EN8591 - waste water Engineering.

Unit: 1 - planning and design of sewage system.

Characteristics and Composition of sewage.

physical characteristics of sewage.

* The physical characteristics of wastewater include those item that can be detected using the physical senses.

They are.

→ Temperature → Color.

→ Odor → Turbidity.

Temperature:-

- Beginning - 20°c.
- At decomposition stage - 65°c.
- Temperature is inversely proportional to dissolved Oxygen.

Color:

- Fresh sewage - Brown (or) grey.
- Septic (or) stale - Black colour.
- Depends on time.

Odor:-

- Odor Smell of the fresh sewage is oily (or) Soapy (or) muddy Smell.
- The Septic Sewage develops an objectionable.
- H_2S is the major Sources of pollution.

- Odor is due to degradation of proteins in organic matter.

Turbidity

- The term "turbid" is applied to water/wastewater containing suspended matter or in which the visual depth is restricted.

- Measured by Jackson turbidity meter @ turbidity rod.

Chemical characteristics of sewage.

Solid

- The matter that remains as residual upon evaporation and drying @ 103 ± 2°C

- Those solid that are not dissolved in wastewater are called suspended solids. when suspended solid float, they are called floated solid or scum.

- All solid that burn or evaporate at 500°c to 600°c are called volatile solid.

- Those solids that do not burn or evaporate at 500°c to 600°c, but remain as a residue, are called fixed solids.

pH

- Generally - 7.5 to 7.9.

- Fresh sewage - Alkaline stage.

- Decomposition stage - Acidic

- Oxidized sewage (After treatment) – Alkaline

Chlorides :-

- Chlorides
  - Domestic
    - Kitchen
    - Human Excreta
    - Urine
  - Industrial
    - Meat salting factory
    - ice cream factory
    - Hotel

Generally – 120 PPM in sewage.

Nitrogen :-

- Ammoniacal Nitrogen – Release at the beginning
- Organic Nitrogen – start of decomposition stage.
- Nitrites – partially oxidized sewage.
- Nitrates – fully oxidized sewage.

{Ammoniacal Nitrogen} + {Organic Nitrogen} = {Kjheldhal Nitrogen}

Dissolved Oxygen (Do)

- waste water that has Do is called aerobic (or) fresh.
- The solubility of oxygen in fresh water ranges from ~~14.9~~ 14.6 mg/L @ 0°c to about 7mg/L @ 35°c
- Release into river requires minimum of 4 PPM.

Biological Oxygen Demand :- (BOD).

→ BOD is defined as the amount of oxygen required by the bacteria while stabilizing decomposable organic matter under aerobic condition.

→ It is the amount of oxygen required by aerobic bacteria to decompose/stabilized the organic matter at a standard temperature of 20 degree celcius for a period of 5 days".

→ For domestic sewage 5 day BOD represent approx. 2/3 times of demand for complete decomposition.

BOD Level in mg/liter	Water Quality.
1 - 2	Very Good:- There will not be much organic matter present & water supply.
3 - 5.	Fair:- Moderately clean.
6 - 9	Poor:- Somewhat polluted - actually indicated the organic matter present and micro organisms are decomposing that waste.
100 (or) more	Very poor:- Very polluted - Contain organic matter.

Chemical Oxygen Demand:- (COD).

⇒ By definition the COD is the amount of oxygen required to stabilized the organic matter and inorganic matter chemically.

Population Equivalent:-

⇒ Population Equivalent is defined as the ratio of standard BOD_5 of industrial sewage to the standard BOD_5 of domestic sewage per person per day.

$$\text{Pop. equivalent} = \frac{\text{Std } BOD_5 \text{ of industrial sewage (kg/day)}}{\text{Std } BOD_5 \text{ of Domestic Sewage} \left(\frac{kg/day}{person}\right)}$$

Relative Stability

⇒ Relative stability is defined as the ratio of the amount of oxygen available in the sewage to amount of oxygen required to satisfy the first stage BOD demand.

$$\text{Relative Stability} = 100\,(1 - 0.794\, t_{20^\circ C})$$
$$= 100\,(1 - 0.605\, t_{37^\circ C})$$

$t_{20^\circ C}$ & $t_{37^\circ C}$ = Number of day @ $20^\circ C$ & $37^\circ C$.

Hydraulics of flow in sanitary sewer.

→ Sewage and drain are designed as open channels.

Hydraulic design formulas.

1.) Chezy's formula :-

$$V = C\sqrt{RS}$$

where,

V → velocity of flow in open channel.

R → Hydraulic mean radius $\boxed{R = A/P}$

A → wetted area.

P → wetted perimeter

S → Longitudinal slope.

2) Kutter's formula :-

$$C = \frac{23 + \frac{1}{n} + \frac{0.00155}{S_0}}{1 + \left[23 + \frac{0.00155}{S_0}\right]\frac{n}{\sqrt{R}}}$$

n → Rugosity / Roughness Co-efficient.

S → Bed slope.

R → Hydraulic mean radius $\boxed{R = A/P}$

A → Wetted area.

P → Wetted perimeter.

3) Bazin's formula:

$$C = \frac{157.6}{1.81 + \frac{k}{\sqrt{R}}}$$

R → Hydraulic mean radius. $R = A/P$

A → wetted area.

P → wetted perimeter.

K → Bazin's Constant.

4) Manning's formula:-

$$V = \frac{R^{2/3} S^{1/2}}{n}$$

n → Rugosity / Roughness Co-efficient.

S → Bed slope.

R → Hydraulic mean radius $R = A/P$

A → wetted area.

P → wetted perimeter.

5) William Hazen formula :-

$$V = 0.85 C_{HW} R_h^{0.63} S^{0.54}$$

C_{hw} → Hazen's Constant.

S → Bed slope.

R → Hydraulic mean radius.

Minimum Velocity

- The velocity should be equal to self cleansing velocity.
- The velocity without causing sedimentation and scouring.
- Expressed for Shield.

Self-cleansing velocity

$$V_s = \frac{1}{n} R^{1/6} \sqrt{k(S_s - 1) D_p}$$

$n \rightarrow$ roughness Co-efficient.

$R \rightarrow$ Hydraulic mean radius $= A/P$.

$A \rightarrow$ Area of the channel.

$P \rightarrow$ wetted perimeter of the channel.

$S_s \rightarrow$ Specific gravity of the particle.

$k \rightarrow$ Dimensionless Constant, 0.04 for granular particles, 0.8 for organic matters.

$D_p \rightarrow$ Diameter of the particle for which the sewer will be designed, this is the maximum particle size the sewer can safely carry.

Sewer are always designed to attain the self cleansing velocities.

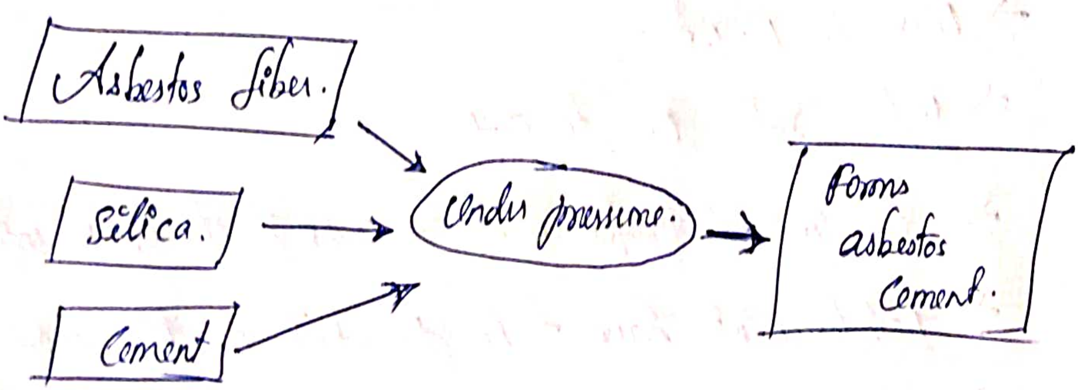
Sewer materials.

Factors of consideration

* The following factor must be considered before selecting a sewer material

- ⇒ Resistance to Corrosion.
- ⇒ Resistance to Abrasion.
- ⇒ Strength and durability.
- ⇒ Light weight.
- ⇒ Imperviousness.
- ⇒ Cost of the material.
- ⇒ Hydraulically efficient. (should have smooth interior surface and minimum loss)

I) Asbestos Cement sewer. :



- ⇒ Size (10 - 90) cm dia and 4m length.
- ⇒ Requires Ring tie coupling.
- ⇒ The coupling consists of sleeve and two rubber ring arrangement.

