTIC WASTEWATER SAMPLING

SAMPLING

- Representative sampling of wastewater streams is decisive for correct modelling of wastewater treatment processes.
- While in laboratories usually high efforts are made to execute chemical analyses of wastewater samples with high accuracy, wastewater sampling is sometimes carried out by people who are not trained in sampling. Thus, experts assume that errors in wastewater analyses caused by mistakes during sampling are several orders of magnitude higher than by analytical errors in the chemical laboratory.
    - Sampling programs are undertaken for a variety of reasons such as to obtain :-
    - Routine operating data on overall plant performance.
    - Data that can be used to document the performance of a given treatment operation or process.
    - Data that can be used to implement proposed new programs/projects and
    - Data needed for reporting regulatory compliance.

To Meet The Goals Of The Sampling Program, The Collected Sample Must Be :

- <u>Representative:</u>
  The data must represent the wastewater or environment being sampled.
- <u>Reproducible:</u>
  The data obtained must be reproducible by other following the same sampling and analytical protocols.
- <u>Defensible:</u>
  Documentation must be available to validate the sampling procedures. The data must have a known degree of accuracy and precision.
- <u>Useful:</u>
  The data can be used to meet the objectives of monitoring on going plant/plannedproject.

Sampling Plan :

Number of sampling locations, number and type of samples, time intervals. (e.g., real time and/or time-delayed samples.)

Sample Types And Size :

- Different kinds of sampling are possible.
- Both kinds of sampling can either be carried out manually or automatically. Automatic samplers are being used increasingly. They are effective and reliable and can significantly increase the frequency of sampling. Especially for composite samples taken during long periods (days, weeks), automatic samplers are convenient and help to save manpower.

Sample Labeling And Chain Custody :

- Sample labels, sample seals, field log book, chain of custody record, sample analysis request sheets, sample delivery to laboratory, receipt and logging of sample and assignment of sample for analysis.

Sampling Methods :

Specific techniques and equipment to be used (e.g., manual, automatic or sorbent sampling).

Sampling Storage And Preservation :

Types of containers (e.g., glass or plastic), preservation methods, maximum allowable holding times.

Sample Constituents :

A list of the parameters to be measured.

Analytical Methods :

- A list of the field and laboratory test methods and procedures to be used and the detection limits for the individual methods.
- Parameters which cannot be stabilized by sample preservation and have to be measured immediately after sampling at the sampling location or directly in the wastewater.
- Each step of handling the samples has to be documented in the sampling protocol which should also contain :
- The sample designation (which has to be marked also on the sample container),
- Date and day time of sampling,
- Sampling location,
- Name of person collecting the samples,
- Purpose of sampling, mode of sampling (grab or composite sample etc.),
- Results of measurements performed at the sampling site,
- Sample preparation measures (e.G. Sedimentation of sample),
- Preservation procedure(s),
- Sample storing conditions until delivery to laboratory, comments upon reference samples simultaneously collected,
- Comments about subsequent changes occurring in the sample,
- Comments about deviations from routinely performed sampling (e.g. Application of another automatic sampler,
- More frequent transfers of samples to other bottles than usually done),
- Observations at sampling site (weather, wastewater irregularities as foam, bulking sludge, odor etc.),
- Comments about irregularities observed on the sampling site (e.g. Construction operations within a treatment plant etc.).
- Sampling documentation forms can serve as check lists. For further analyses in the laboratory, samples must be transported as soon as possible to the laboratory. For keeping the samples unchanged during the transport, the sample containers should be tightly sealed, kept cool (e.g. using a cooling bag - which should be exclusively used for sampling but not for food transport for safety reasons) and dark.
- In vehicles used for sample transport, samples must be protected against being tilt over. If samples are shipped by mail or express services, by railway, ship or aero plane, special safety measurements have to be taken. The bottles must be sealed absolutely tight and protected against shock in order to avoid leakages of the sample bottles.

- The samples as well as the sampling protocols have to be received by the laboratory staff in a responsible manner because of registration and eventual transfer of some samples to other laboratories for special analyses. Working safety has to be obeyed not only in laboratories, but also during sampling.
- It is clear that sampling of wastewater (and also of other media) has to be carefully prepared (providing sampling equipment like suitable sample bottles in sufficient number etc.). There must be a good communication between sampling staff and the analytical laboratory concerning number of samples, parameters which must be analyzed, time of delivery of samples to the laboratory, because the laboratory has to organize the enforcement of the analyses as well as to provide storing space in refrigerators or freezers.

Sampling As A Tool For Controlling Of Process Of A Wastewater Treatment Plant :

- Some parameters for controlling the process of the activated sludge system are pH, dissolved oxygen concentration (DO) and acid capacity with electrodes.
- The pH value and acid capacity are often used for dosage of liquids to stabilize the activated sludge process. The concentration of dissolved oxygen is used to control the activity of the aeration system. If the aeration system produce more oxygen than the process needs, the operation costs increase.
- At effluent point of aeration tank, a grab sample will be taken directly out of the aeration tank to determine the concentration of the mixed liquor suspended solids (MLSS) and the sludge volume index (SVI).

Some Hints For Taking Samples :

- Use a clean glass or plastic bottle for samples
- Label a bottle (e.g. point and kind of sampling, date and time, name of sample collector, parameters of analyses).
- Do not touch the inner of the bottle with your fingers (contamination).
- Through the first flush out of a pipe away and than take your sample.
- Stir the sample before you fill it into the flask.
- Fill the bottle up to the top. Oxygen in the flask let continue a biological process and the concentration of ammonium will decrease and the concentration of nitrate will increase.
- Take care that the volume of the samples will be big enough for analyses.
- Carry the sample as soon as possible to the laboratory or analyse it onsite (biological degradation still takes place!).
- Cool the sample, do not leave it in the sun.
- Sample should be stirred, homogenized or filtrated before you start the analyse (depends on the kind of parameter for analyses).
- Check and clean automatically working sampling units frequently.
- Control the cooling system (wrong temperature will change the ingredients.
- Take care that the whole volume of the connected samples will not be bigger that the volume of the flask.

APPENDIX

Determination	Sample size mL	Preservation	Storage recommended/ Regulatory (1)
Acidity	100	Refrigerate	24 h / 14 d
Alkalinity	200	Refrigerate	24 h / 14 d
BOD	1000	Refrigerate	6 h / 48 h
Carbon, organic, total	100	Analyze immediately or refrigerate and add HCl to pH<2	7 d / 28 d
Carbon dioxide	100	Analyze immediately	Stat/ N.S.
COD	100	Analyze as soon as possible or add H_2SO_4 to pH<2, refrigerate	7 d / 28 d
Chlorine, residual	500	Analyze immediately	0.5 h / Stat
Color	500	Refrigerate	48 h / 48 h
Conductivity	500	Refrigerate	28 d / 28 d
Fluoride	300	None required	28 d / 28 d
Hardness	100	Add HNO_3 to pH<2	6 months
		For dissolved metals filter immediately, add $HNO_3$to pH<2	6 months / 6months
Ammonia	500	Analyze as soon as possible or add H_2SO_4 to pH<2, refrigerate	7 d / 28 d
		Add H_2SO_4 to pH<2, refrigerate	None / 28 d
Organic Kjeldahl	300	Refrigerate, add $H_2SO_4$to pH<2	7 d / 28 d
Oil and grease	1000	Add $H_2SO_4$to pH<2, refrigerate	28 d / 28 d
Oxygen, dissolved:	300		
		Add H_2SO_4	2 h / Stat.
Phosphate	100	For dissolved phosphate filter immediately; refrigerate	48 h / N.S.

Salinity	240	Analyze immediately or use wax seal	6 months / N.S.
Sludge digester gas	-	-	28 d / 28 d
Solids	-	Refrigerate	7 d / 2 -7 d see cited reference
Sulfate	-	Refrigerate	28 d / 28 d
Sulfide	100	Refrigerate, add 4 drops 2N zinc acetate/100 mL, add NaOH to pH>9	28 d / 7 d
Taste	500	Analyze as soon as possible, refrigerate	24 h / N.S.
Temperature	-	Analyze immediately	Stat. / Stat.
Turbidity	-	Analyze same day; store in dark up to 24 h, refrigerate	24 h / 48 h

CHAPTER-5

TYPES OF TREATMENT

TYPES OF TREATMENT

1) Preliminary Treatment
2) Primary Treatment
3) Secondary Treatment
4) Tertiary/Advanced Treatment

1) Preliminary Treatment :

- Preliminary systems are designed-
  - to remove or cut up the larger suspended and floating materials
  - to remove the heavy inorganic solids and excessive amounts of oil and grease.
- The purpose of preliminary treatment is
  - to protect pumping equipment and the subsequent treatment units.
- However, The quality of wastewater is not substantially improved by preliminary treatment.
- Preliminary treatment includes:
- Screening:
- Grit Chamber:
- Oil and Grease Removal System

2) Primary Treatment :

- The Primary treatment is designed
  - to remove the fine suspended organic matter.
  - It reduces 60-70 % of fine settleable suspended solids, which include 30-32 % organic suspended solids.

The primary treatment does not remove the colloidal & soluble organic content of the waste water.

- Primary treatment includes:
  - Coagulation and flocculation unit following by primary sedimentation tank for the removal of inorganic & organic fine suspended solids.

3) Secondary Treatment :

- Secondary treatment is commonly referred to as the biological process.
- Secondary treatment is used to remove the soluble and colloidal organic matter which remains after primary treatment.
- This matter should be removed before discharging to receiving waters, to avoid interfering with subsequent downstream users.
- Secondary Treatment includes:
  - Aeration Tank/Biological treatment unit
  - Secondary settling tank
  - NOTE: Tertiary treatment & Advanced treatment is explained separately.

TYPES OF PROCESSES :

Various types of processes used in Secondary treatment are:

- Aerobic treatment :
  - Extended Aeration
  - Submerged Aerobic Fixed Film Reactor
  - Moving Bed Bioreactor
  - Membrane Bioreactor
- Anaerobic treatment :
  - Up flow Anaerobic sludge blanket reactor
  - Anaerobic Migrating Blanket Reactor

EXTENDED AERATION SYSTEM

- Extended Aeration is a type of activated sludge process with no primary settling and very long aerobic detention time to generate less excess sludge overall.
- It is ideal for smaller flow, modular applications that require low maintenance such as residential subdivisions.
- But the long HRT of Extended Aeration requires larger basins.

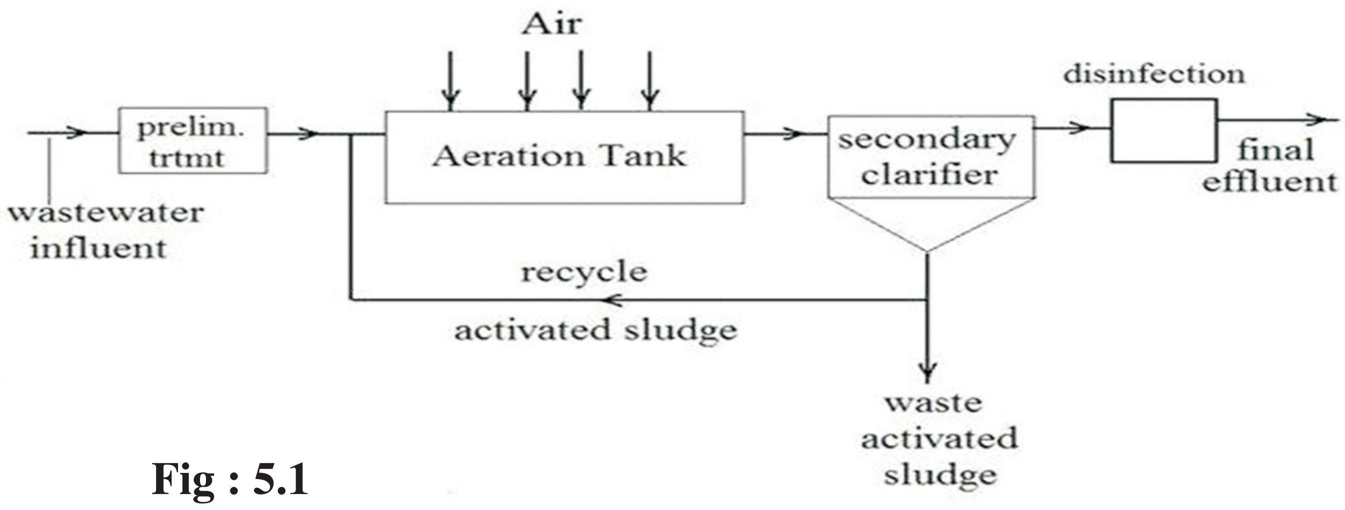

Fig : 5.1

Extended Aeration Activated Sludge Wastewater Treatment Flow Diagram

Applications :

- Municipal and Domestic Sewage Treatment
- Industrial Wastewater Effulents including
- Breweries
- Chemical Processing
- Dairies
- Distilleries
- Pharmaceuticals
- Food Processing
- Textiles etc...

Design Criteria :

- Raw effluent data such as BOD, COD, TSS, TDS, Oil & grease
- FM ratio
- MLSS conc.
- Detention time
- Final treated effluent quality data

SBR (SEQUENCING BATCH REACTOR)

Sequential Batch Reactor :

- The sequencing batch reactor (SBR) is a fill-and draw activated sludge system for wastewater treatment.
- In this system, wastewater is added to a single “batch” reactor, treated to remove undesirable components, and then discharged.
- Equalization, aeration, and clarification can all be achieved using a single batch reactor.

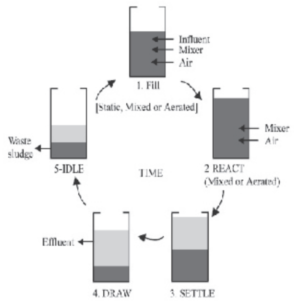

Fig : 5.2

- **PHASE-I** Wastewater fills the tank, mixing with biomass that settles during the previous cycle.
- **PHASE-II** Air is added to the tank to aid biological growth and felicitate waste reduction.
- **PHASE-III** Mixing and Aeration stop during this stage to allow solids to settle.
- **PHASE-IV** Clarified effluent is discharged.
- **PHASE-V** Sludge can be removed during this stage.

Sequential Batch Reactor Process (SBR) :

- Continuos Low System.
- Primarly For Nitrogen Removal.
- Flexible, Inexpensive And Efficient.
- Operational Cost Is High.
- Three Phases
  - ➢ Fill Phase
  - ➢ React Phase
  - ➢ Settle Phase

Fill Phase :

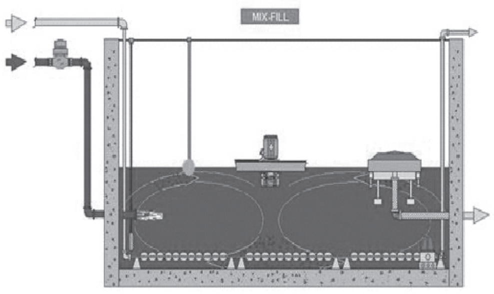

Fig : 5.3

- FILL provides for the addition of influent to the reactor.
- During FILL, the influent wastewater is added to the biomass (i.e. mixed liquor suspended solids) which remained in the tank from the previous cycle.
- Depending upon the treatment objective, the fill may be static, mixed or aerated.
- Static FILL (no mixing or aeration) results in minimum energy input and high substrateconcentration at the end of this phase.
- Mixed FILL (mixing without aeration) results in denitrification, if nitrates are present, a subsequent reduction of BOD and energy input, and in the anoxic or anaerobic conditions required for biological aphosphorus removal.
- Aerated FILL (mixing and aeration) results in starting of aerobic reactions leading to a reduction of cycle time, and holds substrate at lower concentrations, which may be important if biodegradable constituents present in wastewater are toxic at high concentrations.

React Phase :

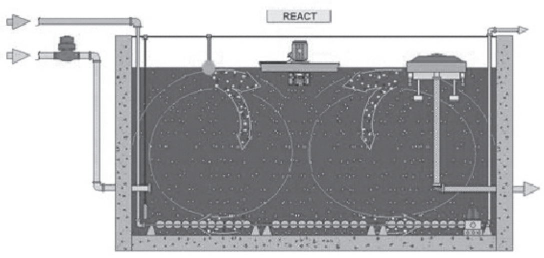

Fig : 5.4

- With the reactor full, the REACT phase begins. In general, vigorous aeration is the feature of this phase. However, as in FILL, the REACT phase may required to be carried out in high dissolved oxygen concentrations (aerated REACT), or in low dissolved oxygen concentrations (mixed REACT).
- The time allocated for REACT should be sufficient to achieve the desired level of effluent quality.
- The time dedicated to REACT phase can vary from a low of zero to more than 50% of the total cycle time.
- If only organics removal is desired, the aeration period can be as short as 15 minutes.
- However, longer aeration periods in the order of 4 hours or more, are normally required for long term stability of the process and nitrification.
- Where denitrification following nitrification is required, aeration during the REACT period is interrupted.
- Anoxic conditions would then prevail over a period of hours followed by a short period of aeration. This will strip away the nitrogen gas bubbles and aid in sedimentation.

Settle Phase :

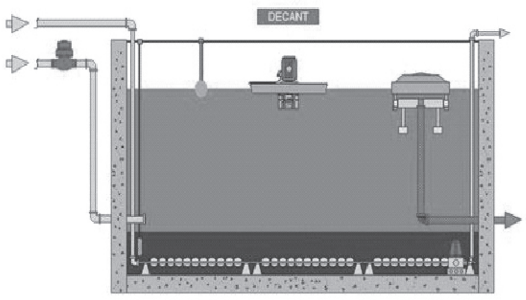

Fig : 5.5

- The SETTLE phase allows for separation of biosolids from the treated effluent without any inflow or outflow, in the SBR reactor that may have a volume more than ten times that of a secondary clarifier used for conventional continuous-flow activated sludge plant.
- The major advantage of SBR is its use as a clarifier, which allows for truly quiescent sedimentation conditions.
- Because all of the biomass remains in the tank until some fraction must be wasted, there is no need for underflow hardware normally found in conventional clarifiers. In contrast, the conventional ASP systems, continuously remove mixed liquor and passes through the clarifier only to return a major portion of the sludge to the aeration tank.
- Thus in conventional systems, quiescent conditions are assumed in design, but not achieved in operation as a result of secondary currents.

Decant Phase :

- This is the withdrawal phase to discharge the clarified effluent from the reactor.
- There are several withdrawal mechanisms available. It may be as simple as a pipe fixed at some predetermined depth with the flow regulated by an automatic valve or a pump.
- Alternatively, an adjustable or floating weir at or just beneath the liquid surface can be used. As with the fixed pipe arrangement, discharge from the weir can be regulated by an automatic valve or a pump.
- In any case the withdrawal mechanism should be designed and operated in a manner that prevents floating matter from being discharged.
- The time dedicated for DRAW phase can range from 5% to more than 30% of the total cycle time.
- The time for DRAW should not be overly extended because of possible problems with rising sludge.
- One hour is the usual time period allowed for this phase of the operation.

Step Feed Process :

- Continuous Low Process.
- Influent Flow Is Split To Several Feed Locations.
- Recycle Sludge Stream Is Sent To The Beginning.
- Higher Solids Retention Time Is Achieved Providing Enhanced Treatment.
- Phosphorus Removal Is Limited.

Fig : 5.6

Advantages :

- Small footprint
- Maximum day flow sizing, not peak hourly
- Can handle large fluctuations in flow and influent quality
- No hydraulic connection between incoming sewage and the outfall
- Flexibility and control
- Deeper tanks
- Modular, adaptable to retrofits & upgrades
- Full back up systems

Disadvantages :

- Requires Highly Skilled Team To Design And Construct The Facilities
- Highly Skilled Operators
- Canbe Higher In Operating Cost, No Control Over The Cost Of Electricity
- Bigger Disinfection System, Batch Discharge
- More Mechanical Equipment.