Advantages

⇒ Light weight.

⇒ Easily assembled at any place.

⇒ Smooth interior surface (N = 0.011)

⇒ Hydraulically efficient.

Disadvantage:

⇒ Not strong (Couldn't bear Compressive stresses).

⇒ Susceptible to corrosion.

⇒ Not suitable for vertical pipes.

2). PCC and RCC Sewers.

⇒ Small dia to larger dia (0.45m - 4.5m).

⇒ Can be made onsite (Cast in situ) or Off-site (pre-cast).

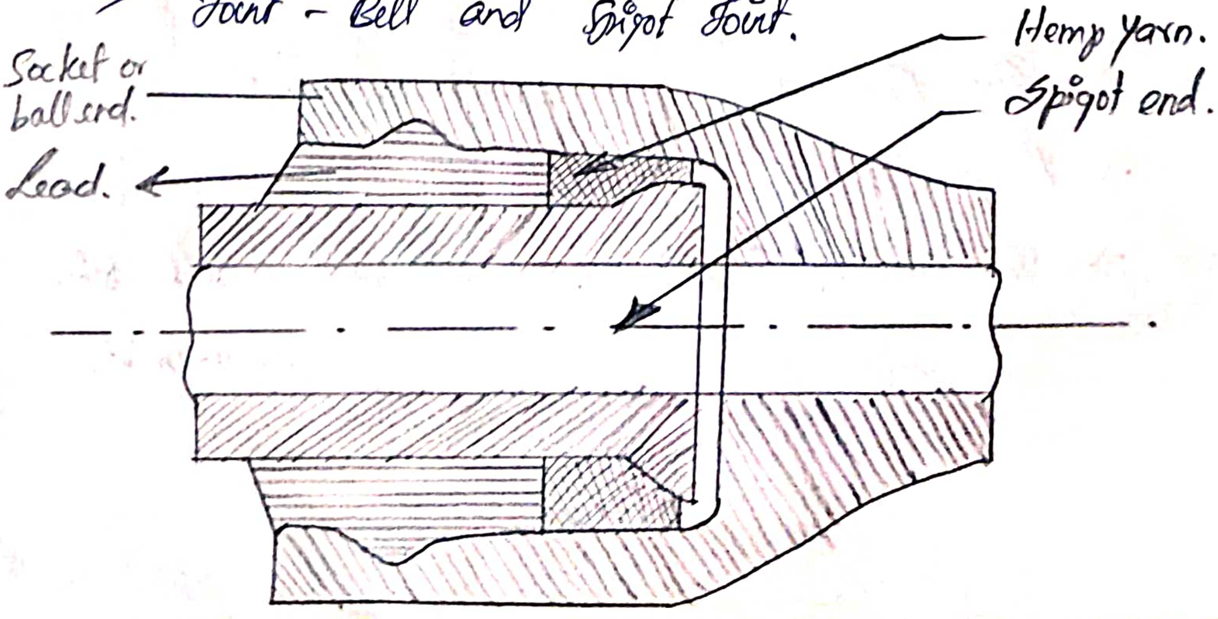
⇒ Mix is 1 : 1.5 : 3.

⇒ W/C ratio 0.5 to 0.7.

⇒ Longitudinal reinforcement = 0.25% of Cross sectional area.

⇒ Reinforcement have to be provided in three way

⇒ Joint - Bell and Spigot Joint.



Single Cage reinforcement :-

⇒ Single reinforcement near the inner surface - to withstand the hoop tension.

Double Cage reinforcement :-

⇒ One reinforcement near the inner surface and other near outer surface - to withstand internal and external pressure.

Elliptical Cage reinforcement :-

⇒ Elliptical reinforcement - to withstand external pressure alone.

Concrete can be poured by

* Ordinary method of pouring and ramming.
* Centrifugal process.
* Cylinder type.

Advantage :-

* Strong in Compression and Tension forces.
* Resistant to erosion and abrasion
* Easily manufactured.
* Economical.

Disadvantage :-

* Get Corroded easily.
* Required lining for protection.

3) Vitrified clay sewer :-

Clay and shale → pulverization & mixing with water → Casting under pressure of 8.5 kg/cm² → Drying in hot kiln @ 1000 degree Celsius

⇓

Addition of Sodium Chloride → Salt vaporizes @ high temperature and produce glazed surface. → Vitrification

Advantage :-

* High resistant to corrosion.
* Suitable for carrying highly polluted sewer.
* Highly impervious.
* Cheap and durable.

Disadvantage

* Heavy and bulk.
* Brittle.
* Difficult to transport.
* Length of the pipe is small - Required many Joint
* Cannot withstand high pressure.

4) Brick Sewer :-

⇒ Can be constructed @ site

⇒ Not in use now a day.

⇒ suitable for construction Large Sewer.

⇒ Require plastering on outer surface to prevent corrosion, entry of roots, Leakage on its surface.

7.

5) Cast iron sewer :-

⇒ Structurally strong and can withstand high tensile and compressive forces.

⇒ Require lining of cement concrete on inner surface and painting by tar on outer surface..

⇒ Manufacture by sand molding and centrifugal process.

⇒ Required Ball and spigot joint

Advantage :-

* Outfall sewer.
* Sewer below heavy traffic load, railway and runways.
* For low lying area.
* For sewer to be laid water pipe line (100% leak proof).
* Stronger and durable.

Disadvantage :-

* Subjected to corrosion.
* Requires lining.

6) Lead sewer :-

⇒ Smooth and soft.

⇒ Easily bent to odd shapes.

⇒ Not affected by acid and alkalis.

⇒ Suitable for small dia pipe (3- 4) cm.

⇒ Used as down taken / connecting pipes from wash basin urinal or geysers.

7) plastic sewers :-

⇒ Suitable for all types of pipes (pressure pipe and variable dia pipes).

⇒ Best for internal water supplies.

⇒ Low deformation (Rate of deformation is less when compared with other pipes)

Corrosion in Sewers – prevention and Control.

Definition :-

⇒ Corrosion of sewer pipe is defined as the failure of pipe and pipe materials due to the action of gases (sulphur gases, mainly H_2S) produced by means of decomposition of organic material present in the sewage.

Cause of Corrosion :-

⇒ Bacteria in the slime under flowing sewage convert sulphate in the sewage into sulphide.

⇒ Sulphide in the liquid make their way to the surface of the sewage and released into the sewer atmosphere as hydrogen sulphide (H_2S) gas.

⇒ H_2S gas in atmosphere makes contact with slime in the crown (surface) of the sewer, which contains more bacteria

⇒ Bacteria action converts H_2S gas to sulphuric acid which cause corrossion in the crown of the pipes and this

8.

Corrosion is called as "Crown Corrosion"

⇒ If pipe material is of corrodible nature sulphuric attack the pipe material and causing ultimate failure.

Types of Corrosion :-

⇒ Corrosion can occur on the outside of a pipe (due to corrosive soil) or on the inside of a pipe (due to corrosive water).

⇒ Either outside or inside a pipe, the creation of the corrosion cell can be through.

* Electrolysis
* Oxygen concentration cells.
* Galvanic action.

Electrolysis

⇒ In electrolysis, a D.C electric current enter a metal pipe and cause flow of electrons through the pipe and to the ground.

⇒ The pipe, fueled by the electric current, becomes the anode while the soil become the cathode.

⇒ The outside of the pipe corrodes, with the metal from the pipe plating out in the surrounding soil.

⇒ Electrolysis can occur when D.C electric current from nearby electric transit system are grounded onto pipes.

(2) Oxygen Concentration cell.

⇒ More commonly, the water and its constituents may set up a corrosion cell within the pipe.

⇒ These corrosion cell, known as oxygen concentration ~~in the water~~ cell result from varying oxygen concentration in the ~~w~~ater.

⇒ The portion of the pipe touching water with a low oxygen concentration become the anode while the part of the pipe in contact with a high oxygen concentration become the cathode.

⇒ Oxygen concentration cell are probably the primary cause of corrosion in the distribution system.

⇒ They may occur @ dead end in the distributed system where water is stagnant and losses it dissolved oxygen.

(3) Galvanic Corrossion.

⇒ when a pipe consist of only one type of metal, impurities in the pipe wall can develop into anode and cathode.

⇒ Alternatively, when two dissimilar metal come into contact, galvanic corrossion will occur.

⇒ Galvanic corrosion is often set up in the distribution system in meter installation and at service connection and coupling

⇒ When two material comes in contact with each other, metal having high oxidation potential corrodes more.

⇒ Oxidation potential – Electron released capacity of a metal when it comes in contact with water molecules.

⇒ Galvanic series have

* Less active metal which have high resistance to corrosion (Cathode).
* High active metal have highly prone to corrosion (Anode).
* Some metal with positive corrosion capacity. They can used as piping material. Eg:- Iron and steel.

⇒ The distance between metal in the Galvanic series determines the intensity of corrosion.

⇒ More distance cause more corrosion. Eg:- Stainless steel and Iron.

Corrosion Control Measure :-

⇒ The following measure should be considered during design for corrosion control in sewer. Design shall provide for self-cleaning velocity, good ventilation, low turbulence, flushing facilities, minimal periods of flow and minimum stagnation.

* Pipes made of Inert material are preferable
* In case of large diameter pipe, RCC with sacrificial

of 25 to 50 mm thick is the suitable pipe material.

* Lining the inside of the RCC pipe with sulphate resistant (or) high alumina cement. This increase the life expectancy of the pipe by 3 to 5 times

* RCC pipes are manufactured with sulphate resistant cement when the soil contains sulphur and other corrosive substances.

* The design of sewer section with a depth of flow of about 0.8D will minimize the change of corrosion.

* Good ventilation usually removes condensation in the immediate vicinity of the air inlet.

* Periodic flushing of sewer is necessary to remove solid accumulation and control their subsequent anaerobic decomposition and H_2S formation.

plumping of Sewage and pumping system

plumbing system:-

→ plumbing system is used for water supply in building

→ It supplies water to kitchen toilet outlet via distribution system of pipes.

→ Drainage system is used to get rid of human water through well-arranged network of drainage pipes.

→ For distribution system pipes. generally used are G.I, Copper, HDPE, CPVC, mostly now a days CPVC plastic pipes are used as they don't get rusted, light weight, easy installation and maintenance and economic

Types of pumps:-

pumps are of two types:-

→ Submersible pump and.

→ open type pump

→ Submersible pump are used inside the water and require very less maintence.

→ Both types can be used for traditional as well as hydro pneumatic system.

Types of Drainage System in Building

Drainage system is of two types:

⇒ Waste water is from shower, basin, kitchen sink, washing machine and the like. This is also called gray water. Normally a minimum of 75 mm dia. pipes are used for drainage of waste water.

⇒ Soil water (or) sewage is from WC and urinals. This is also called black water. Minimum of 100mm diameter pipes are used for waste water. When run horizontally soil water pipes should be runs at a steeper slope, such as 1:40, as they have solids.

⇒ These can be of ~~start~~ cast iron (or) of pvc.

⇒ A grease trap should be used when drainage waste from kitchen. grease should not be allowed to enter the normal drainage system.

⇒ A grease trap is nothing but a small inspection chamber.

⇒ The grease floats, and should be removed manually on a daily basis. The inlet and outlet into this chamber should be designed in a way that minimizes disturbance of the floating grease layer.

Septic Tank:

→ If municipal government drainage is not available on a small project, or exterior of city, provide a septic tank and soak pit

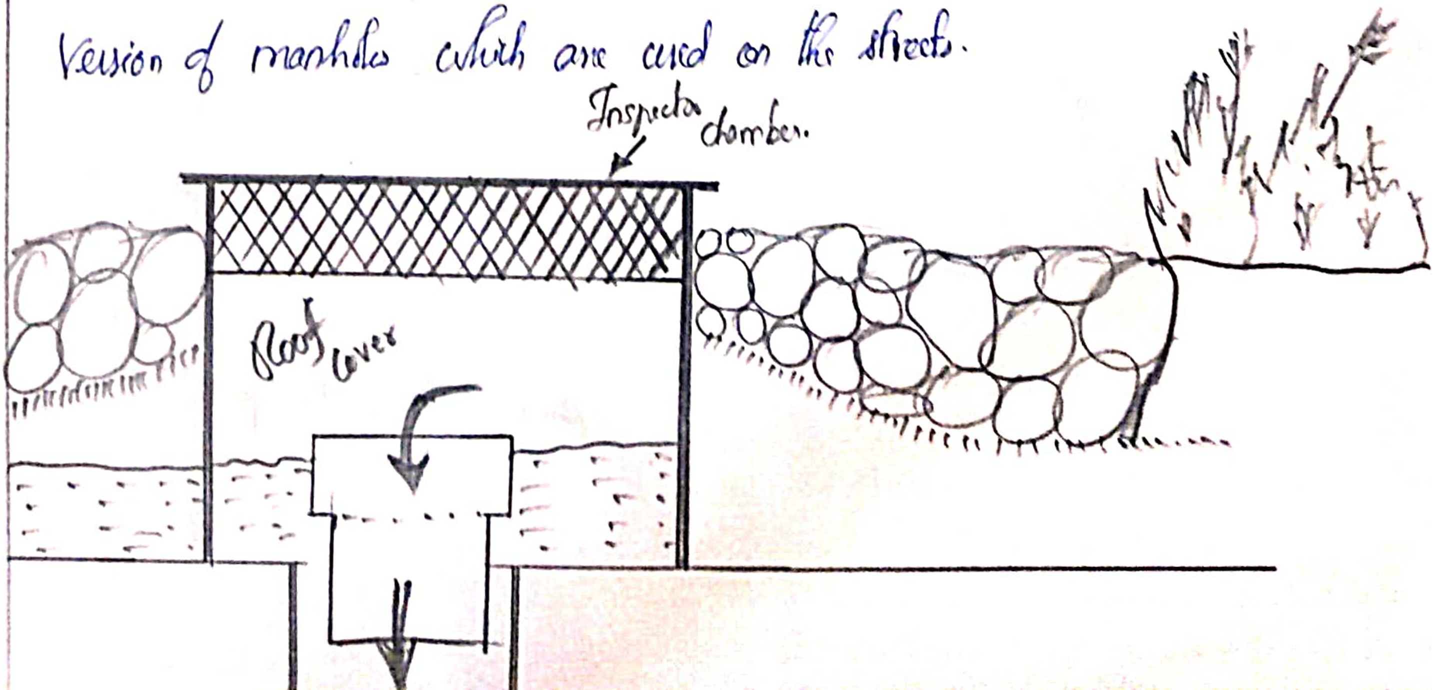
→ A septic tank is a rectangular underground tank with compartment. It is always full of sewage that can be removed manually. The less water put into a septic tank, the better it will function.

→ The effluent that flow out of this, which is about 70% purified is then put into a soak pit. A soak pit is a cylindrical tank with porous brick wall surrounded by a layer of gravel.

Inspection chamber:

→ Stone ware (ceramic) pipes are used when soil and waste water is to be transported in external soil.

→ An inspection chamber is used to clean blockage in the line and change direction of pipe. Inspection chamber is a short version of manholes which are used on the streets.



Unit:-II primary Treatment of Sewage.

Objective:-

⇒ The primary objective of wastewater treatment is generally to permit domestic and industrial effluents to be disposal of without hazard to human health (or) unacceptable damage to the native environment.

⇒ The quality of treated effluent used in agriculture has a great influence on the operation and performance of the waste-water - soil - plant.

⇒ In the case of irrigation - the required quality of effluent will depend on the crop (or) crop to be irrigated, the soil conditions and the system of effluent distribution adopted.

⇒ primary treatment of wastewater involves sedimentation of solid waste within the water. The includes screening out ~~layer~~ large contaminants, aeration, sedimentation

⇒ wastewater is passed through several tanks and filters that treat the water from hazard pollutants. The resulting "sludge" is then fed into a secondary treatment process, in which further processing takes place to treat the wastewater in higher level.

Method of treatment of wastewater can be carried out in four different stages as.

* Preliminary treatment
  {removes material that can cause operational problem}

* Primary treatment (remove ~60% of solid and ~35% of BOD)
* Secondary treatment (remove ~85% of BOD and solids)
* Advanced treatment {remove 95% of BOD and solids, Nitrogen, phosphate.}
* Final Treatment (Disinfection).
* Solid processing (sludge management).

Preliminary treatment.

* The objective of preliminary treatment is the removal of coarse solids and other large materials often found in raw wastewater.

* Removal of these material is necessary to enhance the operation and maintance of subsequent treatment unit.

* preliminary treatment operation typically include coarse screening and grit removal in now adays.

Screening

Screening is a first stage of treatment at the entrance of wastewater treatment plant. The main objective of the screening is to remove the large size of suspended and floating particles present in the wastewater. There are three different types of screens are widely used as. Coarse, medium and fine screen.