DESIGN CRITERIA

- For any wastewater treatment plant design, the first step is to determine the anticipated influent characteristics of the wastewater and the effluent requirements for the proposed system.
- These influent parameters typically include design flow, maximum daily flow BOD5 , TSS, pH, alkalinity, wastewater temperature, total Kjeldahl nitrogen (TKN), ammonia-nitrogen (NH_3 -N), and total phosphorus (TP).
- For industrial and domestic wastewater, other site specific parameters may also be required.
- The state regulatory agency should be contacted to determine the effluent requirements of the proposed plant.
- These effluent discharge parameters will be dictated by the state in the National Pollutant Discharge Elimination System (NPDES) permit.
- The parameters typically permitted for municipal systems are flowrate, BOD5 , TSS, and Fecal Coliform. In addition, many states are moving toward requiring nutrient removal.
- Therefore, total nitrogen (TN), TKN, NH_3 -N, or TP may also be required.
- It is imperative to establish effluent requirements because they will impact the operating sequence of the SBR.
- For example, if there is a nutrient requirement and NH_3 -N or TKN is required, then nitrification will be necessary.
- If there is a TN limit, then nitrification and denitrification will be necessary.
- Once the influent and effluent characteristics of the system are determined, the engineer will typically consult SBR manufacturers for a recommended design. Based on these parameters, and other site specific parameters such as temperature, key design parameters are selected for the system.

OPERATION AND MAINTENANCE

- The SBR typically eliminates the need for separate primary and secondary clarifiers in most municipal systems, which reduces operations and maintenance requirements. In addition, RAS pumps are notrequired.
- In conventional biological nutrient removal systems, anoxic basins, anoxic zone mixers, toxic basins, toxic basin aeration equipment, and internal MLSS nitrate-nitrogen recirculation pumps may be necessary.
- With the SBR, this can be accomplished in one reactor using aeration/mixing equipment, which will minimize operation and maintenance requirements otherwise be needed for clarifiers and pumps.
- Since the heart of the SBR system is the controls, automatic valves, and automatic switches, these systems may require more maintenance than a conventional activated sludge system.
- An increased level of sophistication usually equates to more items that can fail or require maintenance.
- The level of sophistication may be very advanced in larger SBR wastewater treatment plants requiring a higher level of maintenance on the automatic valves and switches.
- Significant operating flexibility is associated with SBR systems.
- An SBR can be set up to simulate any conventional activated sludge process, including BNR systems.
- For example, holding times in the Aerated React mode of an SBR can be varied to achieve simulation of a contact stabilization system with a typical hydraulic retention time (HRT) of 3.5 to 7 hours or, on the other end of the spectrum, an extended aeration treatment system with a typical HRT of 18 to 36 hours.
- For a BNR plant, the aerated react mode (oxic conditions) and the mixed react modes (anoxic conditions) can be alternated to achieve nitrification and denitrification. The mixed fill mode and mixed react mode can be used to achieve denitrification using anoxic conditions.
- In addition, these modes can ultimately be used to achieve an anaerobic condition where phosphorus removal can occur. Conventional activated sludge systems typically require additional tank volume to achieve such flexibility.
- SBRs operate in time rather than in space and the number of cycles per day can be varied to control desired effluent limits, offering additional flexibility with an SBR.

PERFORMANCE

- The Performance Of Sbrs Is Typically Comparable To Conventional Activated Sludge Systems And Depends On System Design And Site Specific Criteria.
- Depending On Their Mode Of Operation, Sbrs Can Achieve Good Bod And Nutrient Removal.
- For Sbrs, The Bod Removal Efficiency Is Generally 85 To 95 Percent.
- Sbr Manufacturers Will Typically Provide A Process Guarantee To Produce An Effluent Of Less Than:
- 10 mg/l BOD
- 10 mg/l TSS
- 5 - 8 mg/l TN
- 1 - 2 mg/l TP

➢ MOVING BED BIOREACTOR

- The Moving Bed Bio Reactor (MBBR) process utilize the attached bio-film and provides smaller foot print solution for with lower capital and operating costs.
- The suspended biomass carriers are designed to create a large surface area for biofilm growth.
- Benefits include-
  - An enhanced biological wastewater treatment process without increasing the plant footprint.
- MBBR process is ideally suited for retrofit/upgrade of existing installation with minimum changes in the existing setup.

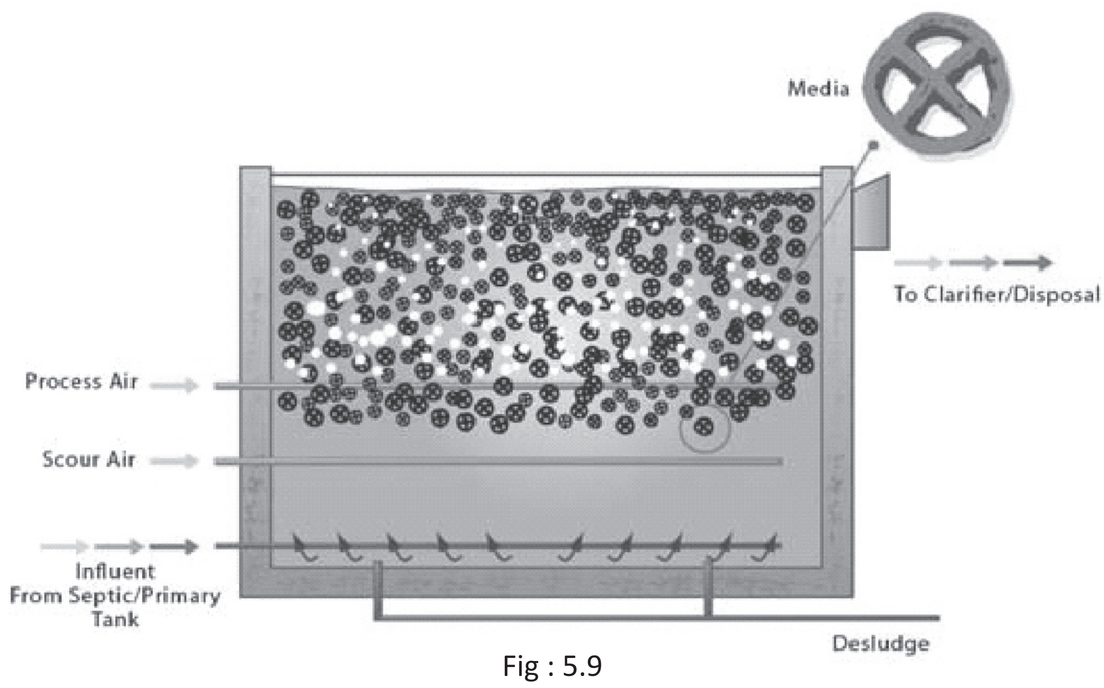

Fig : 5.9

Application :

- Municipal and Domestic Sewage Treatment
- Industrial Wastewater Effluents including
- Breweries
- Chemical Processing
- Dairies
- Distilleries
- Pharmaceuticals
- Food Processing

DESIGN CRITERIA

- Raw effluent data such as BOD, COD, TSS, TDS, Oil & grease
- Organic loading rate
- Final treated effluent quality data

MEMBRANE BIOREACTOR

- Membrane Bio Reactor (MBR) technique, a new method for wastewater treatment, integrates membrane separation and biotechnology
- Rejects activated sludge and macromolecular organic matter in aerobic tank/MBR tank with membrane separation plant, thus saving the use of secondary sedimentation tank.
- Consequently, the concentration of activated sludge rises greatly, the HRT and the SRT could be controlled separately, and difficult degraded matters are constantly degraded and reacting in reactor.
- Fig. shows the typical MBR concept of combination of Activated sludge process and membrane. brane filtration.

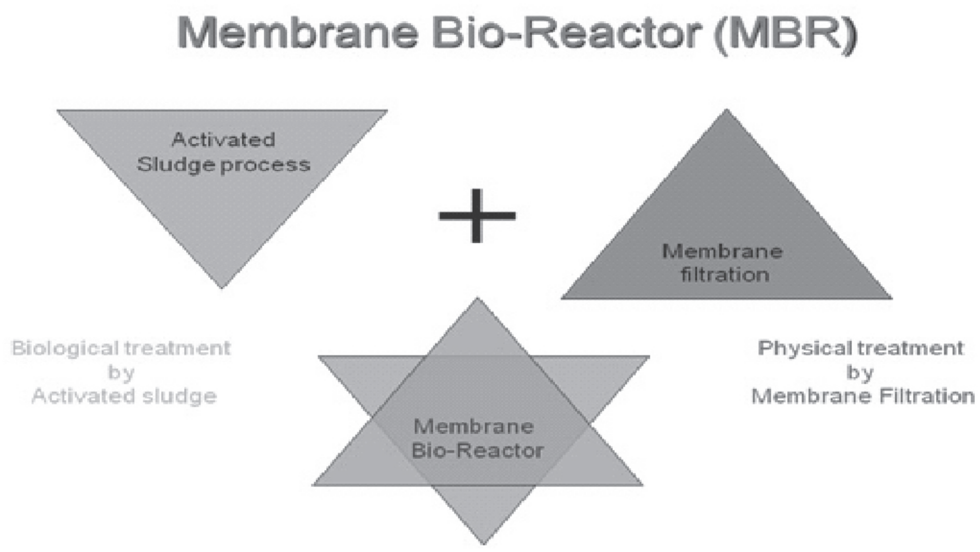

Fig : 5.10

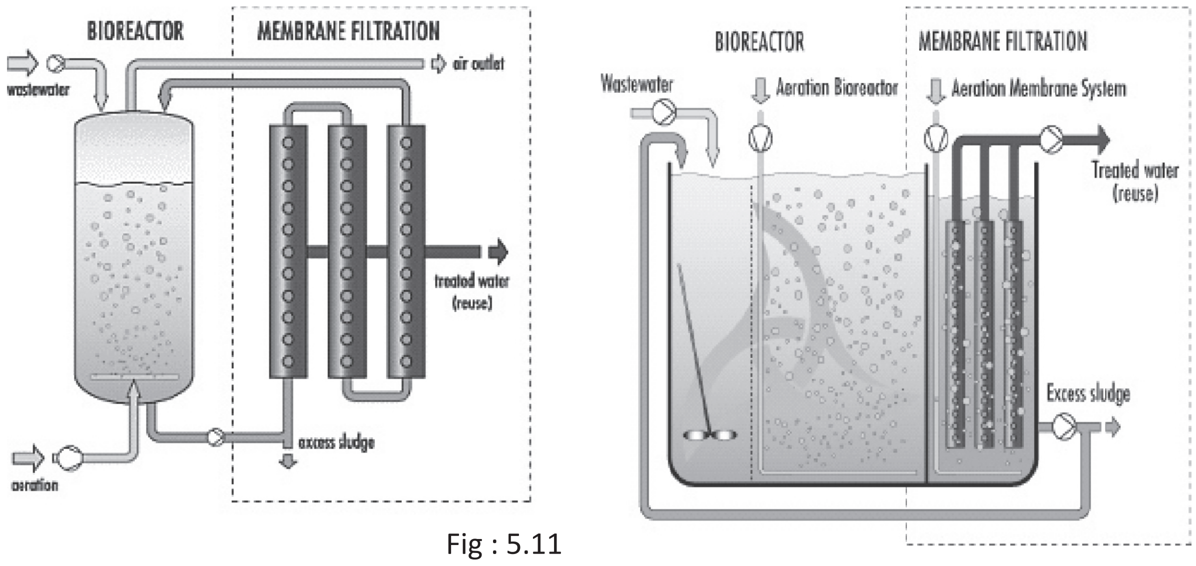

Fig : 5.11

Application :

- Need to upgrade old plant
- Need to preserve appearance of a clean/ tourist area(hospitals, hotels, malls)
- Housing complex
- Hotels & Township
- Golf & Country Club
- Industrial Estates
- Industrial waste treatment
- Waste recycle
- Existing plant upgrade/ capacity expansion
- RO Pretreatment of sea water and brackish waters
- Low area requirement

DESIGN CRITERIA

- Raw effluent data such as BOD, COD, TSS, TDS, Oil & grease
- Organic loading rate
- Final treated effluent quality data

➢ SUBMERGED AEROBIC FIXED FILM REACTOR

- SAFF treatment is based on aerobic attached growth process and used in the secondary treatment of effluent/sewage treatment plant.
- The equipment consists of specially designed synthetic media, which facilitates attached fixed film growth of micro-organisms.
- the media is supported by channels.
- diffusers are provided for efficient oxygen transfer.

SIDE VIEW - FOLDED RACEWAY WITH VERTICAL FLOWS

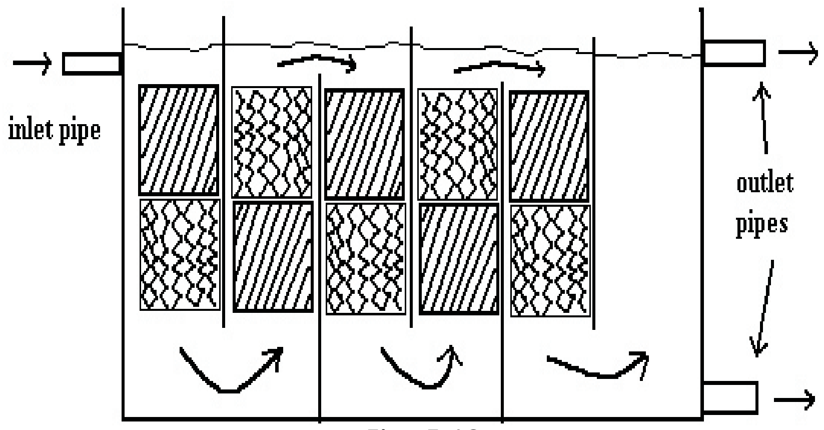

Fig : 5.12

Application :

- Municipal and Domestic Sewage Treatment
- Industrial Wastewater Effluents including
- Breweries
- Chemical Processing
- Dairies
- Distilleries
- Pharmaceuticals
- Food Processing
- Abattoirs
- Textiles etc...

DESIGN CRITERIA

- Raw effluent data such as BOD, COD, TSS, TDS, Oil & grease
- Volumetric loading
- Final treated effluent quality data

➢ ANAEROBIC TREATMENT-UASB

- Influent introduced from bottom which passes through the blanket of sludge.
- Sludge blanket acts as a filter and helps in removal of SS.
- The treated water and biogas is collected from top of the unit.

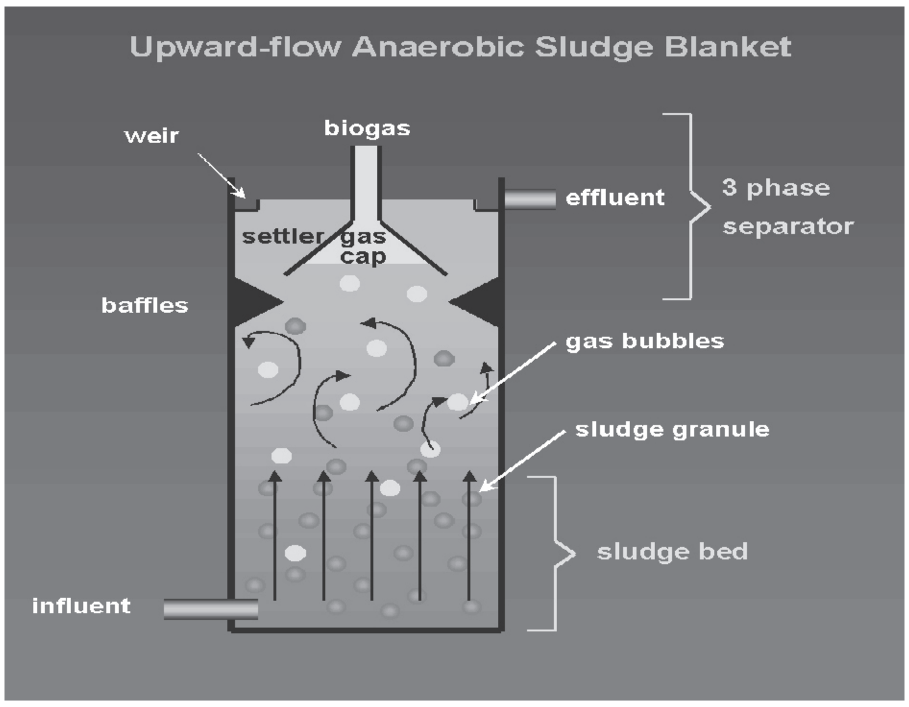

Fig : 5.13

Application :

- Biological treatment of wastewater with low to very high strength of wastewater
- Sewage treatment for medium to large towns/ cities.
- Treatment of distillery spent wash / pulp mill black liquor.
- Simple operation
- Energy production

DESIGN CRITERIA

- Raw effluent data such as BOD, COD, TSS, TDS, Oil & grease
- Organic loading rate

➢ ANAEROBIC TREATMENT-AMBR

- The AMBR is similar to the anaerobic Baffled Reactor (a series of unmixed compartments) with the added features of mechanical mixing in each stage and an operating approach designed to hold the sludge in the system without resort to packing or settler for additional solids capture.
- In the AMBR, the last stage is left unmixed to maximize settling, and the feed and effluent points are alternated periodically to reverse the movement of sludge through the reactor. The last stage becomes mixed when the flow is reversed.

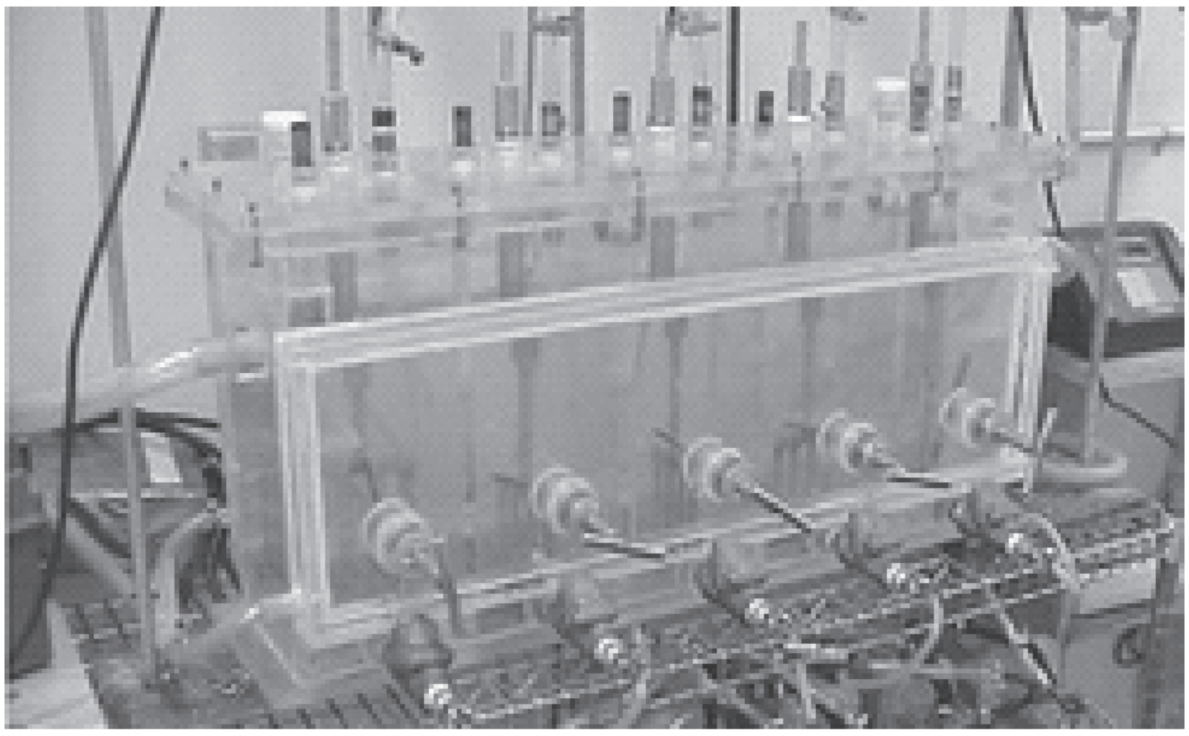

Fig : 5.14

Application :

- Biological treatment of wastewater with Very low to very high strength of wastewater
- Sewage treatment for medium to large towns/ cities.
- Treatment of distillery spent wash / pulp mill black liquor.
- Highly efficient to treat wastewater with low Organic loading.

DESIGN CRITERIA

- Raw effluent data such as BOD, COD, TSS, TDS, Oil & grease
- Organic loading rate

CHAPTER-6

COMPARISON OF TECHNOLOGIES

- Different processes are subjected to a qualitative analysis as a first step to find those that will meet the project requirement. A following table shows some merits and demerits of the technologies.