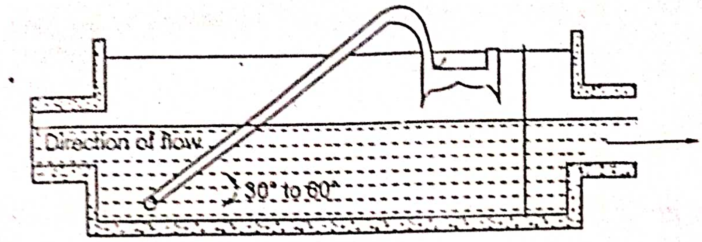
Coarse Screens: It has large opening of 40 to 150 mm in size and used to remove the largest object entering the plants.

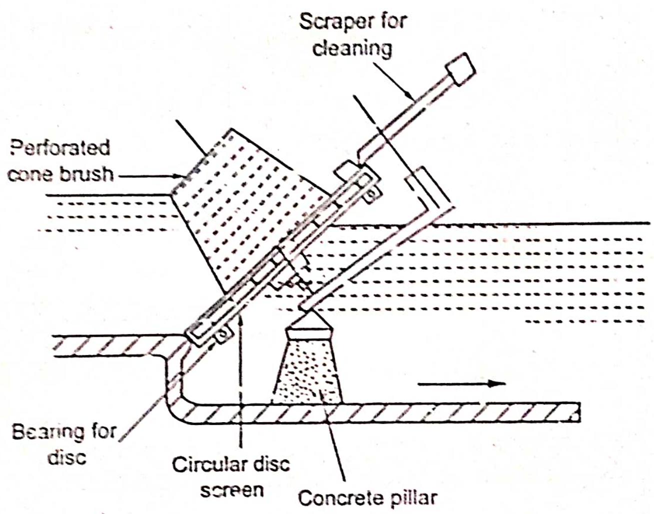
Medium Screens: It has opening of 25 to 50mm in size and in more cases, it is not used in the treatment unit

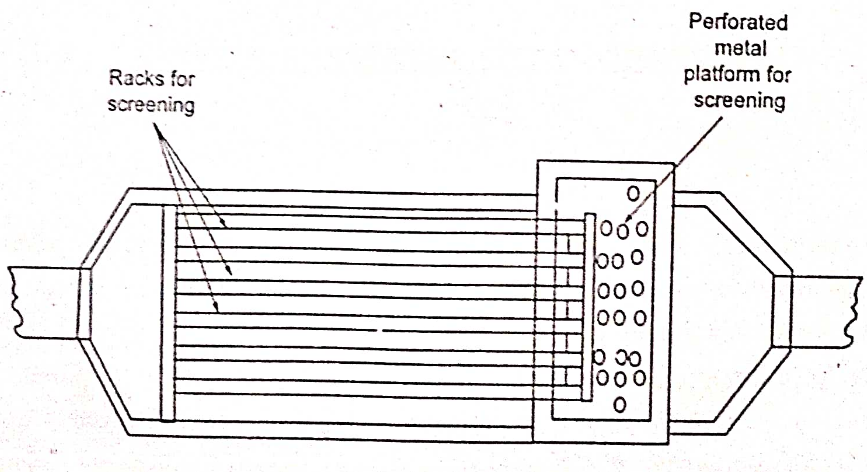
Fine Screening: It has opening of 5 to 40mm in size and used to collect the very smaller particle in wastewater.

Design of Screening chamber:

* It consists of parallel bar, wires (or) grating placed across the flow inclined at an angle of 30°- 60° for effective disposal, the angle is 45°
* Head Loss, $H_L = 0.0729 (V_2 - V_2)$


Direction of flow
30° to 60°


Scraper for cleaning
Perforated cone brush
Bearing for disc
Circular disc screen
Concrete pillar


Racks for screening
Perforated metal platform for screening

Advantages.

⇒ Manually cleaned screens require little (or) no equipment maintenance and provide a good alternative for smaller plant with few screenings.

⇒ Mechanically cleaned screens tend to have less labor cost than manually cleaned screens and offer the advantage of improved flow condition and screenings capture over manually cleaned screens.

Disadvantage:-

⇒ Manually cleaned screens require frequent raking to avoid clogging and high backwater level that cause buildup of a solid mat on a screens.

⇒ The increased raking frequent increase labor cost.

⇒ Removal of this mat during cleaning may also cause flow surges that can reduce the solid-capture efficiency of downstream unit.

⇒ Mechanically cleaned screens are not subject to this problem, but they have high equipment maintenance cost.

Grit chambers:

The grit chamber (or) grit ~~chamber~~ channel, as they are usually called, are the sedimentation basin placed usually after the fine screens and certainly before the primary sedimentation tank. The grit chamber remove the inorganic grit such as sand, gravel and other mineral matter that has a nominal diameter of 0.15 to 0.80 mm. (or) more.

The amount of grit collected is a function of the removal device, it operation, and the quantity of grit in the sewage and therefore, it varies over a wide range. The grit quantity may varies between 0.004 – 0.037 $m^3/1000 m^3$ of sewage for separate sewage system, while this may range between 0.004 – 0.180 $m^3/1000 m^3$ for combined sewage system.

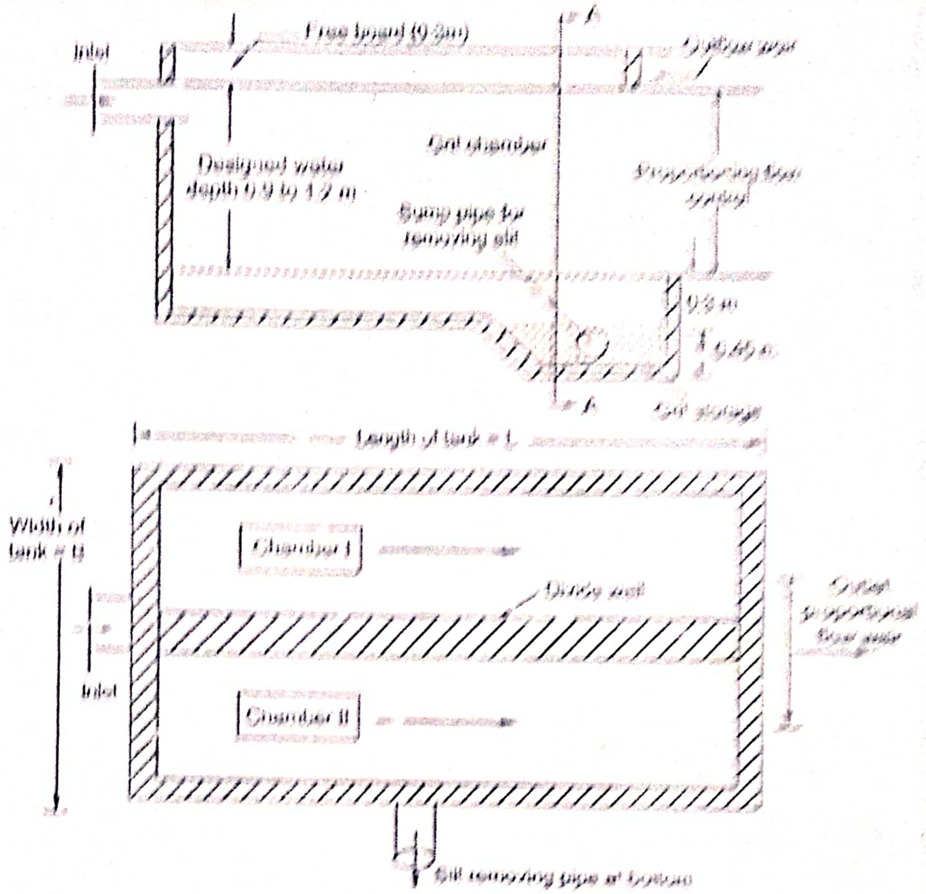
Generally, grit chamber are designed to remove all particles of higher specific gravity of 2.65 (or) so, with a norminal diameter of 0.20mm and more, having settling velocity of about 21 mm/s (at 10°C); although some grit removal channel are designed to remove particle above 0.15mm size having settling velocity of about 15mm/s (at 10°C)

Design of Rectangular Grit chamber provided with a proportioning flow weir at effluent end.

The depth and detention time provided for a grit basin are inter dependent, and are based on the consideration of settling velocity of inorganic particle through water and detention time of about 40 to 60 sec is generally sufficient for a water depth of about 1 to 1.8 m. After fixing the water depth and the detention time, we can easily design the dimension of a rectangular chamber as its length will thus be equal to velocity × detention time.

There should be three separate chamber in parallel one to pass the low flow and other to pass the high flow. This will also help in manual cleaning of the chamber, as one unit can work.