Process	Merits	Demerits
Activated Sludge Process (Conventional	• Process flexibility • Reliable operation • Proven track record in all plant sizes • Low order emission • Energy production	• High energy consumption • Skilled operators needed • Energy production • No nutrient removal
Extended Aeration	• Simple and flexible operation • Ability to absorb shock loads • Not high operator oversight required	• High operating costs • No energy production • No nutrient removal
Membrane Bioreactor	• Excellent effluent quality for reuse • Nutrient Removal possible • Stabilized sludge • Low footprint (area) requirement • Ability to absorb shock loads	• High construction costs • Very high operation cost • High membrane replacement cost • High automation • No energy production
Moving Bed Bio Reactor	• Low area requirement • Sludge recirculation not needed • Smaller area • Satisfactory effluent quality	• High energy consumption • Plastic media must be cleaned periodically ,with some breakage • Suitable for small applications • Skilled operators needed • No energy production • Effluent quality not upto the mark in India. • No nutrient removal
Sequencing Batch Reactor	• Excellent effluent quality • Smaller footprint because of absence of primary, secondary clarifiers and digester • Recent track record available in large applications in India also • Excellent effluent quality • Biological nutrient (N&P) removal • High degree of coliforms removal • Less chlorine dosing required • Ability to absorb shock hydraulic and organic loads	• Comparative energy consumption • Comparative automation • High skilled operators needed • No energy production

Process	Merits	Demerits
Upflow Anaerobic Sludge Blanket +FPU	• Simple operation • Energy production	• Large Land requirement • More man-power require for O & M • Effluent quality is not upto the mark • High chlorine dosing required. • No nutrient removal
Activated Sludge Process (with Nitrification-Denitrification & Bio-P Removal)	• Process flexibility • Reliable operation • Proven track record in all plant sizes • Low odor emission • N&P Removal • Energy production	• High energy consumption • Skilled operators needed • Fairly large area requirement

Table : 6.1

CAPITAL AND O & M COST FOR DIFFERENT STPS

SL.no	STP Process	Energy Requirement	Capital Cost Rs. Million / MLD	O&M Cost, Rs. Million/Year/MLD
1	Waste Stabilization Pond System (WSPS)	Negligible	2.5-5.0	0.09-0.15
2	Duckweed Pond System (DPS)	Negligible	2.5-5.0	0.25
3	Facultative Aerated Lagoon (FAL)	18 kWh/ML	2.2-3.0	0.15-0.2
4	Trickling Filter (TF)	180 kWh/ML	4.0-5.0	0.5
5	Activated Sludge Process (ASP)	180-225 kWh/ML	5.0-6.0	0.5-0.7
6	BIOFOR Technology (Biological Filtration and Oxygenated Reactor)	220-335 kWh/ML	10-12	1.2
7	High Rate Activated Sludge Biofor – F Technology	180 kWh/ML	7.5	0.8
8	Fluidized Aerated Bed (FAB)	99-170 kWh/ML	6-8	0.9-1.0
9	Submerged Aeration Fixed Film (SAFF) Technology	390 kWh/ML	9	1.4
10	Cyclic Activated Sludge process (CASP)	150-200 kWh/ML	11	1.4
11	Upflow Anaerobic Sludge Blanket (UASB) Process	10-15 kWh/ML	3.0-4.0	0.12-0.17

Table : 6.2

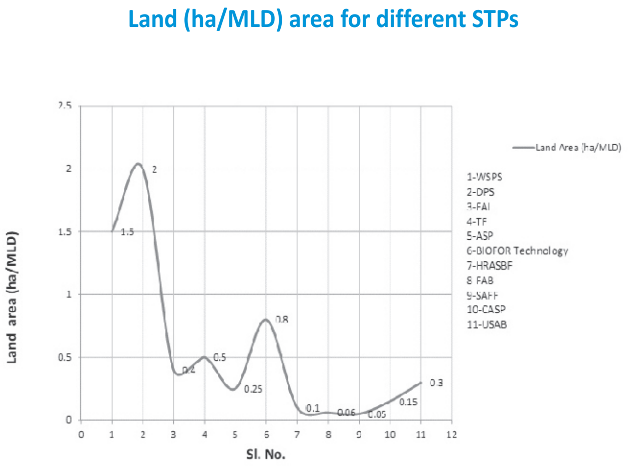

Fig : 6.1

WSPS =Waste Stabilization Pond System
DPS= Duckweed Pond System
FAL= Facultative Aerated Lagoon
TF= Trickling Filter
ASP= Activated Sludge Process
HRASBF= High rate Activated Sludge Biofor – F Technology
FAB= Fluidized Aerated Bed
SAFF=Submerged Aeration Fixed Film Technology
CASP= Cyclic Activated Sludge Process
UASB= Up flow Anaerobic Sludge Blanket Process

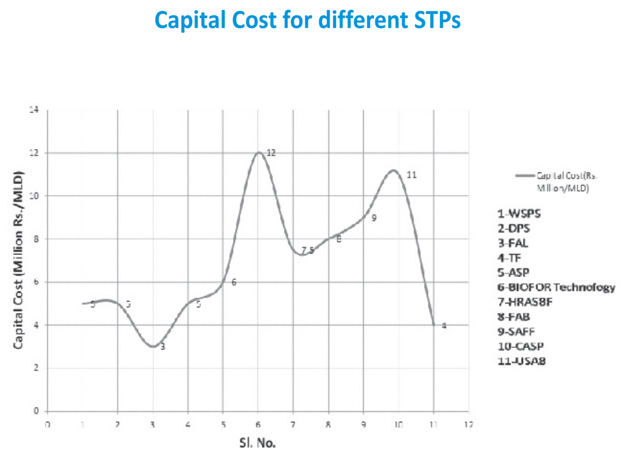

Fig : 6.2

WSPS =Waste Stabilization Pond System
DPS= Duckweed Pond System
FAL= Facultative Aerated Lagoon
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HRASBF= High rate Activated Sludge Biofor – F Technology
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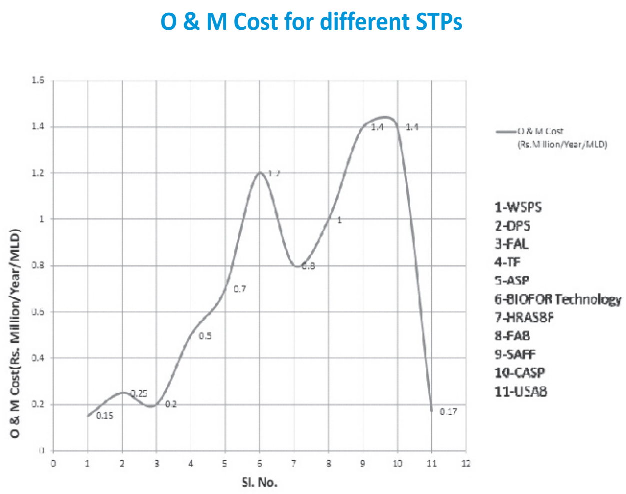


Fig : 6.3

WSPS =Waste Stabilization Pond System
DPS= Duckweed Pond System
FAL= Facultative Aerated Lagoon
TF= Trickling Filter
ASP= Activated Sludge Process
HRASBF= High rate Activated Sludge Biofor – F Technology
FAB= Fluidized Aerated Bed
SAFF=Submerged Aeration Fixed Film Technology
CASP= Cyclic Activated Sludge Process
UASB= Up flow Anaerobic Sludge Blanket Process

TECHNOLOGY COMPARISON (TECHNO-COMMERCIAL)

Parameter	UASB+EA	ASP+EA	MBBR	MBR	SBR
BOD, mg/l	<30	<20	<20-30	<3-5	<10
COD, mg/l	<150	<100	<100	<50	<100
TSS, mg/l	<100	<20	<20	<5	<10
TKN &P, mg/l	No Treatment	<10 <2	No Treatment	No Treatment	<10 <2
Area, Hectares(100MLD)	7.5	6	3.5	2	3

Table : 6.3

Technology Selection In STP :

- Objective1 → Reduce Capital Cost → UASB or ASP or MBBR
- Objective2 → Reduce Space → SBR or MBR or MBBR
- Objective3 → Reduce O & M cost → UASB or SBR
- Objective4 → Recycle reuse → SBR or MBR

CHAPTER-7

ADVANCE TREATMENT

➢ ADVANCED WASTEWATER TREATMENT

- Advanced wastewater treatment is defined as the methods and processes that remove more contaminants from wastewater than the conventional treatment. The term advanced treatment may be applied to any system that follows the secondary, or that modifies or replaces a step in the conventional process. The term tertiary treatment is often used as a synonym; however, the two are not synonymous. A tertiary system is the third treatment step that is used after primary and secondary treatment processes.
- Important role in Zero Liquid Discharge theory in future for water reuse purposes.

TYPES OF ADVANCED TREATMENT :

Water Filtration

- When we refer to water purification, it makes little sense to discuss the subject without first identifying the contaminants that we wish to remove from water. **Also,** the source of the water is of importance
- Filtration system,
- for the removal of suspended particles and unsettled flocs.
- Types of filtration systems are:
  - Pressure Sand Filter
  - Activated Carbon Filter
  - Dual Media Filter
  - Iron Removal Filter
  - Swimming pool Filtration

➢ PRESSURE SAND FILTER

- Removes suspended and visible impurities like sand, dust particles & turbidity.
- Consist of pressure vessel including sand layers , pebbles and gravels to enhance filtration
- Water is distributed uniformly from top and filtered water is collected in under drainage

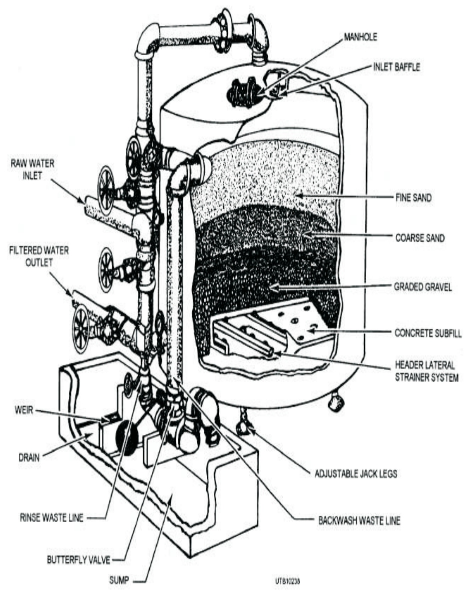
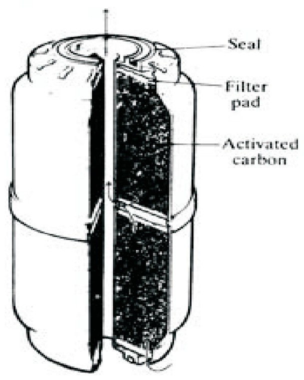


Fig : 7.1

➢ ACTIVATED CARBON FILTER



Activated carbon water filter.

Fig : 7.2

- Used for removal of chlorine and Micro-organisms through adsorption.
- Also effective in removal of color & odor.
- Activated granular carbon is used as a filter bed where free chlorine , color, odor etc are removed.

➢ DUAL MEDIA FILTER

- Combination of PSF and ACF with filtering media as sand and anthracite .
- These dual media filters have high dirt removal capacity.
- Sand media for removal of SS and carbon for the removal of odor , color.

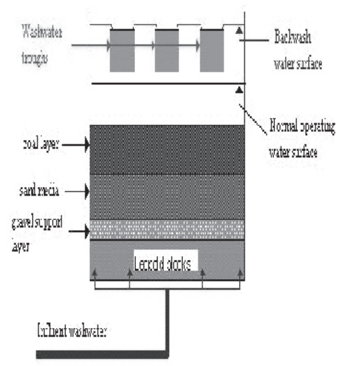


Fig : 7.3

➢ IRON REMOVAL FILTER

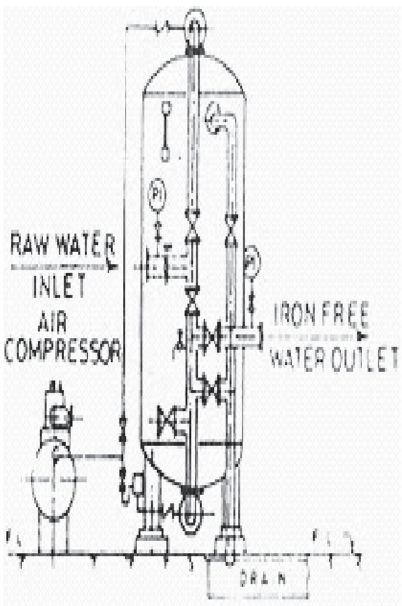


Fig : 7.4

- Removes iron along with other turbidity from the wastewater.
- Removal mechanism based on iron oxidation followed by sand filtration.
- Iron removal filter is processed catalytic filtration unit when the raw water passed through the layer of compressed air, processed catalyst & quartz filter media respectively.
- The dissolved ferrous iron salts are converted into insoluble ferric salt and precipitin over the filter bed and then the iron free filtered water comes out.

➢ SWIMMING POOL FILTRATION

- Swimming pool filtration is generally divided in 3 steps:
- Filtration: By use of sand filter, small sediments and debris are removed from water incoming through human contact or rain or air.
- Ozonization: acts as a powerful oxidant , to destroy algae , bacteria ,inactive viruses and other contaminants present in water.
- Chlorination: for disinfection purposes , which kills harmful micro-organisms that can be harmful to health.

➢ DISINFECTION-ELECTRO CHLORINATOR

- Low capacity system which produces sodium hypochlorite from salt water, by the process of electrolysis.
- Sodium hypochlorite acts as a strong disinfectant for drinking water and wastewater.

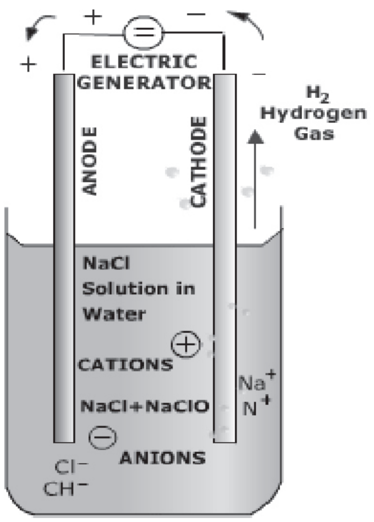


Fig : 7.5

➢ ELECTRO COAGULATION

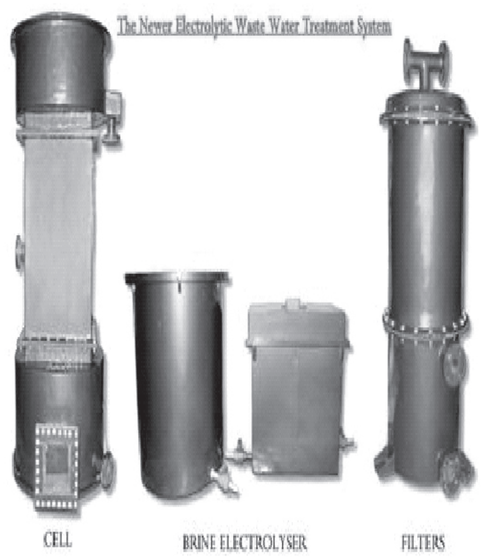


Fig : 7.6

- Treating the effluent by passing electricity- technique known as Electro dialysis.
- The current destabilizes dissolved colloidal particles and alters the charge on suspended particles permitting their coagulation, floatation and separation.
- Removes color , odor, SS, organic, oil and grease etc..

➢ ELECTRO COAGULATION

- ***<u>Special Features Of The Process:</u>***
- Chemical Free, Non Biological
- Modular In Construction
- Custom Designed
- Easily Expandable
- Designed For Continuous Operation
- Can Be Retrofitted In The Existing Facility
- Small Foot Print
- ***<u>Advantages:</u>***

  Treatment of-
- Raw Water
- Swimming Pool
- Sewage Waste Water
- Cooling Tower &
- Industrial Effluent

➢ COMPARISON OF ELECTROLYTIC PROCESS WITH CHEMICAL PROCESS

Electrolytic process

- Chemical Free
- Does not Increase TDS
- Eliminates Hazardous Elemental Chlorine
- Eliminates Procurement, Storage and Dosing of Chemicals
- Generates Low Volume of Sludge with Better Dewatering
- Compact Plant with Small Foot Print

Chemical process

- Chemicals Added
- Increases TDS
- Uses Hazardous Elemental Chlorine
- Chemicals are to be Procured, Stored, Prepared and Dosed
- Generates High Volume sludge
- Large Plant with Big Foot Print

➢ ULTRA FILTRATION

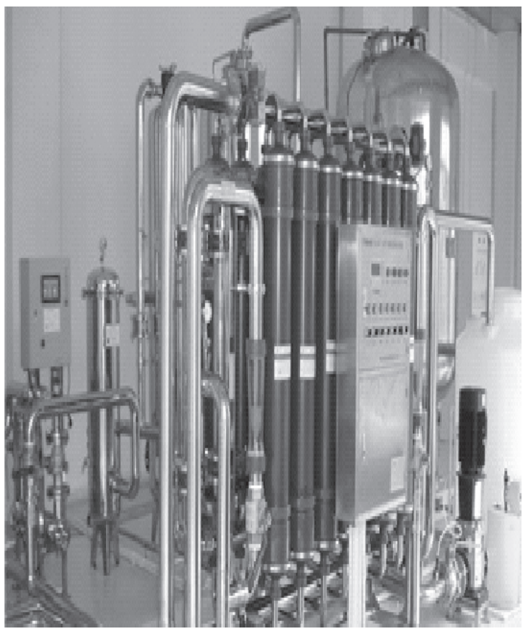


Fig : 7.7

- Ultrafiltration (UF) is a pressure-driven barrier to suspended solids, bacteria, viruses, endotoxins and other pathogens to produce water with very high purity and low silt density.
- Typically, Ultrafiltration will remove high molecular-weight substances, colloidal materials, silt (SDI), and organic and inorganic polymeric molecules.
- It serves as a pretreatment for surface water, seawater, and biologically treated municipal effluent before reverse osmosis and other membrane systems.
- Ultrafiltration is a separation process using membranes with pore sizes in the range of 0.1 to 0.001 micron.

➢ REVERSE OSMOSIS

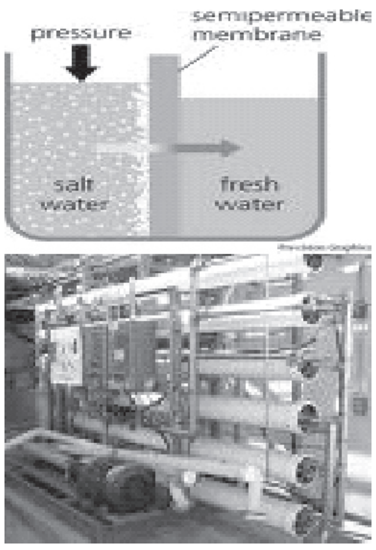


Fig : 7.8

- Reverse osmosis is also a process of separation. The feed water stream is separated into a stream of purified water and a stream of concentrated solutes and particulates. This is as compared to standard filtration where the entire feed stream passes through the membrane pores, leaving the particulates embedded in the filter media.
- Reverse Osmosis are field proven, highly reliable and cost effective answer to treat a wide range of brackish water and sea water. Designed with flexibility, the series utilize state-of-the-art spiral wound reverse osmosis membranes to suit a given application. These systems can remove 90 - 98% of total dissolved salts.

➢ WATER SOFTENING

- Hardness causing multevallent ions – Calcium and Magnesium lead to the formation of scale which in turn results into clogging of pipelines and fixtures, scaling of boiler tubes, cooling towers fins, solar heater coils or stains on fabric.
- Basic principle: Ion exchange , through a resin where the harness ions exchange with the sodium ions in resin and eventually produce soft water.
- Zeolite : a type of resin used for Ion Exchange purposes.