The grit chamber can be cleared periodically at 3 week interval either manually, mechanically (or) hydraulically. Hand cleaning is done only in case of smaller plant. while mechanically (or) hydraulic cleaning is adopted for larger plant. In manual cleaning grit is removed manually by shovels. In mechanical cleaning grit is removed. with help of machines. In hydraulic cleaning grit is removed by the force of water Jet.



The removed grit may contain serious organic matter and can be washed prior to its disposal and the wash water returned to the plant influent. Washed grit may still contain about 1 to 2% of putrescible organic matter.

The silt and grit etc. removed by the grit chamber can be easily disposed off either by burial (or) burning. It cannot be used for preparation of concrete as contain sufficient organic matter.

Primary treatment :-

The objective of primary treatment is the removal of settleable organic and inorganic solid by sedimentation and the removal of material that will float by skimming process.

Approximately 25 to 50% of the incoming biochemical oxygen demand (BOD) 50 to 70% of the total suspended solid and 65% of the oil and grease are removed during primary treatment.

Some organic nitrogen, organic phosphorus and heavy metal associated with solid are also removed during primary sedimentation. The effluent from primary sedimentation unit is refered to as primary effluent.

Working principle of sedimentation tank :-

The main principle involved in the sedimentation tank is to reduce the flow velocity of water which allow the major number of suspended particles to settle down. The velocity with which the particle is settling is known settling velocity.

The number of suspended particle collected at bottom of the tank is based on different factor like shape and size of tank, size of particle, temperature of water, flow velocity, detention period etc.

The settling velocity of the particle "V_s" is calculated by Stokes law which was obtained from.

$$V_s = \sqrt{\frac{4}{3}\frac{g}{C_d}\frac{(\rho_s-\rho)d}{\rho}}$$

where V_s ⇒ Settling velocity of particle

g → Acceleration due to gravity

ρ, ρ_s ⇒ Mass density of water and particle.

d ⇒ diameter of particle

C_d → Drag Coefficient and it is obtained by knowing the Reynold's number (R).

Design parameter:-

To design sedimentation tank following element are required to the consideration: over flow velocity, Detention period, Flow through velocity, Dimension of the tank, Sludge zone depth, Efficiency.

Over flow Velocity (V_o):

The over flow velocity is calculated from the formula.

$$V_o = \frac{\text{Discharge}}{\text{Surface area}} = \frac{Q}{B \times L}$$

In general over flow velocity of sedimentation tank = 12 to 18 $m^3/day/m^2$

Flow Through Velocity (v):

The velocity of water with which it travel from inlet to outlet of sedimentation tank is called flow through velocity (v). The allowable flow through velocity of water is sedimentation tank is 0.005 m/s

$$\text{Flow through velocity}, V = \frac{\text{discharge}}{\text{area}} = \frac{Q}{B \times H}.$$

Dimension of Sedimentation tank:

The basic dimension length, breadth, depth of tank are calculated from the volume of the tank and over flow velocity.

The breadth of sedimentation tank should be provided is 10 to 12m, when the length of tank should be at least 4 times the breadth of tank. The depth of tank should be 3 to 4.5m.

Area (A) = Volume of water / over flow velocity

Sludge Zone depth:

Sludge zone depth is used to collect the sludge which is nothing but settled particle. It is provided only when removal of the sludge takes places manually. It is limited to 0.8 to 1.2 meters.

Efficiency:

Efficiency is nothing but the performance of Sedimentation tank. It is maximum when the maximum amount of suspended particles in the raw ~~material~~ water are separated. In Sedimentation tank, efficiency purely depend upon the settling velocity and over flow velocity.

$$\text{Efficiency of Sedimentation Tank } (\eta) = \left(\frac{V_s}{V_o}\right) \times 100$$

Design Details:

1) Detention period : for plain Sedimentation : 3 to 4h and for Coagulated Sedimentation : 2 to 2.5h.

2) Velocity of flow : Not greater than 30 cm/min (Horizontal flow).

3) Tank dimension : L:B = 3 to 5:1. Generally L = 30m (Common) maximum 100m. Breadth = 6m to 10m. Circular. Diameter not greater than 60m. Generally 20 to 40m

4) Depth 2.5 to 5.0 m (3m)

5) Surface Over flow Rate: For plain Sedimentation 12000 to 18000 L/d/m² tank area. for thoroughly flocculated water 24000 to 30000 L/d/m² tank area.

6) Slopes: Rectangular 1% toward inlet and Circular 8%

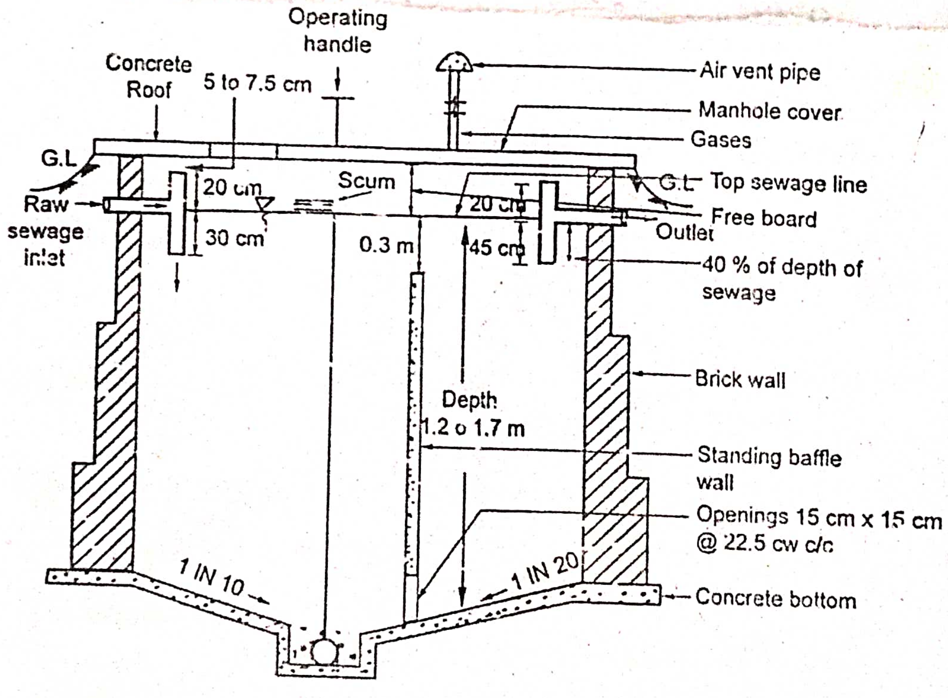
7.

Septic Tank:

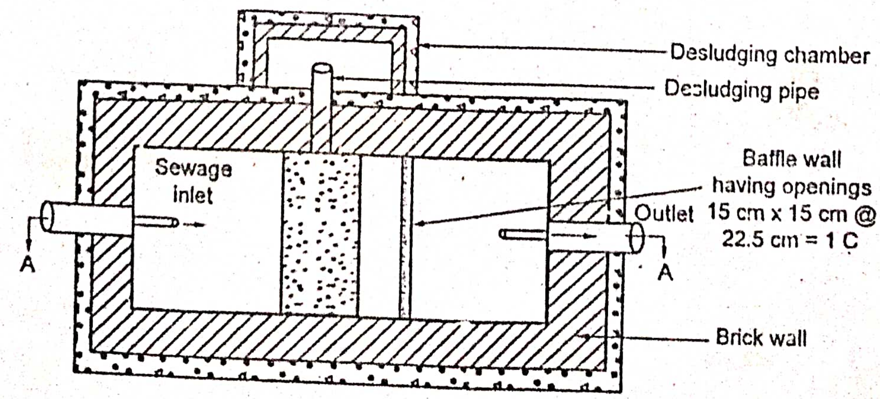
A Septic tank may be defined as a primary sedimentation tank with a longer detention period and with extra provision for digestion of the settled sludge. Since the the digestion of the settled sludge is carried out be anaerobic decomposition process, the septic tank unit is generated classified under the unit which work on the principle of anaerobic decomposition of the settled sludge, foul gases will be evolved in the tank and as such a septic tank will be a completely covered tank provided with a high vent shaft for escape of gases.

A Septic tank, is thus a horizontal continuous flow type of a sedimentation tank directly admitting raw sewage and removing about 60 to 70% of this dissolved matter from it. The effluent from such a tank will be sufficiently foul in nature and will have to disposed of either for such surface irrigation (or) in cess-pola (or) soak pits (or) to be treated in trickling filters before disposing it of in water courses as will be discussed a little late. The sludge settled at the bottom of the tank and the oil and greasy matter rising to the top surface of sewage as scum are allowed to remain in the tank for a period of several months, during which they are decomposed by the anaerobic bacteria to form gases and liquid by the process of sludge digestion. The resultant sludge so obtained will consequently be much less than that obtained in ordinary settling tank.