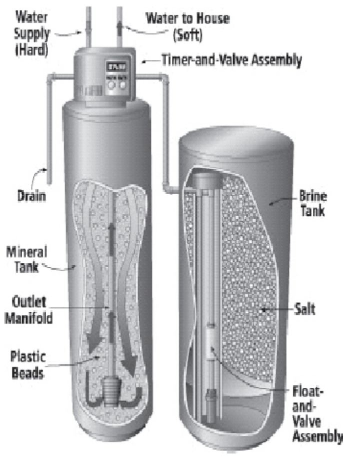


Fig : 7.9

Application :

- Boiler Feed
- Cooling Tower Make-up.
- Air Conditioning Plant.
- Textile Processing.
- Beverage Production.
- Filter High Quantity Of Water
- Thermoelectric Power Plants
- Low Pressure Boiler Feed
- Dairies
- Food And Beverages
- Hotels And Restaurants
- Laundries

DESIGN CRITERIA

- Raw effluent data for hardness
- Final treated effluent quality
- Regeneration period
- Output between two regeneration(OBR)

ADVANCE TREATMENT FOR OIL & GREASE REMOVAL

➢ DAF (DISSOLVED AIR FLOTATION)

- DAF system separates and removes suspended and colloidal solids , as well as fats, oils and grease from liquid
- It is designed to meet the needs of a wide variety of industrial markets including food processing , refining, metals, mining , pulp and paper, chemicals , tanning and others , the DAF system is also used in municipal applications as a sludge thickener
- The most common procedure is that of dissolved air flotation (DAF), in which the waste stream is first pressurized with air in a closed tank. After passing through a pressure-reduction valve, the wastewater enters the flotation tank where, due to the sudden reduction in pressure, minute air bubbles in the order of 50- 100 microns in diameter are formed.
- As the bubbles rise to the surface, the suspended solids and oil or grease particles adhere to them and are carried upwards.
- It is common practice to use chemicals to enhance flotation performance.
- One alternate design involves the recycling of part (10-30%) of the treated water.
- All systems contain a mechanism for removing the solids that may settle to the bottom of the flotation tanks, usually by a helical conveyor placed in the conical bottom.
- The main advantage claimed of DAF systems is the faster rate at which very small or light suspended solids can be removed in comparison with settling.
- Performance of DAF systems has been reported to be dependent on several factors:
  - the solids concentration
  - the ratio of air to solids (A/S)
- Key factors in the successful operation of DAF units are
  - the maintenance of proper pH
  - proper flow rates
  - the continuous presence of trained operators

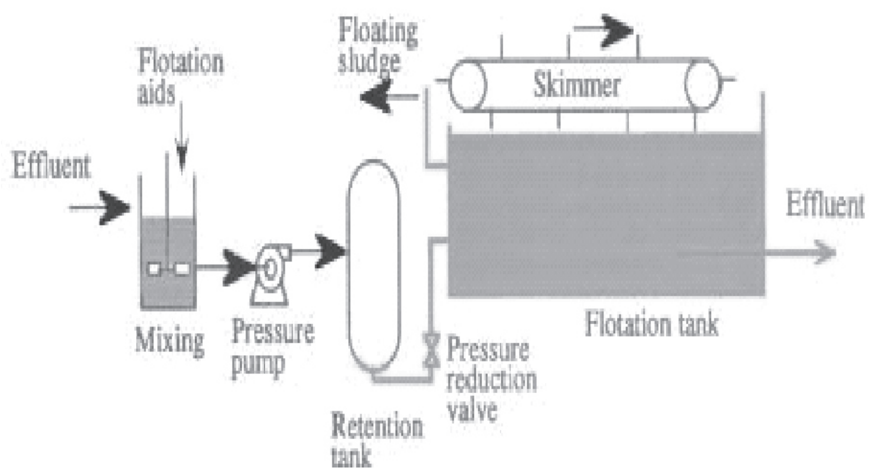


Fig : 7.10

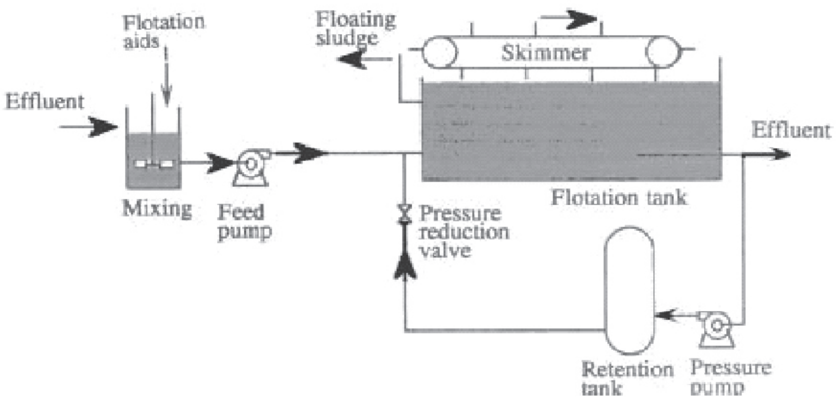


Fig : 7.11• Diagram of a DAF system with recycle

Fig : 7.12

The Davco Products Dissolved Air Flotation (DAF) system separates and removes suspended and colloidal solids, as well as fats, oils, and grease from liquid. Designed to meet the needs of a wide variety of industrial markets including food processing, refining, metals, mining, pulp and paper, chemicals, tanning, and others, the DAF system is also used in municipal applications as a sludge thickener.

Advantages of Circular Tanks Over Rectangular Tanks :

- Minimized maintenance due to fewer moving parts,no submerged bearings,sprockets or chains.
- Flexible nozzle orientation.
- Lower installed costs.
- More complete separation due to varying velocity through the tank.

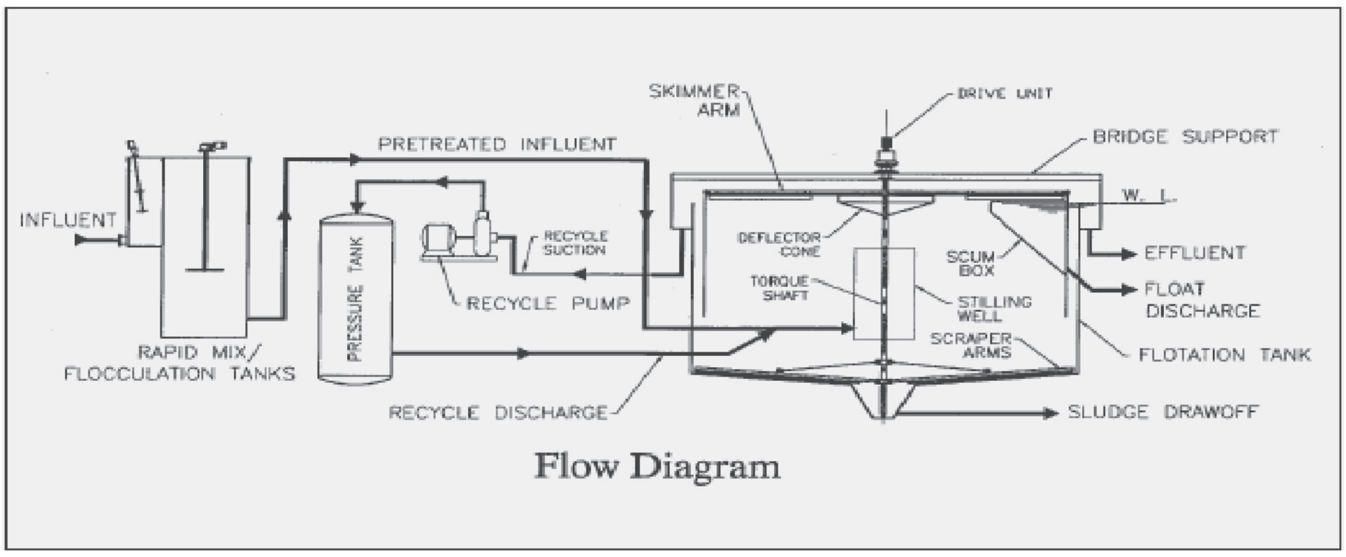


Fig : 7.13

CHAPTER-8

AEROBIC & ANAEROBIC DIGESTION

AEROBIC AND ANEROBIC DIGESTION

Fig. : 8.1

Types of Digestion :

- Aerobic digestion
  - Use “Free” Oxygen
- Anaerobic digestion
  - No “Free” Oxygen

➢ AEROBIC DIGESTION

- Advantages
  - Effective for “secondary”
  - Simple operation
  - No hazardous gas production
- Disadvantages
  - Higher operating costs
  - High energy demands
  - No burnable gas
  - Higher organic content

ANAEROBIC DIGESTION PROCESS

"TWO-STAGE" Process
OR
"Two Phase" Process
Two Types of Bacteria
Each Relying On The Other

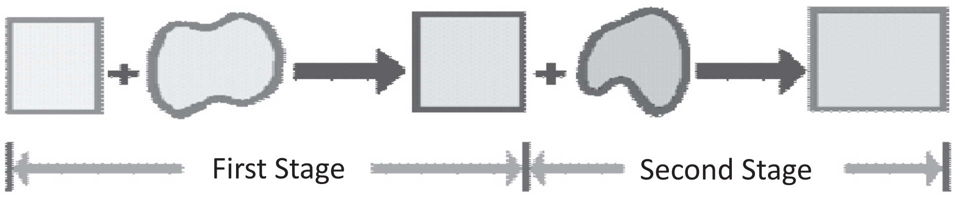


Fig.: 8.2

- Organic Material Changed
- By Acid Forming Bacteria
- To Simple Organic Material

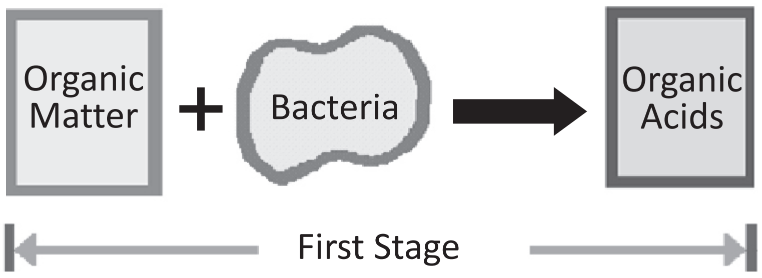


Fig.: 8.3

- Methane-Forming Bacteria
- Use Organic Acids
- Produce Carbon Dioxide and Methane

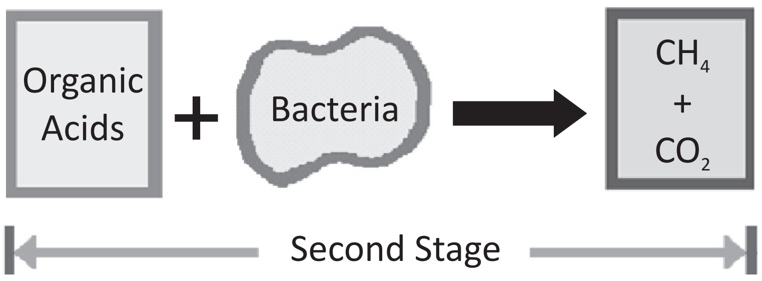


Fig.: 8.4

ANAEROBIC DIGESTION

- Anaerobic digestion is a collection of processes by which microorganisms break down iodegradable material in the absence of oxygen. The process is used for industrial or domestic purposes to manage waste and/or to produce fuels.
- Much of the fermentation used industrially to produce food and drink products, as well as home fermentation, uses anaerobic digestion.
- Anaerobic digestion occurs naturally in some soils and in lake and oceanic basin sediments, where it is usually referred to as "anaerobic activity"
- The digestion process begins with bacterial hydrolysis of the input materials. Insoluble organic polymers, such as carbohydrates, are broken down in to soluble derivatives that become available for other bacteria.
- Acidogenic bacteria then convert the sugars and amino acids into carbon dioxide, hydrogen, ammonia, andorganic acids. These bacteria convert these resulting organic acids into acetic acid, along with additional ammonia, hydrogen, and carbon dioxide.
- Finally,methanogens convert these products in to methane and carbon dioxide.
- The methanogenic archaea populations play an indispensable role in anaerobic wastewater treatments.
- It is used as part of the process to treat biodegradable waste and sewage sludge.
- As part of an integrated waste management system, anaerobic digestion reduces the emission of landfill gas into the atmosphere.
- Anaerobic digesters can also be fed with purpose-grown energy crops, such as maize.
- Anaerobic digestion is widely used as a source of renewable energy. The process produces biogas, consisting of methane, carbondioxide and traces of other 'contaminant' gases.This biogas can be used directly as fuel, in gas engines or upgraded to natural gas-quality biomethane.

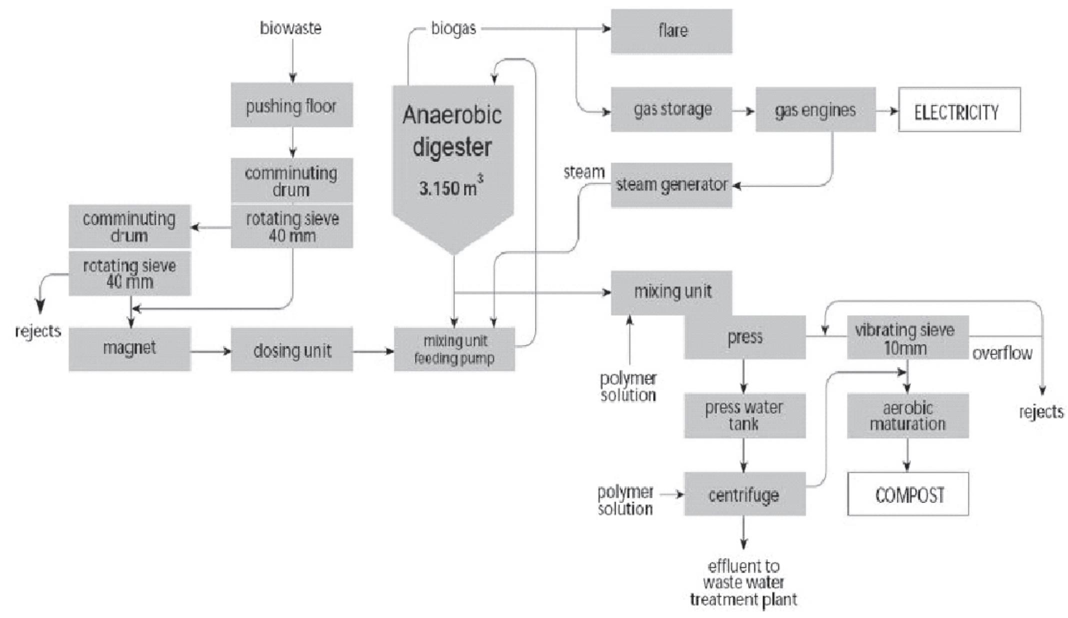


Fig.: 8.5

PROCESS DESCRIPTION

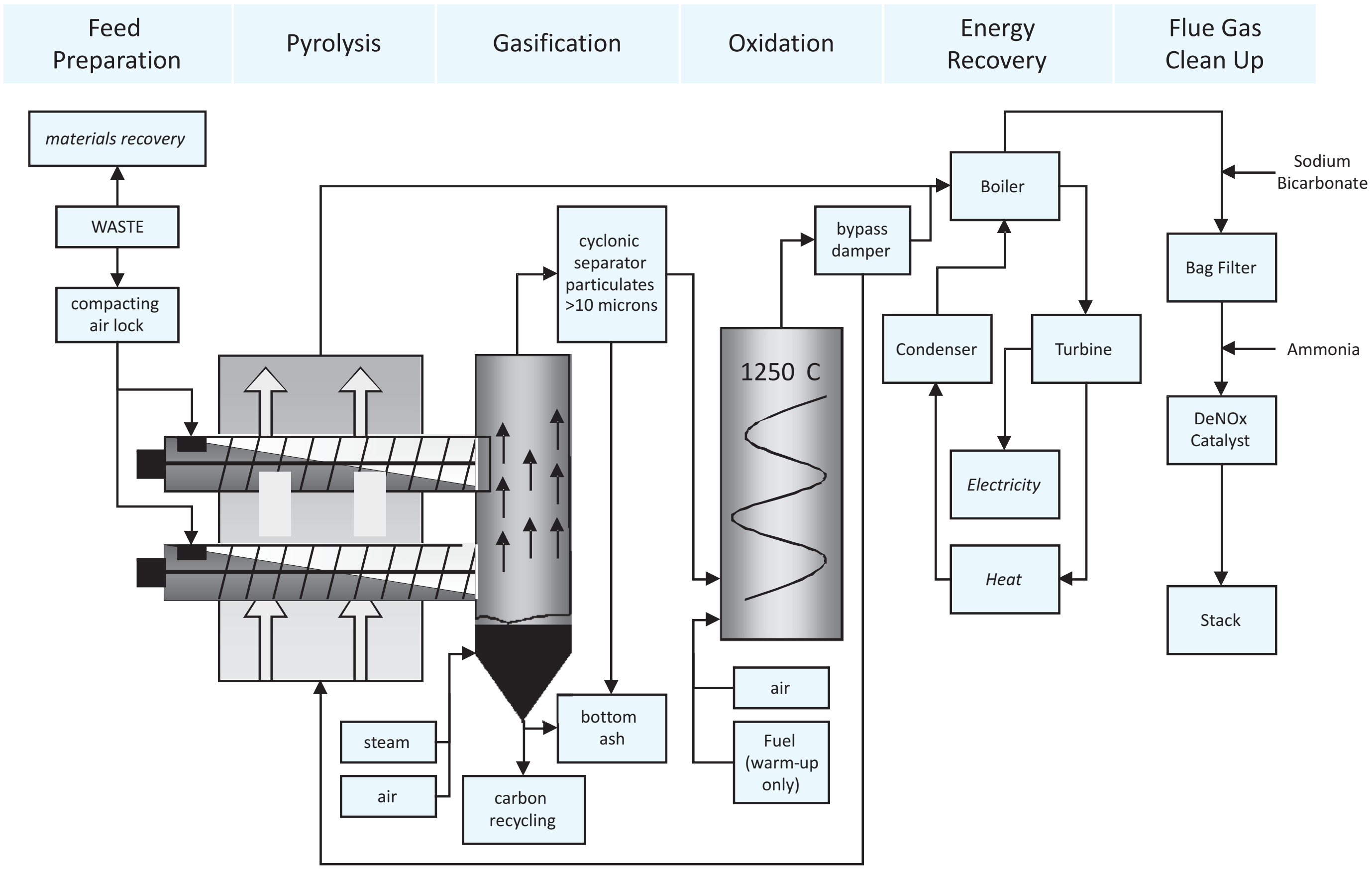


Fig.: 8.6

Fig.: 8.7 Anaerobic Digester

Anaerobic Digestion Process :

Products of Digestion

1. Gases
   - Methane (CH_4)
   - Carbon Dioxide (CO_2)

2. Scum
   - Lighter Solids

3. Supernatant
   - Liquid Removed

4. Digested Sludge
   - "Stabilized"

Anaerobic Digestion :

Advantages

- Low operating costs
- Proven effectiveness
- Burnable gas produced

Disadvantages

- Long start-up time
- Affected by changes in loading and conditions
- Explosive gas produced

Digestion Factors :

1 Bacteria
2. Food
3. Loading
4. Contact
5. Environment

Operation And Control:

1. Bacteria

- Maintain Adequate Quantity
  - Don’t Remove Too Much
  - Don’t Displace Too Much
  - Plan For Re-Start

2. Food

- Minimize Amount of Inorganics Entering
  - Industrial Discharges Grit Systems
  - Eliminate Toxic Material

3. Loading

- Amount
  - Applied to the Treatment Process
  - Related to the SIZE of the System
- Pump Thick Sludge
  (High % Total Solids)
  - Excess Water Requires More Heat
  - Excess Water Reduces Holding Time
  - Excess Water Removes Bacteria and Buffers
- Pump Several Times per Day
  - Uniform Digester Loading
  - Uniform Plant Operations

4 Contact (Mixing)

- Contact
  - Bacteria and Food
- Heat Distribution
  - Even Throughout
- Minimize Settling
  - Reduces Available Volume
- Minimize Scum
  - Operational Problems

5 Environment

- Temperature Control
  - 90 to 95°F
  - Methane Formers Very Sensitive to Changes
  - Good Mixing Essential

Digestion Factors

Environment

- Anaerobic
  - No Oxygen
- Temperture
  - Mesophilic-Constant
- pH
  - Best - 6.8 to 7.2
- Volatile Acids
  Not Excessive
- Buffers (alkalinity)
  - Incoming Sludge and Created
- Toxic Materials
  - Inhibit Biological Activity

CHAPTER-9

BIOLOGICAL NUTRIENT REMOVAL

BIOLOGICAL NUTRIENT REMOVAL

- Biological nutrient removal (BNR) removes total nitrogen (TN) and total phosphorus (TP) from wastewater through the use of microorganisms under different environmental conditions in the treatment process
- Nitrogen and phosphorus are the primary causes of cultural eutrophication (i.e., nutrient enrichment due to human activities) in surface waters.
- Uptake into biological cell mass

♦ **Nitrogen Removal Is Done In Two Stages:**

  - Nitrification (conversion to Nitrate)
  - Denitrification (conversion to N_2 gas)
  - NitrifictionConversion of Ammonia to Nitrite (Nitrosomonas)

  $NH_4^+ + 2\ O_2$ ➤ $NO_2^- + 2\ H^+ + H_2O$

➤ BIOLOGICAL NITRIFICATION

Conversion of Nitrite to Nitrate (Nitrobacter)

$NO_2^- + 0.5\ O_2$ ➤ $NO_3^{-\backslash}$

- For each mg of NH_4^+ converted...
- 3.96 mg of O_2 are utilized (Need Oxygen)
- 0.31 mg of new cells are formed
- 7.01 mg of alkalinity are removed
- Nitrifying bacteria are sensitive and susceptible to a variety of conditions.

♦ The following factors affect nitrification:

  - Conc of NH_4^+ and NO_2^-
  - BOD/TKN ratio (BOD should be gone/removed)
  - Dissolved oxygen concentration (need oxygen)
  - Temperature
  - pH (7.5 to 8.6)

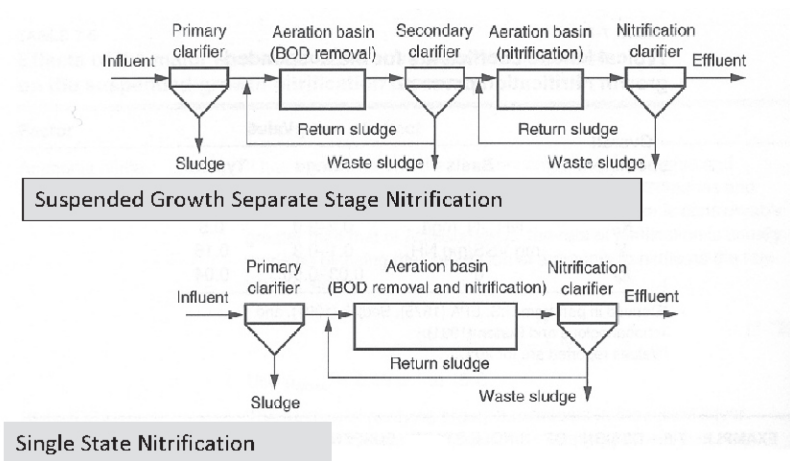
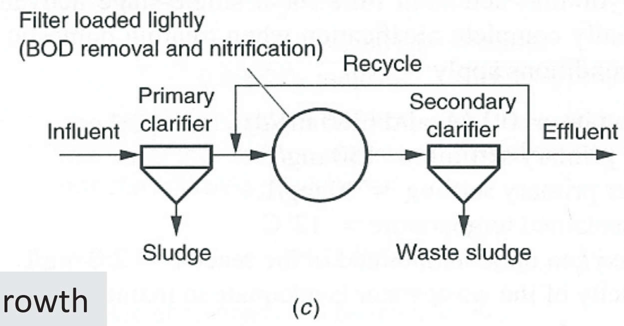
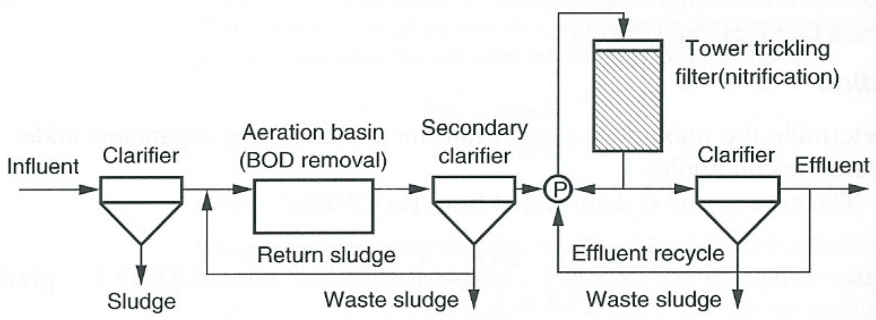


Fig. : 9.1 Nitrification Processes



Attached Growth



Attached Growth Nitrification following Act. Sludge

Fig. : 9.2 Nitrification Processes

➢ BIOLOGICAL DENITRIFICATION

- Need low (no) oxygen (< 1 mg/l)
- Need carbon source (BOD in Wastewater)
- Neutral pH (pH 7)
- Conc of nitrate
- Separate denitrification reactor

  or
- Combined Carbon Oxidation-nitrification-denitrification reactor
- A series of alternating aerobic and anoxic stages
- Reduces the amount of air needed
- No need for supplemental carbon source
- A modification of aerobic pathways (no oxygen)
- Same bacteria that consume carbon material aerobically
- Denitrifying bacteria obtain energy from the conversion of NO_3^- to N_2 gas, but require a carbon source

$$NO_3^- + CH_3OH + H_2CO_3 \rightarrow C_5H_7O_2N + N_2 + H_2O + HCO_3^-$$

COMBINED NITRIFICATION/DENITRIFICATION

(note alternating regions of aerobic and anoxic)

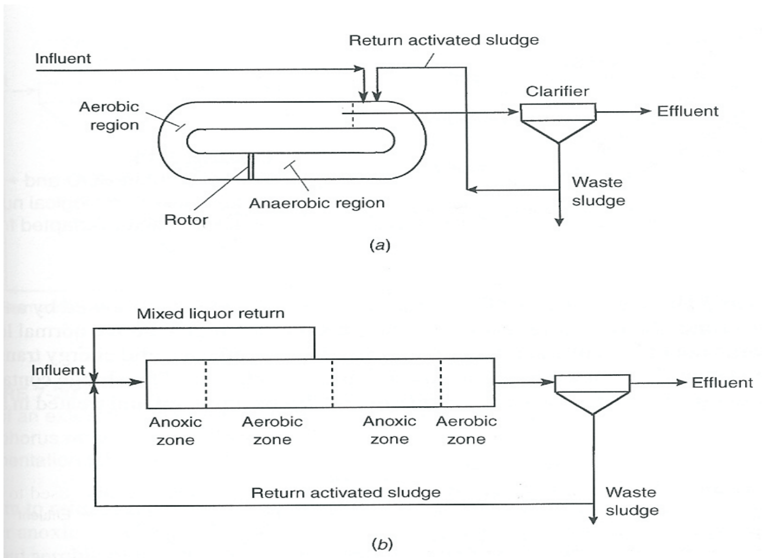


Fig. : 9.3
Combined single-stage nitrification-denitrification systems: (*a*) oxidation ditch and (*b*) four-stage plug-flow Bardenpho.

PHOSPHORUS REMOVAL

- Total effluent phosphorus comprises soluble and particulate phosphorus. Particulate phosphorus can be removed from wastewater through following methods:-
- Chemical Precipitation
- Calcium (lime) addition at high pH (>10)
- Reacts with alkalinity
- Alum (Aluminum Sulfate) precipitation
- Iron precipitation

CHAPTER-10

PUBLIC HEALTH & HYGIENE

GENERAL HYGIENE

- **Health** is defined in the WHO constitution of 1948 as: a state of complete physical, social and mental well-being, and not merely the absence of disease or infirmity.
- **Hygiene** is the science of preventing and protecting the health of people through control of the environment.
- **Environment** is our surroundings described as physical surroundings (air, water and land), biological surroundings (animals and plants), and social surroundings.

CONVENTIONAL SANITATION

- Due to disease risks caused by faecal wastewater, in large European cities sewers were constructed to drain the wastewater away from the people's surroundings to the nearby water courses, and ultimately into the sea. Later it was found that discharging raw wastewater had deteriorated aquatic environment of the receiving water body, and at the same time it caused diseases to the people, who received their drinking water from the same river downstream. Because of drinking water contamination, epidemics of cholera had periodically caused heavy losses of life in large European cities.
- The outbreak of cholera in 1892 for instance, took place all over in Hamburg, where drinking water supply was extracted from the river Elbe. To protect these rivers from the pollution as well as the public health from water borne diseases, the wastewater was since then treated at the end of the sewer before discharging it into the river. This tradition has been widely established as a standard way of managing wastewater world wide.
- However, most of the wastewater is discharged without any treatment mostly in developing countries.
- Centralised wastewater management systems have been built and operated for more than hundred years. In the mean time, because of advanced technological development, the wastewater management has reached a high standard in many industrialised countries.
- However, in developing countries the present situation is still similar to that of the currently industrialised countries in the 19th century in many respects.
- About 95 % of wastewater in developing countries is still discharged without any treatment into the aquatic environment . This contributes largely about 1.2 billion people without access to clean drinking water. Almost 80 % of diseases throughout the world are water-related. Water-borne diseases account for more than 4 million infant and child deaths per year in developing countries.

- The following factors are lethal to most of the pathogens:
  - high pH (> 9)
  - Low moisture contain (< 25%)
  - High temperature (> 55 OC) over more than 10 hours
  - Long retention time (> 6 months)
  - Ammonia and high salt content
  - Limited nutrients (competition for food)
  - predator-prey relationships
  - antagonism
  - High pH can be obtained by adding alkaline material such as ash or lime (but lime is not preferable) that reduces the moisture additionally. Moisture can be lowered by drying.
  - High ammonia and salt can be obtained from urine.

SUSTAINABLE SANITATION

If the ecological sanitation can fulfil furthermore as well as social and ecological requirements, it is called "sustainable sanitation". Such a sanitation is also form the hygienic point of view desirable, due to the fact, that it includes also other aspects, which save health in order to a risk management. Some further aspects of sustainable sanitation are (see figure):

- Closing and separating the cycles of water and nutrients; avoidance of hygienic problems due to the separation of faeces from the water cycle
- Reclamation of nutrients (phosphorus and nitrogen) for agricultural use and hence saving of resources and energy (for the production of artificial fertilizer)
- Considerable savings of freshwater through the use of water saving toiletsystems (vacuum, separating or dry toilets)
- Energy production (biogas) instead of energy consumption (for carbon degradation in sewage plants)
- Savings of construction, operation and maintenance costs compared to the conventional central sewerage systems
- Sophisticated modular system, which can be adapted perfectly to local social, economical and environmental conditions
- Easier operation and maintenance compared to centralized technology; local job creation

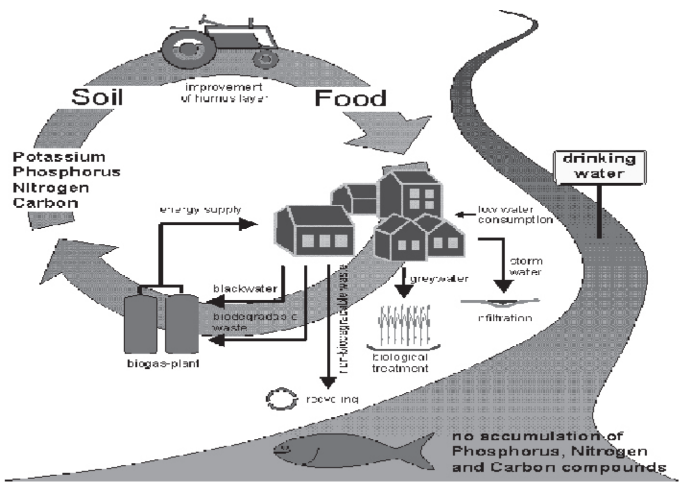


Fig. : 10.1 Sustainable Sanitation System

CHAPTER-11

OPERATION & MAINTENANCE OF STP

OPERATION & MAINTENANCE PROBLEMS IN VARIOUS EQUIPMENT OF STP

O & M Considerations For Bar Screen :

- Check and clean the bar screen at frequent intervals
- Do no allow solids to overflow/escape from the screen
- Ensure no large gaps are formed due to corrosion of the screen
- Replace corroded/unserviceable bar screen immediately

Troubleshooting

Problem	Cause
Large articles pass Through, and chock the pumps	Poor design / poor operation / screen damaged
Upstream water level is much higher than downstream level	Poor operation (inadequate cleaning)
Excessive collection of trash on screen	Poor operation
Excessive odor	Poor operation / trash disposal practices

Table : 11.1

O&M Considerations Of Oil And Grease/ Grit Trap :

- Check and clean trap at frequent intervals
- Remove both settled solids (at bottom) and the floating grease
- Do not allow solids to get washed out of the trap
- Do not allow oil and grease to escape the trap
- Redesign the trap if solids and grease escape on a regular basis, despite good cleaning practices

Troubleshooting

Problem	Cause
Oil and grease pass through the trap	Poor design/ poor operation
An excessive amount of solids passes through the trap	Poor design/ poor operation
Excessive odor	Poor operation/ waste disposal practices

Table : 11.2

O&M Considerations of Equalization Tank

- Keep air mixing on at all time
- Ensure that the air flow/ mixing is uniform over the entire floor of the tank. adjust the placement of diffusers and the air-flow rate as needed.
- Keep the equalization tank nearly empty before the expected peak load hours (otherwise it will overflow)
- Check and clean clogged diffusers at regular intervals
- Manually evacuate settled muck/ sediments at least once in a year

Troubleshooting

Problem	Cause
Insufficient mixing/ aeration	Poor design, engineering
Excessive odor	Poor design, engineering
Insufficient capacity to handle peak flows	Poor design
Usable capacity reduced due to solids accumulation	Poor maintenance

Table : 11.3

O&M Consideration Of Raw Sewage Lift Pumps :

- Switch between the main and standby pump every 4 hours (approximately).
- Switch between the main and standby pump every 4 hours (approximately).
- Check oil in the pump every day; top up if necessary
- Check motor-to-pump alignment after every dismantling operation
- Check condition of coupling and replace damaged parts immediately
- Check for vibrations and tighten the anchor bolts and other fasteners
- Check condition of bearings, oil seals, mechanical seal and replace if necessary
- Completely drain out oil and replace afresh as per manufacturer’s recommendation
- Always keep safety guard in its proper position
- Follow the LOTO safety principles while performing maintenance activities
- Ensure discharge of raw sewage into the aeration tank is visible and can be monitored
- Maintain the flow rate at designed level (no tampering with the bypass valve)

Troubleshooting Of Sewage Lifting Pumps :

Problem	Cause
Excessive noise	Poor engineering / maintenance
Excessive vibration	Poor engineering / maintenance
Overheating	Poor maintenance
Loss in efficiency of puming	Poor maintenance

Table : 11.4

O&M Considerations Of Sedimentation Tank :

If Properly Designed, Engineered And Constructed, Clarifiers Call For Very Little Attention In Terms Of Operation And Maintenance. Indeed, The Unmechanized (hopper-bottom) Settling Tanks May Be Said To Be Zero- Maintenance Units. Some Parts Of The Mechanical Rake (such As The Motor, Gearbox Etc.) Call For Only Routine Maintenance. The Sacrificial Rubber Squeegees Sweeping The Floor Of The Clarifier Need To Be Checked And Replaced, Possibly Once In Two Years.

Troubleshooting

SIGN & SYMPTOMS	POSSIBLE CAUSES	SUGGESTED ACTIONS
Floating sludge in all tanks	Accumated sludge decomposing in the tank and buoyed to the surface	Removed sludge more completely and more often
Floating sludge not in all tank	Affected tank receiving to much sewage	Reduce a flow to affected tank
Bubbles rising in tank	Septic conditions	Report and empty tank completely as soon as possible
Contains black and odorous material	Septic sewage or strong digester supernatant	Take action to eliminate septicity or improve digester operation to improve quality of supernatant
Excessive settling in inlet channels	Velocity to low	Reduce cross sectional area by installing inner wall or agitated with air or water to prevent deposition
Excessive suspended matter in effluent over tanks	Accumulated sludge flow through tank to fast or humus sludge returned to fast	Clean tanks more often or reduce pumping rates
Sludge pipes choke	Sludge to thick or sludge contains grit	Clean grit chamber more often. Change sludge piping necessary
Sludge hard to remove from hopper	High contain of grit or clay. Low velocity in withdrawal lines	Reduce grit contents.

Table : 11.5

Troubleshooting Of Aeration Tank :

- **Operation And Maintenance Considerations**
- Operation considerations include maintaining the correct design level of MLSS (biomass concentration) in the aeration tank. Problems arise both in the case of excess or shortage of biomass, causing an imbalance, leading to failure of the process. The next chapter shows how to maintain the correct design level of MLSS in the aeration tank.
- Visual observation will indicate if there is uniform aeration and mixing over the entire area of the tank. Local violent boiling/ bubbling is indicative of ruptured membranes. Dead zones on the sewage surface indicate that membranes are blocked from the air side or the liquid side. Both conditions call for immediate attention, by cleaning or replacing the membranes.
- Cleaning of membranes is generally carried out by lifting out the defective units and scouring out the adhering materials by high-pressure hosing. Scrubbing with mild acid solution may also be resorted to in case of stubborn encrustation.
- Foaming in the aeration tank may be caused by excessive inflow of detergent-like substances: In a great majority of cases, the cause may be traced to an imbalance in the aeration tank recipe (Food: Microorganisms: Air: Nutrients), and corrective measures may be taken as indicated.

CHAPTER-12

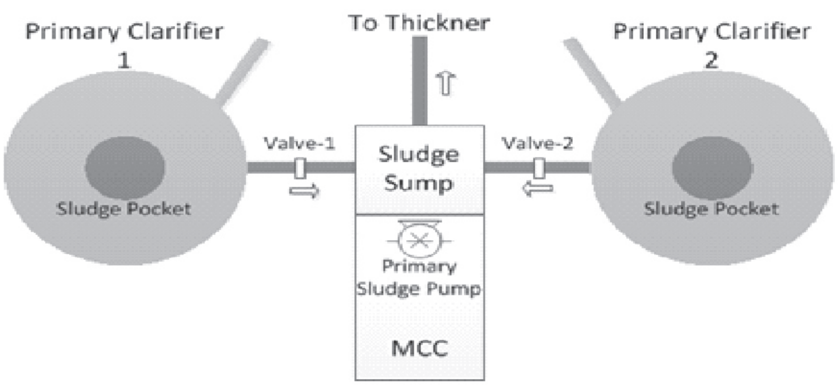
STANDARD OPERATING PROCEDURE OF STP

STANDARD OPERATING PROCEDURE OF STP :

- The objective is to develop a strong operating procedure, which in turn useful in reducing maintenance expenses and getting optimum performance.
- Following are the main pumps and blowers, which are needed to be operated carefully.

1) PRIMARY SLUDGE PUMP (PSP):

- Scrapper mechanism of the Primary Clarifier runs continuously and settled sludge is collected into sludge pocket located in the center. From sludge pocket sludge is taken to the thickener for further process.
- Quantity: Total 6 PSP, two in each stream one working and one stand-by



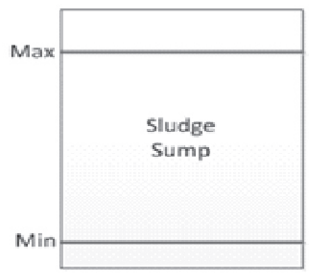


Fig.: 12.1

1. Check and OPEN Valve-1 of Primary Clarifier-1
   - Duration: 1 hour or until all sludge drained into sludge sump, whichever is lesser
   - Time: Morning 9:00 AM
   - Caution: Fill the sump up to the Max level mark, CLOSE valve afterwards
2. After an hour CLOSE Valve-1, check and OPEN pump valves (valves connected to pump)
3. START PSP by pressing GREEN push button given besides pump
   - Duration: 1-1.5 hours or until all sludge drained into Thickener
   - Time: Morning 10:00 AM
   - Caution: Monitor sludge sump level and STOP pump when level drops to min mark
4. STOP PSP by pressing RED push button given besides pump
5. Check and OPEN Valve-2 of Primary Clarifier-2
   - Duration: 1 hour or until all sludge drained into sludge sump, whichever is lesser
   - Time: Afternoon 2:00 PM
   - Caution: Fill the sump up to the max level mark, after that shut the valve
6. After an hour CLOSE Valve-2, check and OPEN pump valves (Valves connected to pump)
7. Check sludge sump level and START PSP
   - Duration: 1-1.5 hours or until all sludge drained into Thickener
   - Time: Afternoon 3:00 PM
   - Caution: Monitor sludge sump level and STOP pump when level drops to min mark
8. STOP PSP by pressing RED push button given besides pump

2) AIR BLOWERS:

In the process of bio-degradation of organic matter, micro-organism consumes dissolve oxygen. In the aerobic process, it is required to provide oxygen to these micro-organisms and this is done using air blowers.

Quantity: Total 18 air blowers, 6 for each stream. To maintain sufficient oxygen level it requires 3 air blowers for each tank. Air blower runs in 4 shifts each of 6 hours.

- Shift-1: 6:00 AM morning to 12:00 PM afternoon
- Shift-2: 12:00 PM afternoon to 6:00 PM evening
- Shift-3: 6:00 PM evening to 12:00 PM night.
- Shift-4: 12:00 PM night to 6:00 AM morning
- Combination of 3-3 air blowers runs in one after another pattern.