Septic tank are generally provided in area where sewers have not been laid and for catering to the sanitary disposal of sewage produced from isolated communities, schools hospital, hotel other public institution etc.



Sectional Elevation A - A



Plan

The plan and section of a typical septic tank is designed to prevent direct currents between the tank inlet and output. This ensures effective sedimentation and is achieved by using pipe tees with submerged ends as inlet and outlet (or) alternatively a better arrangement is to provide hanging baffle in front of inlet and outlet. The T-pipe (or) the baffle at the outlet will also help in retaining the scum in the tank.

It may be noted that holding of scum in the tank not only frees the effluent from it but it also desirable to hold back odours and to create a sort of heat insulation which aids the bacterial action. The tank is generally covered at top with R.C.C slab. Man hold covers are provided in the top slab to permit inspection and maintenance. The foul gases produced by the anaerobic decomposition of deposited sludge are separately removed through a vent pipe projecting sufficiently high above the ground so as not to cause nuisance to the neighbouring areas. The sludge deposited and digestion is removed at an interval of 6 to 12 months into a side sump well through a pipe under hydrostatic head (or) with the help of a portable pump.

Design Consideration :-

The Septic tank will be designed like ordinary sedimentation tank with following data.

(i) Capacity of Septic Tank :-

The volume of liquid which a Septic tank can accommodate is called its Capacity. It should having a Capacity of storage the sewage flow during the detention period and additional volume of sludge for 6 month to 3 years depend on periodicity of cleaning.

The sludge and the scum will accumulated in the tank varying rates depending upon the characteristics of raw sewage and the efficiency of the sedimentation and digestion. The rate of accumulation of sludge has been recommended as 30 litres/person/year.

The minimum capacity of a Septic tank for about 8 to person may be kept 2.250 L and 1400 L.

(ii) Inlet and Outlet baffles :-

The baffles or tees should extend upto top level of the scum but must stop a little below the bottom of the covering slab, so as to allow for free movement of gases.

(iii) Detention period:-

The sludge retention (or) detention time for the influent varies from 12 to 36 hours. and in practice it is taken as 24 hours for septic tank.

(iv) Length to width ratio:-

Septic tank are usually rectangular with their length at about 2 to 3 times the width. width should not be less than 90 cm. The depth of tank generally ranges between 1.2 to 1.8m

Disposal of the Effluent from the Septic Tank:-

The effluent coming out from the septic tank is no better than the effluent of an ordinary sedimentation tank. It contain large amount of putrescible organic matter. It's BOD is high (100 to 200 mg/l). The effluent should be disposed carefully to cause minimum nuisance.

There are three method of disposal of septic tank effluent are usually adopted.

1) Soil absorption system.
2) Biological filter and.
3) Upflow anaerobic filters

Soil Absorption System:

It involves the disposal of effluent on land and can be adopted only when sufficient land is available and the soil is sufficiently porous to give percolation rate not exceeding 60 minutes.

The percolation rate of a soil or a ground is defined as the time in minutes required for ~~seepage~~ seepage of water through that ground by 1 cm. Higher percolation rate naturally would reflect porous soil. The soil absorption system may be of following two types

ⓐ Seepage pit or Soak pit and ⓑ Dispersion trench.

Disposal in Soak pit:

A soak pit is a circular pit, through which the effluent is allowed to be soaked or absorbed into the surrounding soil. The soak pit may be either be filled with stone aggregate or may be kept empty. When the soak pit is empty, the pit is lined with bricks, stone and concrete block with dry open joints

(6) Disposal in Absorption Trenches :-

In this method the septic tank effluent is allowed to enter into a masonry chamber from where it is uniformly distributed through an underground network of open jointed pipes into absorbed trenches called as dispersion trenches.

Dispersion trenches are not recommended in area where fibrous root of trees (or) vegetation are likely to penetrate like system and cause blockages.

It may be adopted on soil having percolation rate not exceeding 60 minutes.

The minimum absorption area of the pits (or) trenches required shall be worked out on the basis of the max allowable rate of effluent application which can be computed by using empirical equation.

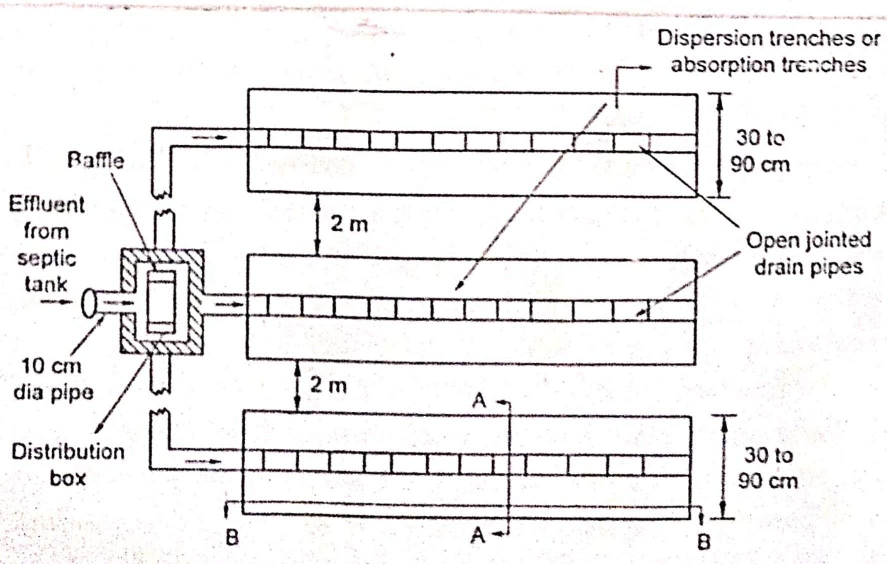
$$q = 130\sqrt{t}$$

where, q = max. rate of effluent application in $l/m^2/day$ of leaching surface.

t → standard percolation rate in minutes.

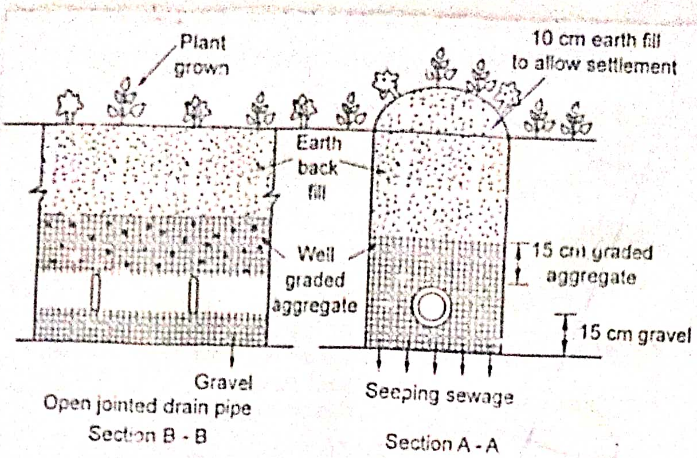
Location of Sub-Surface absorption system:-

A sub-surface dispersion system shall not be installed closer than 18m from any sources of drinking water such as well to mitigate the possibility of bacterial pollution of water supply.



(a) Plan (Under ground)

11.



(b) Section of Dispension Trench

Advantage of Septic tanks:

(i) Septic tank can be easily constructed and don't require any skilled supervision during construction.

(ii) Their cost is reasonable compared to the advantages and sanitation they offer in rural (or) semi urban area.

(iii) They are best suited for isolated rural areas and for isolated hospital, building etc.,

Disadvantage of Septic tanks:

(i) They require too large size of serving several people..

(ii) Leakage of gases from the top cover of septic tank may cause bad smell and environmental pollution.

(iii) The working of a septic tank is unpredictable and non-uniform.

Biological Filters.

It is suitable for treatment of septic tank effluent where the soil is comparatively impervious (or) in water - logged area (or) where limited land area is available. In a biological filter the effluent from septic tank is brought into contact with suitable medium the surface of which become coated with an organic film. The biological filter requires ample ventilation and an efficient system of under drains leading to an outlet as discussed earlier.

The depth of medium should be 1.4 m but never less than 0.9 m. Biological filters may either be rectangular (or) circular. A series of fixed channel (or) rotating arm distribution may be used for distribution the effluent on the media. Adequate ventilation of biological filter is essential. Air vents communicating with the floor level of the filter should be provided. Normally the filter should not be covered but wire netting may be used to prevent falling of leaves fouling the surface of the filter. (or) blocking the ends of vent pipe.