1. Check and CLOSE air valve-1
2. Check and OPEN valve V-1, V-2 and V-3
3. START air blower B-1, B-2 and B-3 by pressing GREEN push button given besides each of it
    - Duration: 6 hours
    - Time: 6:00 AM morning (Shift 1)
    - Caution: Check the valve status properly, and must follow above procedure in given order
4. Check and CLOSE Air valve-1
5. STOP Air blower B-1, B-2 and B-3 by pressing RED push button given besides each of it.

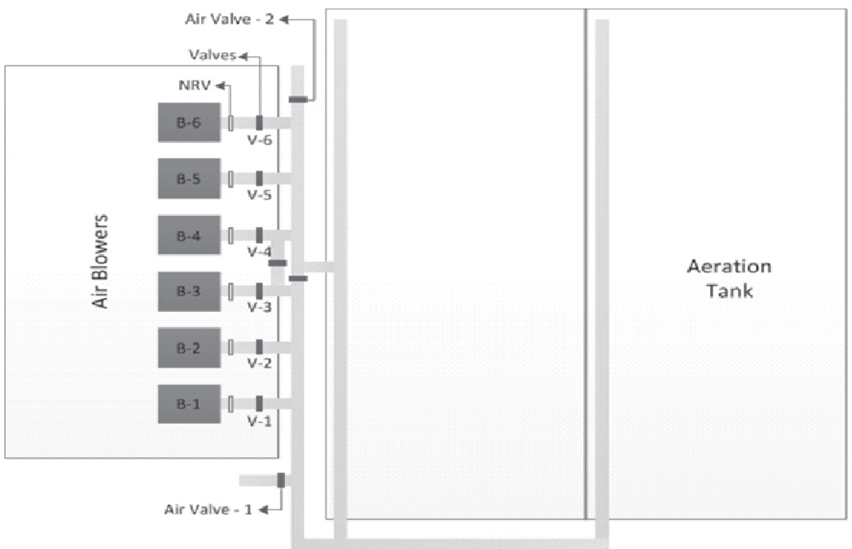


Fig. : 12.2

6. Check and CLOSE valve V-1, V-2 and V-3
    - Time: 12:00 PM afternoon
    - Caution: Check the valve status properly and must follow above procedure in given order
7. Repeat same procedure in next shift for air valve-2, valve V-4, V-5, V-6 and air Blower B-4, B-5, B-6 respectively
8. Follow same procedure for all shifts

3) RETURN SLUDGE PUMP (RSP):

To maintain MLSS (Mixer Liquor Suspended Solids) level above 4000mg/l in the Aeration tank we need to recirculate sludge from secondary clarifier. MLSS calculation is done in our laboratory on daily basis and lab in-charge commands for RSP according to results.

Quantity: Total 6 RSP, each stream is provided with two RSP one working and one stand by.

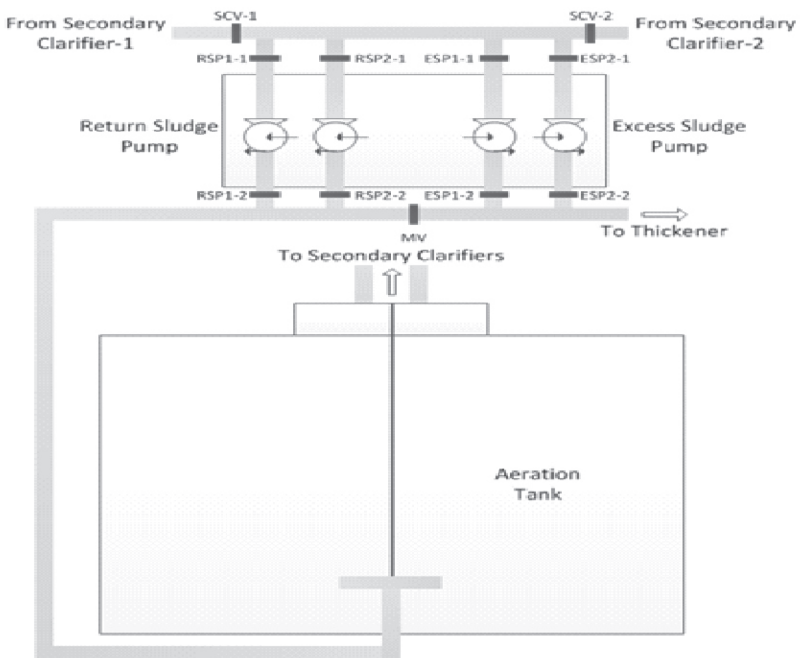


Fig. : 12.3

1. Check and OPEN SCV-1 and SCV-2 valve (Secondary Clarifier Valves)
2. Check and CLOSE ESP1-1 and ESP2-1 valve (Excess Sludge Pump Valves)
3. Check and OPEN RSP1-1 & RSP1-2 or RSP2-1 & RSP2-2 valve(Return Sludge Pump Valves)
4. Check and close MV (Middle Valve)
5. START RSP by pressing GREEN push button given besides pump
    - Duration: Each pump can run continuously for 8 hours, use stand-by pump afterwards
    - Time: Depends on MLSS counts, decided by lab in-charge
    - Caution: Check the valve status properly, and must follow above procedure
6. STOP RSP by pressing RED push button given besides pump

4) EXCESS SLUDGE PUMP (ESP):

- Same as in Primary clarifiers, sludge in secondary clarifiers is collected into sludge pocket located in the center.
- This sludge is taken to Thickener for further process.
- Quantity: Total 6 ESP, each stream is provided with two ESP one working and one stand by.

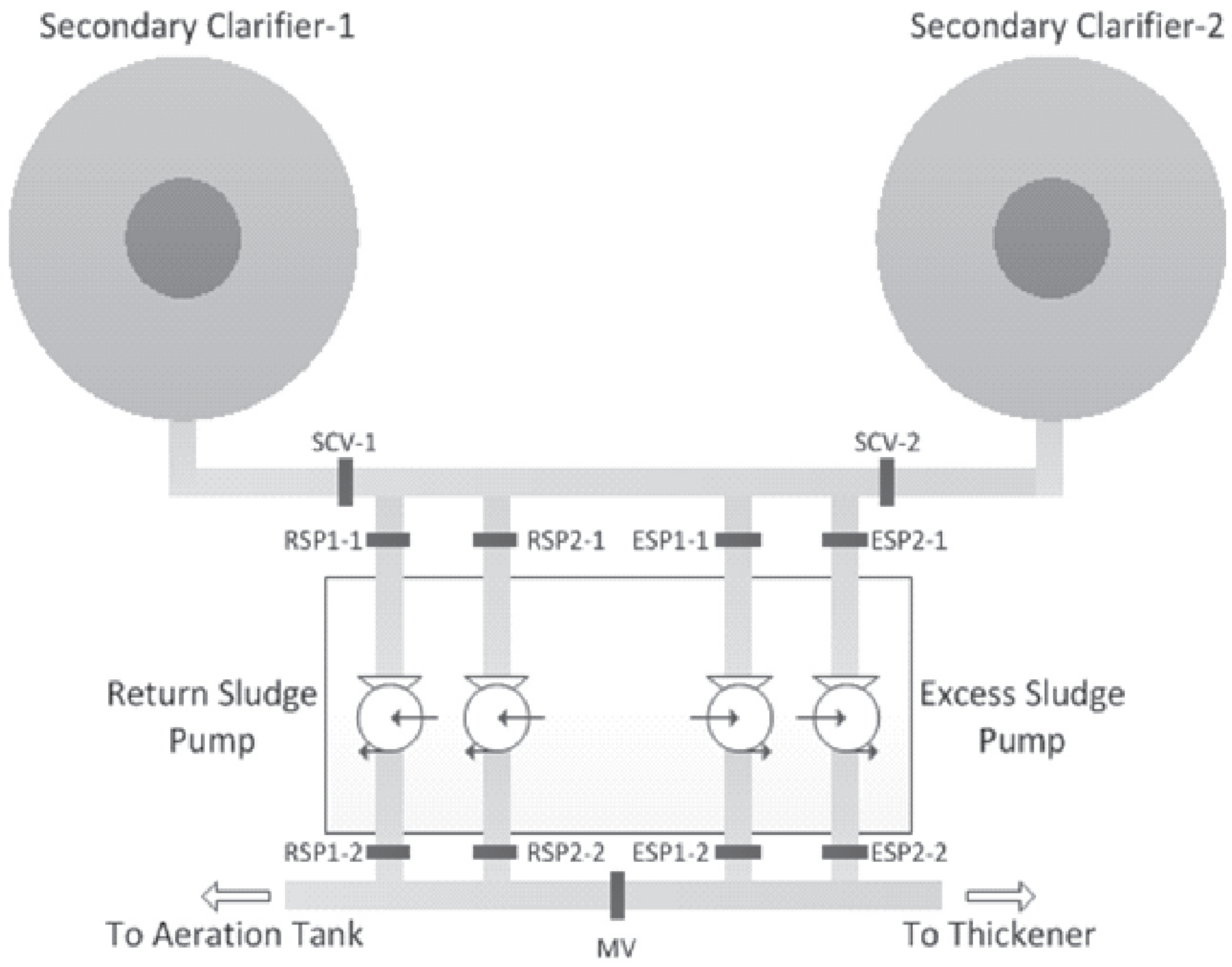


Fig. : 12.4

1. Check and OPEN SCV-1 and SCV-2 valve (Secondary Clarifier Valves)
2. Check and CLOSE RSP1-1 and RSP2-1 valve (Return Sludge Pump Valves)
3. Check and OPEN ESP1-1 & ESP1-2 or ESP2-1 & ESP2-2 valve(Excess Sludge Pump Valves)
4. Check and close MV valve (Middle Valve)
5. START ESP by pressing GREEN push button given besides pump

- Duration: Each pump can run continuously for 8 hours, use stand by pump afterwards
- Time: Depends on MLSS counts, decided by lab in-charge
- Caution: Check the valve status properly, and must follow above procedure

6. STOP ESP by pressing RED push button given besides pump

5) THICKENER SLUDGE PUMP (TSP):

From Thickener, sludge is taken into digester for Gas generation.
Quantity: Total 6 TSP, two TSP for each stream one working and one stand-by.

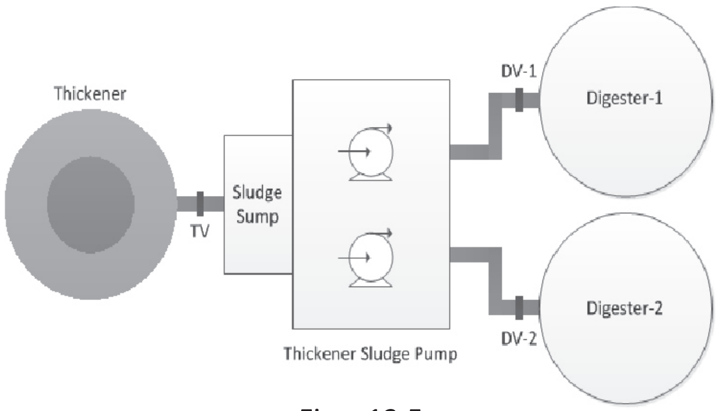


Fig. : 12.5

1. Check and OPEN TV (Thickener Valve)
2. Check and OPEN DV-1 and DV-2 (Digester Valves)
3. Check and OPEN pump valves (Valves connected to pump)
4. START TSP by pressing GREEN push button given besides pump
    - Duration: 7 hours
    - Time: 9:00 AM morning to 4:00 PM evening
    - Caution: Check the valve status properly, and must follow above procedure

5. STOP TSP by pressing RED push button given besides pump

6) DILUTION WATER PUMP (DWP):

To maintain thickness of the sludge, sometime water is added in the thickener. This dilution water is taken from secondary clarifier.
Quantity: Total 6 DWP, two DWP for each stream.

1. Check and OPEN DWPV-1 (Dilution Water Pump valve)
2. Check and OPEN DWPV-2 and DWPV-3

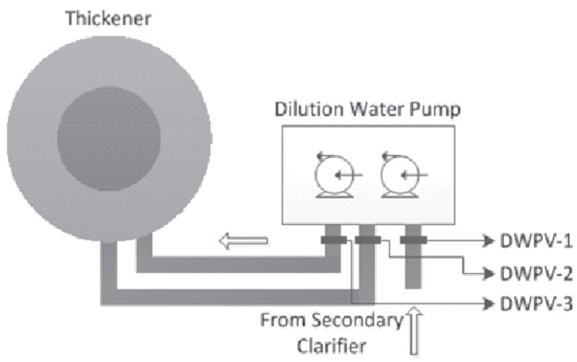


Fig. : 12.6

3. Monitor water level in the sump
4. START DWP by pressing GREEN push button given besides pump
    - Duration & Time: As per sludge thickness
    - Caution: Check the valve status properly and must follow above procedure

5. STOP DWP by pressing RED push button given besides pump

7) DIGESTER SLUDGE MIXING PUMP (DSMP):

It is necessary to recirculate sludge for optimum gas generation. For this digester is provided with sludge mixing pumps. These pumps are also used to drain sludge towards Belt Filter Press sludge sump.
Quantity: Total 9 DSMP, three pumps in each stream, two working and one stand-by.

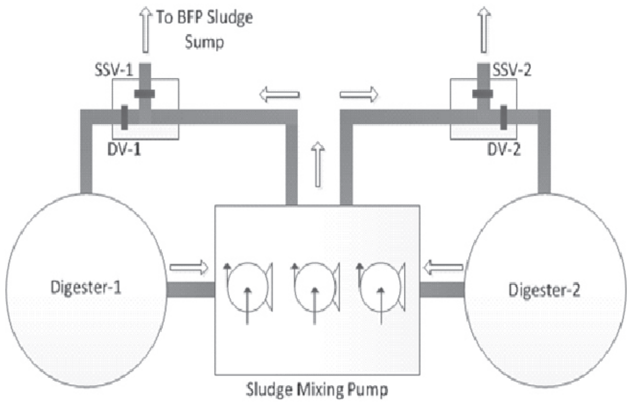


Fig. : 12.7

1. Check and OPEN DV-1 and DV-2 valves (Digester Valve)
2. Check and OPEN pump valves (Valves connected to pump)
3. START DSMP by pressing GREEN push button given besides pump
   - Duration: 9 hours in day
   - Time: Morning 6:00 AM to 12:00 PM, Evening 2:00 PM to 5:00 PM
   - Caution: Check the valve status properly, and must follow above procedure

4. STOP DSMP by pressing RED push button given besides pump

8) GAS BLOWER :

Theses blowers will suck and pump the gas generated in digesters. Gas is collected in gas dome and then safely flared into atmosphere.
Quantity: Total 6 gas blowers, two gas blowers in each stream, one working and one stand-by.

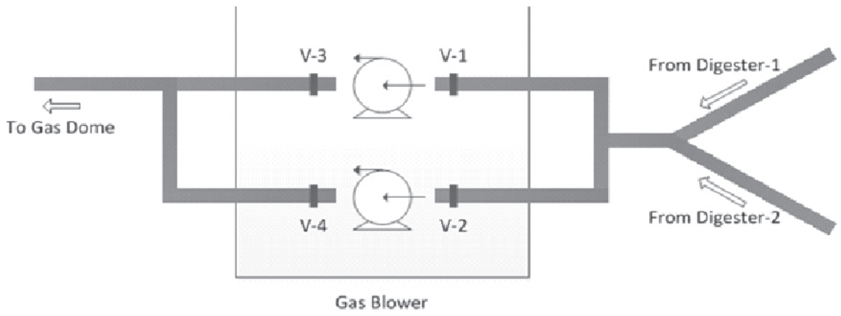


Fig. : 12.8

1. Check and OPEN blower valve V-1 and V-3 and/or V-4 and V-2
2. In case of single blower, close blower valves of other one
3. START blower by pressing GREEN push button given besides blower
   - Duration: 9 hours in day
   - Time: Morning 6:00 AM to 12:00 PM, Evening 2:00 PM to 5:00 PM
   - Caution: Check the valve status properly, and must follow above procedure
4. STOP blower by pressing RED push button given besides blower

CHAPTER-13

LABORATORY EQUIPMENT
&
ITS PURPOSE

INSTRUMENT & ITS PURPOSE

LIST OF EQUIPMENTS	PURPOSE
1) pH Meter	--used to measure the **pH** which is either the concentration of Hydrogen ions in an aqueous solution or the activity of the Hydrogen ions in an aqueous solution.
2) TDS Meter	--used to indicate the Total Dissolved Solids (TDS) of a solution.
3) Weighing Machine	--used to determine the weight or mass of an object.
4) BOD Incubator	--used to grow and maintain microbiological cultures or cell cultures at 20° C.
5) COD Incubator	--used to oxidize the sample.
6) Oven (hot air)	--used for heating and undertaking other oven dry tests in the laboratory.
7) Muffel furnace	-- used to determine what proportion of a sample is non-combustible and non-volatile.
8) Colorimeter	--used to measures the absorbance of particular wavelengths of light by a specific solution.
9) Dhona balance	--used to measure tool for balancing rotating machine parts such as rotors for electric motors, fans, turbines, disc brakes, disc drives, propellers and pumps
11) Gas Chromatography	--used in analytical chemistry for separating and analysing compounds that can be vaporized without decomposition.
12) Auto clave	--used to sterilize equipment and supplies by subjecting them to high pressure saturated steam.
13) Hot Furnace	--used to achieve desire temperature for multi purpose.
14) Refrigerator	--used for preservation of samples.
15) Jar apparatus	--used as jar test apparatus to correctly estimate the dosing of alum and such other coagulants.
16) Vacuum pump	--used to removes gas molecules from a sealed volume in order to leave behind a partial vacuum.
17) Spectrophoto Meter	--is an instrument which measures the amount of light of a specified wavelength which passes through a medium.
18) Auto Sampler	--used to take automatic sampling.
19) Magnetic starrer	--used for mixing and dissolution.

Table : 13.1

CHAPTER-14

TROUBLESHOOTING

TROUBLESHOOTING

SIGN & SYMPTOMS	POSSIBLE CAUSES	SUGGESTED ACTIONS
Sludge Floating to surface of secondary clarifiers	• Filamentous organisms predominating in mixed liquor (Bulking Sludge).	· Check SVI, if > 150, bulking. · Microscopic examination for the presence of filamentous organisms. · Increase DO in aeration tank, if less than 1.5 mg/L at the effluent end of aerator, · Increase SRT to greater than 6 days. · Increase return sludge & reduce wasting. · Supplement deficiency of nutrients so that BOD to nitrogen ratio is more than 100 mg/L total nitrogen, 1mg/L phosphorus and 0.5 mg/L iron. · Add 5 -10 mg/L chlorine to return sludge until SVI< 150 (should be controlled within 2 -3 days).Microscopically examine sludge to avoid destruction of beneficial organisms during chlorine application. · Increase pH to 7.0 · Add 50 -200mg/L hydrogen peroxide to aeration tank until SVI<150.
Pin -Point flocs in secondary settling tank overflow -SVI is god but effluent is turbid.	· Excessive turbulence in aeration tank	· Measure DO and reduce aeration addition by reducing air blower output or RPM of Surface aerator.
	· Overoxidized sludge	· Check sludge appearance, Increase sludge wasting to decrease MCRT.
	· Anaerobic conditions in aeration tank	· Monitor DO in aeration tank. Increase DO in aeration tank to at least 1.0-1.5mg/L in aeration effluent.
	· Toxic shock load	· Microscopically examine sludge for inactive protozoa. Reseed the sludge with sludge from another plant if possible; enforce industrial waste ordinances. · Stop wasting sludge. · Return rate as high as possible to reestablish cultures.
Very stable dark tan foam an aeration tanks which sprays cannot break up.	· MCRT too long	· Check MCRT, if >9days, may be the cause. Increase sludge wasting so as to reduce MCRT. Increase should be at a modest rate and trends watched carefully.

Thick billows of white sudsy foam on aeration tank.	MLSS too low	Check MLSS; Decrease the sludge wasting so as to increase MLSS and MCRT.
	· Presence of non-biodegradable surface active material.	· If MLSS are appropriate, surfactants are probable cause. Monitor industrial discharge, enforce industrial waste ordinances.
Aeration tank sludge is dark - Sludge blanket lost in secondary clarifier.	· Inadequate aeration, dead zones and septic sludge.	· Measure DO and increase aeration addition by increasing air blower output or adding another blower in service. · Check aeration system piping for leaks. · Clean any plugged diffuser or add more diffuser if possible.
MLSS concentrations differ substantially from one aeration basin to another	· Unequal flow distribution to aeration tanks	· Measure flow to each basin. Adjust valves and/or inlet gates to equally distribute flow.
	· Return sludge distribution unequal to aeration basins.	· Check RAS flow to each basins and adjust it.

Table : 14.1

• TROUBLESHOOTING-BLOWER

SIGN & SYMPTOMS	POSSIBLE CAUSES	SUGGESTED ACTIONS
Unusual noise & vibration	Coupling misalignment	Align coupling with blower at operating temperature according to manufacturer
	Loose nuts, bolts and screws	Tighten
Air system Low pressure	Bypass valve open, leaks of breaks in distribution piping	Close valve, repair leaks or breaks
Air system high pressure	Plugged diffusers	Blow out or remove and clean
Low air flow	High ambient temperature Blower air control malfunction	Add more air, if needed Repair or replace control
System oil low pressure	Oil level too low Oil filter dirty Check valve sticks open Incorrect oil type	Add oil Replace Replace valve Drain and refill with proper oil type

SIGN & SYMPTOMS	POSSIBLE CAUSES	SUGGESTED ACTIONS
Unusual noise & vibration	Coupling misalignment	Align coupling with blower at operating temperature according to manufacturer
	Loose nuts, bolts and screws	Tighten
Air system Low pressure	Bypass valve open, leaks of breaks in distribution piping	Close valve, repair leaks or breaks
Air system high pressure	Plugged diffusers	Blow out or remove and clean
Low air flow	High ambient temperature Blower air control malfunction	Add more air, if needed Repair or replace control
System oil low pressure	Oil level too low Oil filter dirty Check valve sticks open Incorrect oil type	Add oil Replace Replace valve Drain and refill with proper oil type
System oil high pressure	Incorrect oil type	Drain and refill with proper oil type
Oil discharge low pressure	Suction lift too high Air or vapor in oil Coupling slipping on pump shaft	Reduce lift Purge air at filter Secure coupling
Oil temperature low	**Oil cooler water flow too high**	**Throttle water flow**
Oil temperature high	Oil cooler water flow too law Incorrect oil type Insufficient oil circulation	Increase water flow Drain and refill with proper oil type Replace oil filter, check oil lines for restrictions
Hot bearings	Blower speed too high Defective bearings Oil cooler water flow too low	Reduce speed to recommended RPM Check bearings for clearance, hot spots, cracks or other damage. Repair or replace. Increase water flow
Motor doesn't start	Overload relay tipped	Check and reset
Motor noisy	Noisy bearings	Check and lubricate
Motor high temperature	Restricted ventilation Electrical	Check openings and duct work for obstructions. Check for grounded or shorted coils and unbalanced voltages between phases check

Table : 14.2

O&M OF SLUDGE RECIRCULATION

- The manufacturer's O&M manual must be followed with diligence.
- Ensure discharge of sludge recirculation into the aeration tank is visible and can be monitored
- In addition, if an intermediate sludge sump is provided, it is advisable to force-flush the sludge line of the clarifier at frequent intervals, so that the pipe remains clear at all times, and incidence of choking is minimized.

Troubleshooting

Problem	Cause
Excessive noise	Poor engineering / maintenance
Excessive vibration	Poor engineering / maintenance
Overheating	Poor maintenance
Loss in efficiency of pumping	Poor maintenance

Table : 14.3

O&M PROBLEMS IN UASB REACTOR TECHNOLOGY

SIGN & SYMPTOMS	POSSIBLE CAUSES	SUGGESTED ACTIONS
Effluent gutters have more flow on one side than the other	Improper Leveling of the effluent gutter	Adjust Leveling gutter
Water level of over flow weirs of influent distribution system is not equal	Improper adjustment of the distribution boxes or over flow weirs	Adjust position of distribution box or overflow weirs
Gas production lower than normal	Intoxication of the sludge.	• Take sample of sludge and determine methanogenic activity. • When toxic conditions are still present in sewage, suspend feeding until situation improves. If not, continue feeding and respond as during start-up. continue feeding and respond as during start-up
	Leak in gas collection system Gas meter defect	• Check critical points with soap solution • Repair leaks • Repair Gas meter

During start-up at short HRT the sludge does not improve	Solids loading rate is too high to allow growth of the methanogenic population.	• Check biodegradability of the solids. • Stop feeding of the reactor and allow digestion of the solids until gas production is lowered considerably till it is more or less constant.
	The sewage contains a large fraction of poorly degradable organic solids	• Re-start at HRT=24 hours and lower step-wise until maximum loading is obtained. Most probably the designed HRT cannot be reached.
Effluent turbid	Reactor overloading due to high hydraulic loading rate	Check Flow-rate to reactor. If sludge quality and methanogenic activity of sludge are normal and organic leading rate is normal, then reduce flow-rate.
		When sludge quality and methanogenic activity are normal, then reduce organic loading rate by increasing HRT
		Increase Sludge quantity in the reactor. Allow for improvement of methanoenic activity, for instance by stopping feeding of the reactor
	Reactor overloading due to high organic loading rate Reactor, overloading due to low bio-degradation capacity of the reactor	Check organic loading rate of reactor Check quantity and methanogenic activity of the sludge
Large fraction of solids in effluent	High hydraulic loading rate	Check flow -rate to the plant Reduce flow-rate
	The pump switch levels not properly adjusted	Check switch levels of the pumps
		Adjust switch levels
	Sludge level in the reactor is too high	Check sludge profile and the level of the top of the sludge blanket Discharge sludge
Fast growing floating layer on top of the reactor	High organic loadings rate of the reactor	Organic loading -rate and sludge loading rate Adapt organic loading rate or improve sludge quality
Odours when sludge is applied to sludge drying beds	Inadequate digestion of sludge	Check reactor loading rates Adjust reactor loading rates to design values. In extreme cases stop feeding of reactor until sludge has stabilized.

Table : 14.4

LIFE CYCLE ASSESSMENT FOR SELECTION OF TREATMENT TECHNOLOGIES:

Following Points to be Considered for Life Cycle Assessment :-

Life-cycle assessment (LCA) is a systems-based approach to quantifying the human health and environmental impacts associated with a product's life from "cradle to grave." A full LCA addresses all stages of the plant life-cycle and should take into account alternative uses as well as associated waste streams, material transport, construction activity, product manufacturing, distribution and use, repair and maintenance, and wastes or emissions associated with a product, process, or service as well as end-of-life disposal, reuse, or recycling.

1. Foot print area:

Environmental footprint analysis is an accounting tool that measures human demand on ecosystem services required to support a certain level and type of consumption by an individual, product, or population. Ecological,materials, carbon, nitrogen, and water footprint analyses are common methods available for calculating environmental footprints.

Ecological Footprint: Ecological footprint measures the amount of land and/or ocean required to support a certain level and type of consumption by an individual or population. This measurement is estimated by assessing the total biologically productive land and ocean areas required to produce the resources consumed and mitigate the associated waste for a certain human activity or population

Materials Footprint: Materials footprint uses material flow analysis to estimate the total material and waste generated in a well-defined system or specific enterprise. This method provides several useful indicators for measuring the mass of materials entering and leaving a defined system boundary, including domestic material consumption, total materials requirements and material intensity.

Carbon Footprint: Carbon footprint is the most developed of the footprint methods. It is a measure of the direct and indirect greenhouse gas emissions caused by a defined population, system, or activity. Carbon footprints can be calculated by taking an inventory of six greenhouse gases: carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, perfluorocarbons, and hydrofluorocarbons.

Nitrogen Footprint: Nitrogen footprint is a measure of the reactive nitrogen (e.g., nitrous oxides, ammonia, etc.) associated with a population or activity through agriculture, energy use, and resource consumption

Water Footprint: Water footprint measures the total volume of freshwater that is directly or indirectly consumed by a well-defined population, business, or product. Water use can be measured by the volume of water consumed (e.g., the amount evaporated and/or polluted in a given period of time) and is indicative of the water volume required to sustain a given population. The water footprint of a region is the total volume of water used, direct or indirect, to produce goods and services consumed by inhabitants of a region.

2. Capital cost:

It includes the approximate capital cost for construction of new WTP/STP or expansion of existing plants. The cost includes the treatment facilities, piping, clear well storage and administrative and other buildings. The cost does not include acquisition of property, site development or treatment studies.

3. Minimum 10 years O & M period:

The operation and Maintenance period of any new constructed plant shall be minimum 10 years.

4. Energy cost:

It describes the total energy with respect to electricity to be utilized during the construction and efficient working of the plant for at least 10 years after the commissioning of the plant.

5. O & M cost including chemicals:

It represents the operation required for working of the plant and maintenance of the same during the said tenure. It includes chemical cost, labor cost, electricity cost. It also includes changing of chemicals at certain interval, change/repairs of the spares of mechanical and electrical items.

6. Payment return:

It signifies the recovery of the cost of electro-mechanical equipment's within max. 5 years after the successful commissioning of the plant. Biogas generated from treatment unit can be used for energy generation which can in turn lead to cost recovery too.

WATER TREATMENT PLANT

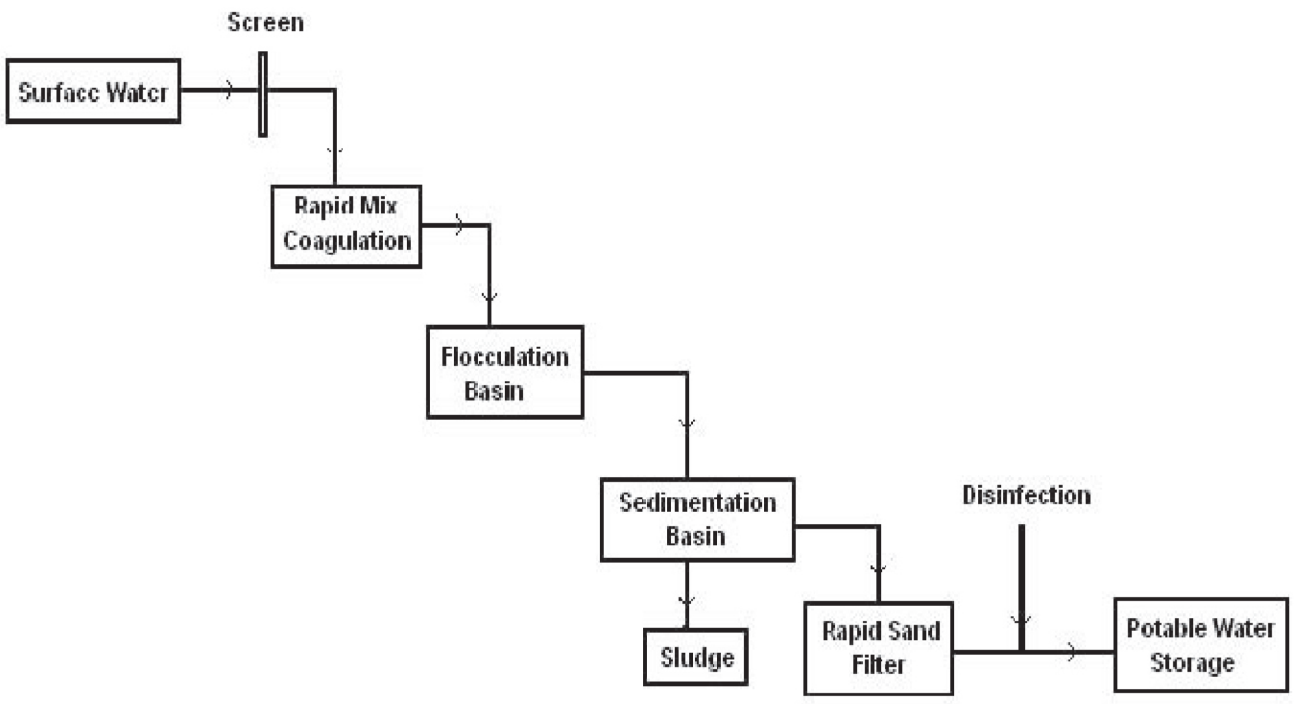


Fig. : 14.1

WASTEWATER TREATMENT PLANTS

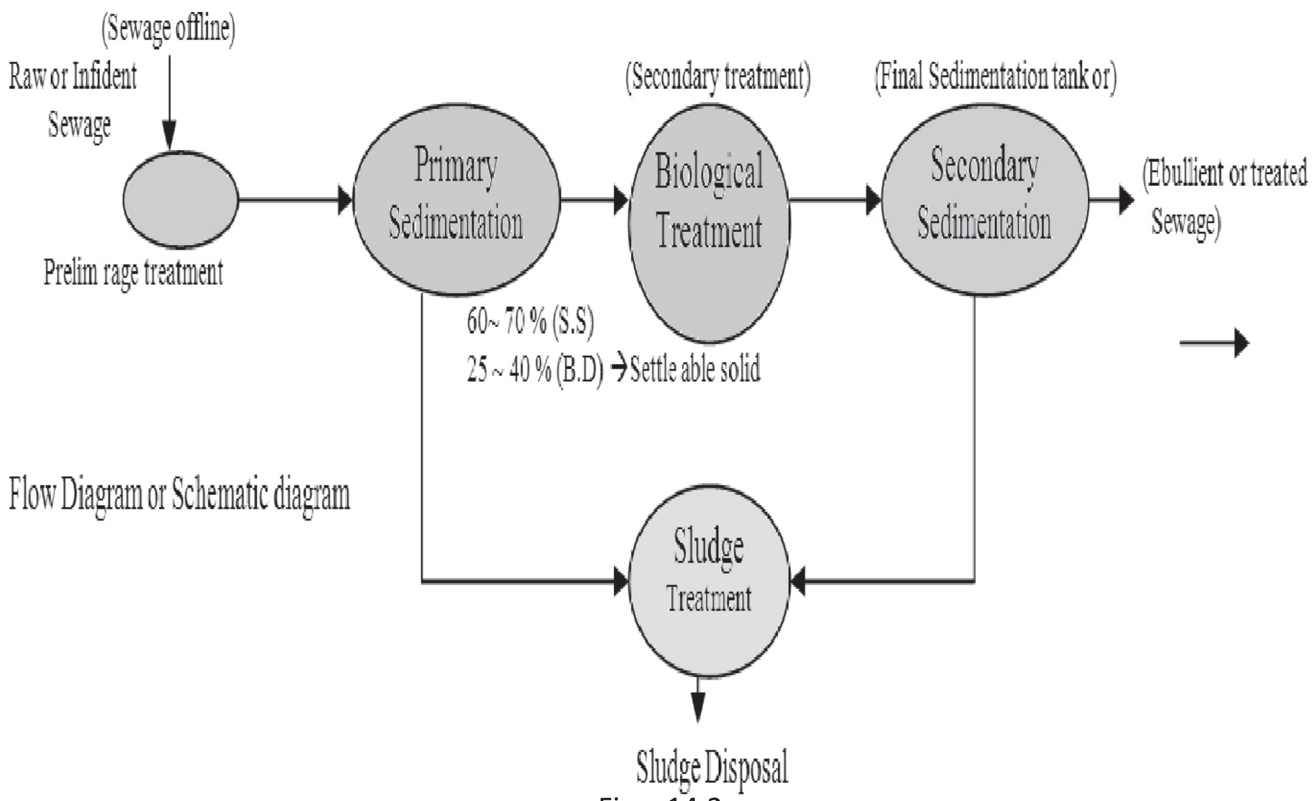


Fig. : 14.2

IMPORTANT QUESTION:

MCQ :

Sample Question:

Que. Which of the following is characteristic of normal raw municipal sewage water?

(A) Black colour

(B) Strong acidic odour

(C) Grey colour

(D) Low temperature compare to ambient temperature

Ans.: (C) Grey colour

1. Which is the following is characteristic of waste water from toilet?

(A) Black Colour

(B) Minimum Daily flow occurring in the afternoon

(C) Grey colour

(D) Strong acidic water

2. What is the Environmental effect of biodegrable organic materials?

(A) Corrosion

(B) Cancerous

(C) Fish death

(D) Risk when bathing and eating

3. At what specified temperature portion of the total solids retained on a filter to be measured after being dried to get Total Suspended Solid (TSS)?

(A) $100^{o}C$

(B) $105^{o}C$

(C) $110^{o}C$

(D) $95^{o}C$

4. What is relationship between turbidity and Total Suspended Solid?

(A) With increase of TSS, Turbidity increase

(B) With increase of TSS, Turbidity Decreases

(C) No relationship

(D) None of the Above

5. Oxygen is ------------------soluble in warm water than in cold water.

(A) More

(B) Less

(C) Equal

(D) None of the above

6. What is the summation of pH and pOH?

(A) Eight
(B) Thirteen
(C) Fourteen
(D) Fifteen

7. How the age of waste water is indicated?

(A) Amount of Carbon dioxide
(B) Amount of Acid
(C) Amount of Oxygen
(D) Amount of Ammonia

8. Why H_2S gas is dangerous for gas engine?

(A) Mixing with Oxygen
(B) Mixing with Water
(C) Mixing with Methane and Carbon Dioxide
(D) None of the above

9. When septic condition occur in the wet well of pumping station or incoming chamber of STP, what physical characteristics of waste water will be observed?

(A) High Turbidity & Forms produced
(B) High temperature & low flow rate
(C) Dark colour and H_2S Odor
(D) Low suspended solids and methane production

10.Which of the following might occur in aerobic digester that are organically overloaded?

(A) Rotten egg
(B) Temperature increase
(C) pH increase
(D) Excessive foaming

11. When the influent waste water flow increase, which of the following could be adjusted to maintain a constant solids loading rate?

(A) Decrease surface area of secondary clarifier
(B) Increase hydraulic loading rate of SCL
(C) Decrease F/M Ratio
(D) Decrease MLSS

12. An Activated sludge process has been operated. What parameter needs to be adjusted to switch to high loading rate?

(A) Increase volumetric loading, Increase F/M and Increase mean cell residence
(B) Increase volumetric loading, Decrease F/M and Increase mean cell residence
(C) Increase volumetric loading, Increase F/M and Decrease mean cell residence
(D) Decrease volumetric loading, Decrease F/M and Decrease mean cell residence

13.Nuisance odors from aerobically digestedsludge can be reducedby

(A) Increasing organic loading to the digester
(B) Increasing dissolved organic content of the digester
(C) Adding lime to increase the pH
(D) None of the above

14. In thickening or dewatering process,one of the most common causes of excessive polymer consumption is

(A) Use of dry polymer
(B) Poor polymer mixing
(C) Use of a non-ionic polymer
(D) Use of an emulsion polymer

15.What is the effect of influent temperature on settling?

(A) There is no effect
(B) Warm influent reduces settling
(C) Cold influent increases settling
(D) Warm influent increases settling

16.Which is the standardized condition for biochemical oxygen demand analysis?

(A) 20degree C for 3 days
(B) 25degree C for 5 days
(C) 20degree C for 5 days
(D) Room temperature for 5 days

17.Which statement is true for pH?

(A) The pH scale ranges from 0-14
(B) Neutral pH represent from a reading of 7
(C) pH above 7 indicates acidic conditions
(D) pH=log(H+)

18.What will happen in an anaerobic digester when the temperature inside the tank is 10 degree C?

(A) Digestion almost ceases.
(B) Methane production increases
(C) Temperature has no effect on anaerobic digestion
(D) None of the above

19.A 200ml/l value of settled sludge volume (SSV) and 2000mg/l of MLSS concentration of an aeration tank sample are obtain from laboratory experiments, what is the sludge volume index of the sample?

(A) 10ml/gm.
(B) 40ml/gm.
(C) 100ml/gm.
(D) 50ml/gm.

20.How much organic suspended solids & BOD are removed in Primary Clarifier?

(A) 60-70% & 30-35% respectively.
(B) 50% & 25% respectively.
(C) 30-35% & 32-35% respectively.
(D) None of the above

21.Storage hours recommended for BOD preservation is?

(A) 10 hours
(B) 24 hours
(C) 48 hours
(D) 6 hours

22.What should be added to sample for determining COD?

(A) HCL with pH1
(B) H_2SO_4 with $pH < 2$
(C) HNO_3 with $pH < 3$
(D) None of the above

23.How much time sample to be preserved for determining ammonia?