Upflow Anaerobic filters.:

⇒ The upflow type of filter operating under submerged condition. Are also used for giving secondary treatment to the effluent of a septic tank before its final disposal.

⇒ Such filter are like biological filters are used in area which do not permit land disposal such as in area of high water table (or) in comparatively less porous area (or) at places where sufficient land is not available.

⇒ The capacity of the unit is 0.04 to 0.05 m^3 per capita (or) ⅓ to ½ the liquid capacity of the septic tank it serves. BOD removal of 70% can be expected and the effluent is clear and free from odour and nuisance.

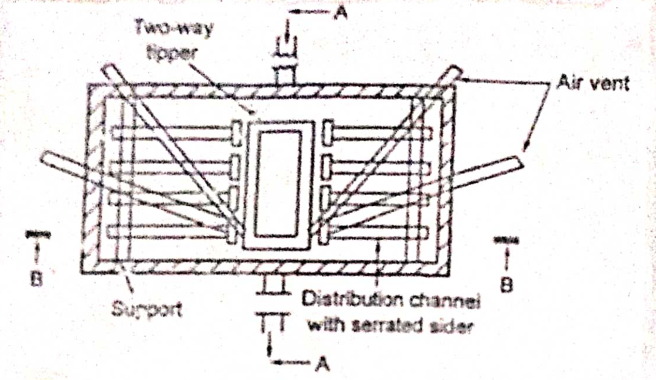
⇒ Single and double chambered rectangular anaerobic filters are used in conjunction with septic tank.

⇒ In a single chambered rectangular upflow tank the chamber is packed with coarse material and the size of the packages media should be 20mm. The stone media rest on a perforated

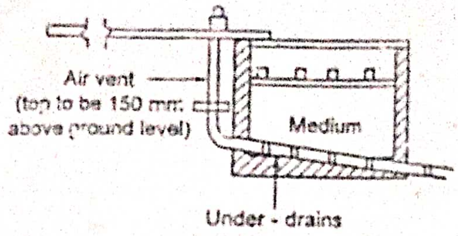
⇒ Concrete false bottom slab. The effluent from the septic tank enter the bottom of the filters chamber through @ 150mm dia pipe. and is distributed upward through the media from a perforated slab at the bottom.

⇒ The vertical inlet is fitted with a tee at the bottom one branch of which lead to the filter and the other branch is kept plugged while the filter functions.

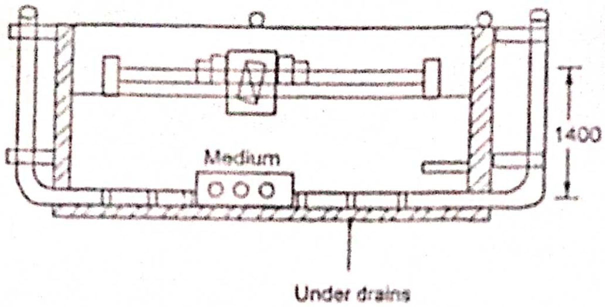
⇒ The plug can be removed to facilitate emptying into an adjoining chamber and cleaning the filter where required. The.



(i) Plan



(ii) Section A - A



(ii) Section B - B

The effluent from the top of the bed is allowed to escape over a V-notch. The still level is kept 150mm above.

→ The filter consist of two inter connected compartment. The first chamber is filled to a depth of 0.55m with 20mm size coarse aggregate.

→ The septic tank effluent falls through a perforated tray over the medium in the first compartment and enter the second compartment directly from the bottom.

→ The effluent passes up through the medium in the second chamber and escapes over a V-notch placed 75mm above the top of the medium. By this arrangement the time of travel of the effluent through the filter is lengthened.

On-Site Sanitation:

Sanitation is an extensive term which includes safe disposal of human waste, waste water treatment effective disposal of solid waste, water supply, prevention from spreading diseases, to maintain the hygiene food and habit.

Open defecation is still in practice in several village and it causes serious social, health, economic and environmental issues. Openly left human waste help in breeding and transmission of pathogens, which carry disease and infection. The problem is most active for children, women and young girl.

There are different method and requirement for the construction of the sanitation facilities. The method adopted can lead to increase public participation and ownership, the development of Job creation and skill development and contribute to the long-term sustainability of the facility.

Impacts of good Sanitation :-

Good sanitation has the following impact on individual and on community are to improves health, decrease in disease and death, improves man-day, improves productivity, improves water quality, minimizes incidence of drop-out in school particularly girl student.

Techniques for on-site Sanitation.

There are several technologies for human waste disposal from household toilet. Selection of technology should be based on socio-cultural and economical aspects of receivers and hydro-geological condition and soil type of the planned area.

Single offsite pit water seal toilet:

The pit is constructed away from the bending platform and connected to the same by a pipe (or) drain, through a junction chamber. The honey comb type wall construction and that help percolate effluent from pit into soil. There is ~~not~~ no vent pipe with pit latrine as gases produced in pit are diffused in soil.

Single pit toilet with provision of double pit:

In rural area several time the village can't afford the cost of a double pit toilet at one time. This second pit is constructed at large stage. before the first pit is filled. Advantage of having a second pit at ~~large~~ later stage is just is that one time initial expenditure for construction of toilet is reduced. These two pit are used alternatively. After first pit is filled, human waste is diverted to the second pit.

11

Greywater harvesting:

Water used in day today life has increased based on the habitat of the people and due to luxury life style.

However, the wastewater generated from baths, showers, washing machine, dishwashers and sink are called as greywater, which typically makeup between 50 - 80% of a household's waste water.

Approximately one third of the water used in ~~hand~~ household in toilet, which comes into contact with human waste and it is known as black water.

But the grey water is much easier to treat when compared to black water. Greywater free from fecal matter and disease - causing bacteria

If recycled properly, greywater can save roughly 70 litres of potable water per person per day in domestic household therefore greywater recycling is one of a number of water solution that we should look to in order to decrease our usage.

Greywater is never going to be safe to drink, even when treated. However, the domestic greywater can be used to flushing toilet, wash cloths and gardens.

Direct use system:

Using this greywater is comparatively simple. You can either draw off it directly from the bath (or) sink (or) fit a valve to the external waste pipe allowing to direct the water to a water tub, so it can be used to water the flowerbed.

Biological System:

Sand filter method:

The initial filtration can be simply achieved using a sand filter that remove any large particle present in the greywater. It enter the top of the sand filter and travel down through the sand via gravity, with the sand removing any sizeable particle.

Once the greywater has been pre-treated it can filtered using a very simple sand filter consist of four layer of different size of soil.

The Top Layer is roughly a feet depth of human rich top soil, which sit on a bed of very fine building sand, which in turn sit on a layer of coarse sand

Finally, there is a large stone at the bottom to achieve excellence drainage. The water is initally pumped in at the top of sand filters where it travel down via gravity through the 4 Level. Most of the filtration takes place in the topsoil Level where Soil Organisms feed and reproduce using the nutrients in the soil essentially purifying it.

Mechanical filters:-

It is Comparatively simple process to undo the U-bend under a sink and Capture wastewater in a bucket, which you Could then manually pour into the Cistern of a toilet.

However practically, this is quite a time-Consuming Job for Something that can be easily automated.

Benefits of Greywater Harvesting:-

Greywater for flushing toilets:-

Typically, around one third of ~~hould~~ house hold water is used for flushing the toilet, but domestic greywater Can be used to fulfil this purpose saving valuable potable mains water Once the greywater was gone through the Complete filter process and treated with chemical to kill all micro organisms it can be used for toilet and bathroom.

Greywater for watering plants:

The greywater can be used in combination with an irrigation system to water the garden automatically. This is good to have in place because it target specific area of garden so it is more environmental friendly way to care for it. The water does not need to be treated with chemical as any organic material remaining in the water can be absorbed by the plant. It is not recommended to use this type of water with home grown vegetable.

Recycled water can used for various ways like cleaning, washing, gardening etc. and reduce the impact of water scarcity.

The result of the greywater harvesting components to maintain the nature environment healthy by avoiding of entering the pollutant into the river (or) any water bodies.

1

Unit :- III : Secondary Treatment of Sewage.

Activated Sludge process. :-

The activated Sludge process provides an excellent method of treating either raw sewage (or) more generally the settled sewage. In this process the sewage effluent from primary sedimentation tank is normally utilised and is mixed with 20 to 30 percent of own volume of activated sludge, which contain a large concentration of highly active aerobic micro-organisms.

(i) BOD removal is upto 80 - 95%

(ii) Bacteria removal is upto 90 - 95%.