(A) 5 days
(B) 7 days
(C) 10 days
(D) 14 days

24. Typical value for the ratio of BOD/COD for the untreated wastewater are ----?

(A) 225
(B) 0.2
(C) 0.3-0.8
(D) None of the above

25. When the wastewater have some toxic components or acclimated microorganisms the ratio of BOD/COD is ---?

(A) 0.4
(B) 0.7
(C) 2
(D) None of the above

26. Which microorganism is responsible for typhoid?

(A) Shigella
(B) Salmonella
(C) T.solium
(D) Salmonella Typhi

27. Membrane Bio-reactor is ----type treatment?

(A) Anaerobic
(B) Aerobic & Anaerobic
(C) Aerobic
(D) None of the above

28. How much energy requirement is there per ml in ASP?

(A) 18 kW/hr.
(B) 300 kW/hr.
(C) 180-225 kW/hr.
(D) Negligible

29. Capital cost for UASB process is Rs. ----- million/MLD?

(A) 10-12
(B) 6-8
(C) 7-8
(D) 3-4

30.Reverse Osmosis is a process of ---------?

(A) disinfection
(B) separation
(C) coagulation
(D) sedimentation

31.Suspended solid present in the waste water generated in blast furnace gas cooling and cleaning plant is removed by

(A) Biological oxygen pond.
(B) Radial settling tank (thickener) using coagulant (lime & ferrous sulphate).
(C) Lagoons.
(D) Filtration.

32.Iron & manganese present as pollutant in water cannot be removed by

(A) Ion exchange process.
(B) Oxidation followed by settling & filtration.
(C) Lime soda process or manganese zeolite process.
(D) Chlorination.

33.Replenishment of dissolved oxygen in water stream polluted with industrial waste occurs by

(A) Natural aeration of water stream.
(B) Photosynthetic action of algae.
(C) Both (a) & (b).
(D) Neither (a) nor (b)

34. TLV of mercury in potable (drinking) water is about ___________ ppm.

(A) 0.001
(B) 1
(C) 0.1
(D) 5

35. Which is the best and the most effective method for the removal of organic contaminant present in the polluted water in very small quantity (say < 200 mg/liter)?

(A) Lagooning
(B) Activated carbon adsorption
(C) Biological oxidation pond
(D) Chemical coagulation

36. Turbidity of water is an indication of the presence of

(A) suspended inorganic matter
(B) dissolved solids
(C) floating solids
(D) dissolved gases

37. The main pollutant in waste water discharged from a petroleum refinery is oil (both in free and emulsified form). Free oil is removed by

(A) biological oxygen pond.
(B) aerated lagoons.
(C) trickling filters.
(D) gravity separator having oil skimming devices.

38. Aerobic biological oxidation ponds used for the purification of polluted water

(A) Destroys/removes pathogen from the sewage.
(B) is not very effective for non-biodegradable substances (e.g. ABS) containing effluents.
(C) Destroys/removes pathogen much more effectively if the sewage is chlorinated.
(D) All (a), (b) & (c).

39. Polluted water having low BOD are most economically treated in

(A) sedimentation tanks
(B) oxidation ponds
(C) sludge digester
(D) clarifier

40.The commonest form of iron & manganese found in ground water as pollutant is in the form of their

(A) carbonates
(B) bi-carbonates
(C) chlorides
(D) sulphides

41. Coal washing waste water containing about 3% suspended solids (comprising of clay, slate, stone etc.) is treated for solid particles removal

(A) by chemical coagulation.
(B) in sedimentation tanks equipped with mechanical scrapper.
(C) in vacuum filter.
(D) in clarifiers.

42. The ratio of oxygen available to the oxygen required for stabilisation of sewage is called the

(A) Bacterial stability factor.
(B) Relative stability.
(C) Biological oxygen demand (BOD).
(D) Oxygen ion concentration.

43. Dissolved oxygen content in river water is around __________ ppm.

(A) 5
(B) 100
(C) 250
(D) 500

44. Oil and grease present in an emulsified state in waste water discharged from industries can be removed by

(A) Biological oxidation.
(B) Skimming off.
(C) Settling out using chemical reagents.
(D) Chlorination.

45. Presence of bacteria in potable (drinking) water causes

(A) turbidity
(B) disease
(C) bad odor
(D) bad taste & colour

46. Bacterial aerobic oxidation of polluted water in biological oxidation ponds is done to purify it. Presence of bacteria helps in

(A) Coagulation and flocculation of colloids.
(B) Oxidation of carbonaceous matter to CO2.
(C) Nitrification or oxidation of ammonia derived from breakdown of nitrogeneous organic matter to the nitrite and eventually to the nitrate.
(D) All (a), (b) and (c).

47. COD of raw municipal sewage may be in the range of about __________ mg/litre.

(A) 1-2
(B) 5-10
(C) 90-120
(D) 1500-2500

48. Maximum permissible turbidity in potable water is __________ ppm.

(A) 1
(B) 10
(C) 250
(D) 1000

49. Presence of __________ hardness is responsible for the temporary hardness in water.

(A) carbonate
(B) calcium
(C) choride
(D) sulphate

50. Dose of chlorine for disinfection of water is about __________ mg/litre of water.

(A) 0.01
(B) 0.1
(C) 0.3
(D) 1

51. Which is the most practical and economical method for removal of suspended solid matter from polluted water ?

(A) Sedimentation
(B) Skimming off
(C) Chlorination
(D) Biological oxidation

52. Iron & manganese present in the polluted water is removed by

(A) simple filtration.
(B) oxidation followed by settling & filtration.
(C) chemical coagulation.
(D) chlorination only.

53. Water effluent generated in printing industry is decolourised by

(A) ion exchange technique.
(B) reverse osmosis.
(C) electrolytic decomposition.
(D) adsorption.

54. Presence of __________ in water stream are deleterious to aquatic life.

(A) soluble and toxic organics.
(B) suspended solids.
(C) heavy metals and cynides.
(D) all (a), (b) & (c).

55. Presence of volatile compounds like gasoline, oil, alcohol, ether etc. in municipal sewers may cause

(A) explosion
(B) non biodegradable foam
(C) undesirable plant growth
(D) corrosion

56. Presence of soluble organics in polluted water causes

(A) undesirable plants growth.
(B) depletion of oxygen.
(C) fire hazards.
(D) explosion hazards.

57. For existence of aquatic life in water, the dissolved oxygen content in it, should not be less than __________ ppm.

(A) 10000
(B) 5
(C) 500
(D) 1000

58. Fresh sewage is __________ in nature.

(A) acidic
(B) neutral
(C) alkaline
(D) highly acidic

59. In a sedimentation tank, the detention period for water ranges from __________ hours.

(A) 2 to 4
(B) 8 to 12
(C) 16 to 20
(D) 24 to 32

60. TLV of lead for public sewer/waste water is about __________ ppm.

(A) 1
(B) 25
(C) 150
(D) 650

61. In sewage treatment, the detention period allowed for oxidation ponds ranges from __________ weeks.

(A) 1 to 2
(B) 4 to 5
(C) 9 to 10
(D) 15 to 20

62. Coal mines drainage waste water (acidic in nature) results from the earth's water percolating through the voids created in coal bed during mining. This polluted water which either drains out naturally to water courses or are removed before starting the mining is

(A) neutralised by alkali treatment.
(B) left as such without any treatment.
(C) diluted with fresh water to reduce its acidity.
(D) none of these.

63. Fine grit present in sewage is removed in the __________ during sewage treatment.

(A) grit chamber
(B) detritus tank
(C) trickling filter
(D) skimming tank.

64. Which of the following is the most lethal water pollutant ?

(A) Phenol and cynide
(B) Chlorine
(C) Alkalis
(D) Suspended solids

65. The permissible color for domestic water supply is __________ ppm.

(A) 1
4 (B) 20
(C) 100
(D) 1000

66. The most commonly used chemical coagulant in water treatment is

(A) ferrous sulphate
(B) alum
(C) lime
(D) hydrazine

67. The biological decomposition of organic substances in wastes controlled conditions is called

(A) incineration
(B) biological oxidation
(C) composting
(D) none of these

68. Pick out the correct statement.

(A) Chemical oxygen demand (COD) is a measure of chemically oxidisable organic matter present in water.
(B) COD is determined by oxidising the organic matter present in water with potassium dichromate in cone, sulphuric acid solution at boiling temperature for specified time.
(C) COD is related to BOD of a given waste in water but the relationship varies for different wastes. Typically COD of potable water may be 1-2 mg/litre.
(D) all (a), (b) and (c).

69. Which of the following is the most widely used disinfectant in water treatment?

(A) Chlorine
(B) Irradiation of water by ultraviolet light
(C) Cation exchanger
(D) Coagulation

70. Color test of water is done with an instrument called

(A) tintometer
(B) colorimeter
(C) electro-chemical cell
(D) turbidimeter

71. Pick out the one which is not a chemical coagulant.

(A) Aluminium sulphate
(B) Ferrous sulphate
(C) Hydrated lime
(D) Chloramine

72. Presence of iron and manganese in water causes

(A) reduction in its dissolved oxygen content.
(B) discoloration of bathroom fixtures.
(C) temporary hardness.
(D) none of these.

73. Septic tanks are used for the ___________ of the deposited solids.

(A) separation
(B) anaerobic decomposition
(C) aerobic decomposition
(D) none of these

74. In the context of the chemical process industries, the term BOD is normally associated with the
Lagooning process is mainly a means of the

(A) sludge disposal.
(B) reduction of excessive flow in sewers.
(C) biological treatment of wastes.
(D) none of these.

75. BOD of raw sewagemay be in the range of about-----mg/litre.

(A) 1-2
(B) 5-10
(C) 150-300
(D) 2000-3000

76. Algae growth in water controlled by

(A) deoxidation
(B) chlorination
(C) bleaching
(D) aeration

77. __________ is removed from water by lime-soda process.

(A) Foul smell and taste
(B) Iron and manganese
(C) Temporary hardness
(D) Permanent hardness

78. Removal of __________ is accomplished by aeration of water.

(A) dissolved gases
(B) suspended solids
(C) dissolved solids
(D) none of these

79. World environment day is observed every year on the 5th of

(A) June
(B) December
(C) July
(D) September

80. The term Biological Oxygen Demand (BOD) is used in relation to

(A) potable water
(B) cooling water
(C) distilled water
(D) industrial effluents

81. The destruction of water-borne pathogens is termed as disinfection of water. Which of the following is a water disinfectant ?

(A) Chlorine
(B) Alkalis
(C) Benzene hexachloride
(D) Alkyl benzene sulphonate (ABS)

82. Disinfection of water is done to destroy pathogenic bacteria and thus prevent water-borne diseases. Disinfection of water may be done by the use of

(A) ozone and iodine.
(B) chlorine or its compounds.
(C) ultraviolet light for irradiation of water.
(D) all (a), (b) & (c).

83. Which of the following processes is involved in the biochemical treatment of sewage effluents?
- (A) Oxidation
- (B) Reduction
- (C) Dehydration
- (D) Fermentation

84. Infective bacteria in water is killed by the __________ process.
- (A) sterilisation
- (B) aeration
- (C) disinfection
- (D) none of these

85. Presence of nitrogen and phosphorous in waste water discharged into lakes and ponds causes
- (A) foaming
- (B) odour nuisances
- (C) undesirable plant growth
- (D) turbidity

86. The pH value of potable water should be between
- (A) 1 to 1.5
- (B) 6.5 to 8
- (C) 13 to 14
- (D) 4 to 5

87. Water filtration rate in a rapid sand filter ranges from __________ kiloliters/m2/hr.
- (A) 0.1 to 1
- (B) 3 to 6
- (C) 10 to 15
- (D) 15 to 20

88. Disinfection of water is done to remove
- (A) color
- (B) bad taste
- (C) foul odour
- (D) bacteria

89. Biological oxidation ponds remove organic matters present in the polluted water by
- (A) Using the activities of bacteria and other microorganisms.
- (B) Aerobic oxidation.
- (C) Both (a) & (b).
- (D) Neither (a) nor (b).

90. Water filtration rate in a slow sand filter ranges from __________ litres/m2/hr.
- (A) 10 to 20
- (B) 100 to 200
- (C) 1500 to 2500
- (D) 4000 to 5000

91. Lagoons used for purification of polluted water

(A) are large shallow artificial lakes also known as clarification lakes, maturation ponds or oxidation ponds.

(B) use micro-organisms/bacteria in presence of dissolved oxygen.

(C) gives an excellent final effluent (with 3 to 4 lagoons arranged in series) having suspended solid < 1 mg/litre and BOD = 3.8 mg/litre.

(D) all (a), (b) & (c).

92. Inorganic impurities causing water pollution is

(A) fats

(B) carbohydrates

(C) salts of metals

(D) protein

93. The main type of sludge gas evolved during sewage treatment in Inhoff tank is

(A) CO2

(B) CH4

(C) CO

(D) H2

94. Insufficient washing of sand grains in a rapid sand filter causes

(A) air binding

(B) shrinkage of filtering media

(C) mud balls

(D) expansion of filtering media

95. Which of the following is the most efficient for removal of very finely divided suspended solids and colloidal matter from the polluted water stream?

(A) Sedimentation tank

(B) Circular clarifier

(C) Mechanical flocculation

(D) Chemical coagulation

96. In sewage treatment, its sedimentation is speeded up by commonly adding

(A) hydrochloric acid.

(B) lime.

(C) coppersulphate.

(D) sodiumsulphate.

97. Presence of __________ bacteria in water causes disease like typhoid.

(A) aerobic

(B) pathogenic

(C) anaerobic

(D) non-pathogenic

98. The detrimental effect on organism and water quality with temperature rise of aquatic system is the reduction of __________ of water.

(A) dissolved oxygen content

(B) biological oxygen demand

(C) vapor pressure

(D) all (a), (b) and (c)

99. Growth of __________ is promoted by the presence of manganese in water.

(A) files

(B) algae

(C) micro-organisms

(D) mosquitoes

100. The type of bacteria which is active in trickling filter during biological treatment is -------type of bacteria?

(A.) Anaerobic

(B.) Aerobic

(C.) Saprophytic

(D.) Parasitic

Short Question:

1. Define settle-able solids?
2. Enlist gases dissolved in wastewater?
3. What is the formula of Henry's Law?
4. What is the unit of turbidity (Full form)?
5. What is the unit of Odor (full form)?
6. What is S.I. unit of Conductivity?
7. Define pH?
8. Define pOH?
9. Enlist usual forms of Phosphorous?
10. What is meant crown rot?
11. Chemically, what are oil & grease?
12. Which are the source of trace metals in waste water?
13. Enlist characteristics of collected sample to meet the goals of sampling programs?
14. How suspended solids is measured (only method)?
15. At final effluent stage, what should be the ratio of BOD/COD?
16. Which organisms are generally found in surface water & wastewater?
17. Which organism is responsible for Cholera?
18. What is the use of Preliminary treatment?
19. Generally, which components are there for secondary system?
20. Demerits of activated sludge process?
21. Merits of SBR(Sequence Batch Reactor)?
22. What is MBR?
23. What is UASB?
24. For what filtration system is used?
25. Enlist types of filtration systems?
26. What is removed in Activated carbon filter?
27. Iron Removal Filter is based on which type of mechanism?
28. What is used as a powerful oxidant?
29. What is the purpose of disinfection?
30. Which chemical is used as a strong disinfectant for drinking water & wastewater?
31. What is Electro-dialysis?

32. Enlist merits of Electro coagulation?
33. Give the range of the membrane pore size used in ultra-filtration?
34. What is the efficiency to remove TDS in RO?
35. Define Zeolite?
36. Which type of technology is used for reducing O & M cost?
37. On what factors the performance of DAF is depend?
38. For successful operation, what are the key factors of DAF units?
39. For what purpose the DAF is designed?
40. Which type of technology is used for reducing space?
41. What is difference between the term AEROBIC & ANAEROBIC?
42. What is anaerobic activity?
43. Which type of bacteria is responsible for conversion of sugar into hydrogen?
44. What is the major role of anaerobic digestion in to the atmosphere?
45. What is biogas?
46. What are the uses of biogas?
47. What is used as a sludge thickener in municipal applications?
48. Which type of technology is used for reducing capital cost?
49. Whether Aerobic or Anaerobic digestion is used as a source of renewable energy?
50. What are the constituents of biogas?
51. Enlist merits & demerits of anaerobic digestion?
52. Which are the factors that affects nitrification?
53. What is Environment?
54. What is hygiene?
55. What is Health?
56. Define sustainable sanitation?
57. What should be done if there is gas meter defect?
58. What should be done if there is high hydraulic loading rate?
59. What should be done if there is high level of sludge in the reactor?
60. What should be done if there is excessive turbulence in aeration tank?
61. What should be done if there is dead zones?
62. What should be done if there is septic sewage condition arises in the plant?
63. Which type of technology is used for recycle and reuse purpose?
64. Enlist the methods for the removal of phosphorus?
65. Enlist demerits of aerobic digestion?
66. In primary treatment unit, what is to be done for the removal of inorganic and organic fine suspended solids?
67. Which equipment consists of specially designed synthetic media, to facilitate attached fixed film?
68. Define BOD?
69. Define COD?
70. What are the effects of temperature?
71. Why electrical conductivity of water is used?
72. What is the important role play by alkalinity, in the treatment of wastewater?
73. Describe importance of BOD/COD ratio?
74. What care should be taken while taking sampling?

75. What are the different types of pumps used commonly for pumping the sewage?
76.Define coagulation?
77. Define filtration?
78. Define hardness? Types of hardness?
79. What are various methods of distribution system?
80. Mention the classification of treatment process of sewage?
81. State the purpose of using the skimming tanks?
82. What is meant by biodegradable organic matter?
83. Define sludge digestion?
84. What are the factors affecting sludge digestion and their control?
85. What are the methods of aeration?
86. Define softening of water?
87. Define sludge volume index?
88. What are the methods of disposing the sewage effluent?
89. Give different types of thickener unit?
90. Enlist different types of solids found in wastewater?
91. Define alkalinity?
92. How can be the actual quantity of oxygen present in solution is governed?
93. Define bio stimulants?
94. What are the types of trickling filter?
95. What are the various test for finding the quality of sewage?
96. Define dilution factor?
97. What is meant by self-purification?
98. Which type of filtration is used in removal colour and odor?
99. Enlist the chemicals which are used during the wastewater treatment?
100. Why is it necessary to remove the nitrogen and phosphorus from the wastewater?

ANSWERS :

1) Black colour
2) Fish death
3) 105
4) With increase of Tss,Turbidity increase
5) less
6) fourteen
7) Amount of Ammonia
8) Mixing with Methane and Carbon Dioxide
9) Dark colour and H2S Odor
10) Excessive foaming
11) Decrease MLSS
12) Decrease volumetric loading.Decrease F/M and Decrease mean cell residence
13) Increasing dissolved oxygen content of the digester
14) Poor polymer mixing
15) Warm influent increases seetling
16) 20 degree for 5 days
17) The pH scale ranges from 0-14
18) Digestion almost ceases
19) 100 ml/gm
20) 30-35% & 32-35% respectively
21) 24 hours
22) H2SO4 with pH <2
23) 7 days
24) 0.3-0.8
25) 2
26) Salmonella Typhi
27) Aerobic & Anaerobic
28) 18 kW/hr
29) 7-8
30) Separation
31) Radial settling tank using coagulant
32) chlorination
33) Both (a) & (b)
34) 0.001
35) Activated carbon adsorption
36) suspended inorganic matter
37) gravity separator having oil skimming devices
38) all (a),(b) & (c)
39) oxidation ponds
40) bi-carbonates
41) in sedimentation tanks equipped with mechanical scrapper
42) relative stability
43) 5
44) settling out using chemical reagents

45) disease
46) all (a),(b) & (c)
47) 90-120
48) 10
49) calcium
50) 1
51) Sedimentation
52) oxidation followed by settling & filtration
53) electrolytic decomposition
54) all (a),(b) & (c)
55) explosion
56) depletion of oxygen
57) 5
58) alkaline
59) 2 to 4
60) 1
61) 1 to 2
62) neutralised by alkali treatment
63) detritus tank
64) Phenol and cynide
65) 20
66) alum
67) composting
68) all (a),(b) & (c)
69) chlorine
70) tintometer
71) Chloramine
72) discoloration of bathroom fixtures.
73) anaerobic decomposition
74) characterisation of liquid effluents.
75) 150-300
76) chlorination
77) Temporary hardness
78) dissolved gases
79) June
80) industrial effluents
81) Chlorine
82) all (a), (b) & (c).
83) Oxidation
84) sterilisation
85) undesirable plant growth
86) 6.5 to 8
87) 3 to 6
88) bacteria
89) both (a) & (b).
90) 100 to 200

91) all (a), (b) & (c).
92) salts of metals
93) CH_4
94) mud balls
95) Chemical coagulation
96) lime
97) pathogenic
98) dissolved oxygen content
99) micro-organisms
100) aerobic

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