In this process, a rather close degree of control is necessary in operation to ensure

(i) Supply of oxygen is present.

(ii) Continuous mixing of sewage and the activated sludge.

(iii) The ratio of volume of activated sludge added to the volume of sewage being treated is kept periodically constant.

When a new plant is put into operation, a period of about 4 weeks may be required to form a suitable return sludge, and during this period almost all the sludge from the secondary sedimentation tank will be returned through the aeration tank.

Various Operation and Unit of Treatment.

Primary Treatment Units:-

→ The removal of grit and larger solid by screening in grit chamber and primary sedimentation tank is generally considered necessary before aeration.

→ Accordingly, grit chamber removal screening and primary sedimental are considered necessary for a conventional sludge process.

→ This period of primary detention may vary with the size of plant and characteristic of sewage, but tank size will generally provide an flow of about 40000 l/m² of plan area per day, depth of about 2.4 m the detention time will be 1.4 hrs.

Aeration Tank:-

The sewage from the primary sedimentation tank flow to the aeration tank and is mixed with the activated sludge. The aeration tank are normally rectangular tank of depth 3 to 4.5 m, width of 4 to 6 m, the length range between 20 to 200 m and the detention period is 4 to 8 hours for municipal sewage. Air is continuously introduced into these tanks.

Method of Aeration.

(i) Air diffusion method.
(ii) Mechanical aeration method.
(iii) Combined aeration.

(1) Air diffusion method

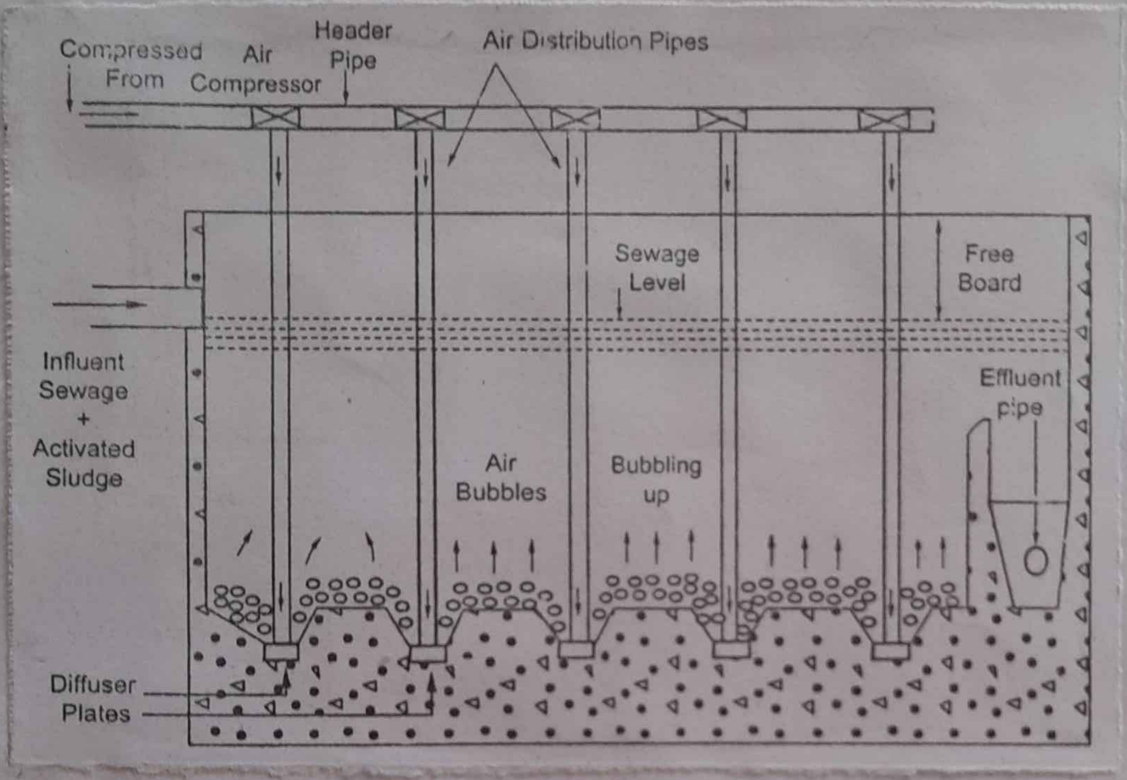
⇒ In this method compressed air under a pressure of 35 to 70 kN/m^2 (0.35 to 0.7) kg/cm^2 is introduced into the aeration chamber, through diffusion plates (or) other devices called diffusers.

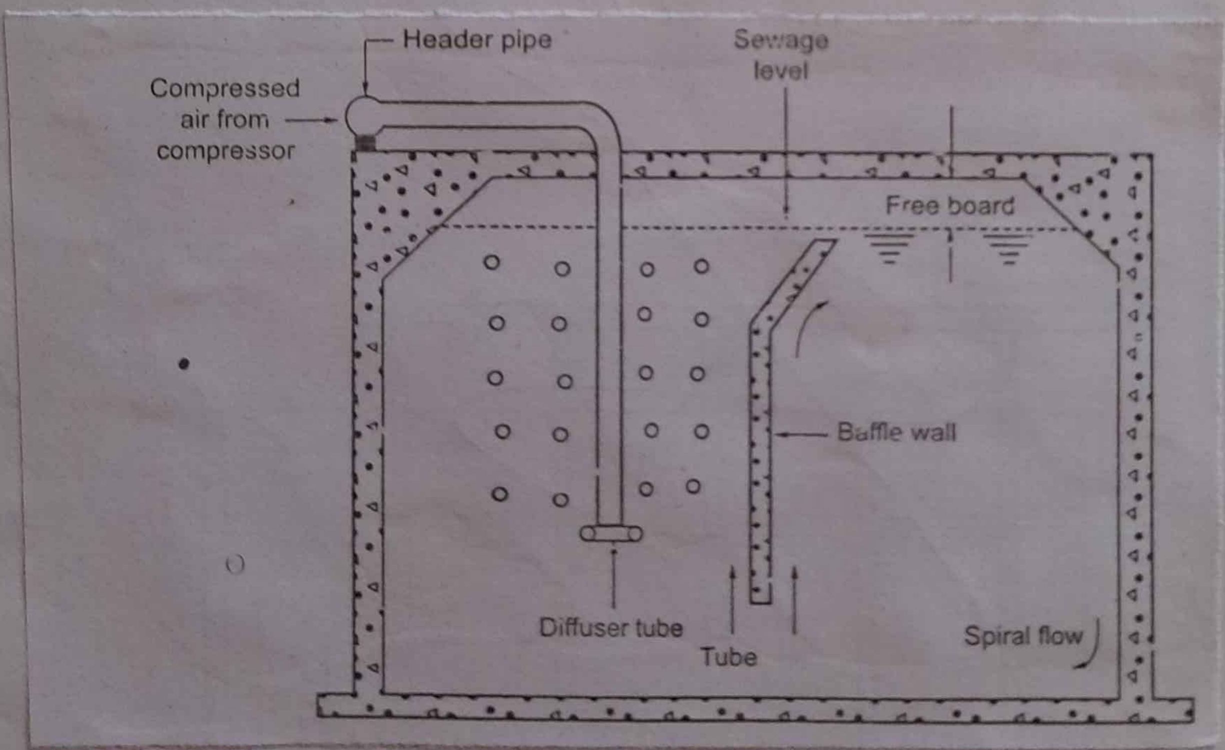
⇒ plates are generally square in shape with dimension of 30 cm × 30 cm and they are usually 25mm thick. These plates are fixed at the bottom of aeration tank and can be taken out for cleaning without emptying the tank.

⇒ The effective areas for the above standard plate and tube diffuser work out to 780 cm^2 and 1160 cm^2, respectively.

⇒ Two types of aeration tank

(i) Ridge and furrow type (ii) Spiral flow types.


Compressed From Air Compressor
Header Pipe
Air Distribution Pipes
Sewage Level
Free Board
Influent Sewage + Activated Sludge
Effluent pipe
Air Bubbles
Bubbling up
Diffuser Plates


Header pipe
Sewage level
Compressed air from compressor
Free board
Baffle wall
Diffuser tube
Tube
Spiral flow

In Ridge and furrow type the air is forced upward through diffuser plates placed at the bottom of the furrow. In Spiral flow type of aeration tank air is introduced near the side of the tank. The compressed air can be supplied either through a plate diffuser (or) a tube diffuser. In order to determine the capacity of air compressor, it is necessary to determine the quantity of air that will be required.

The usual rate adopted is 100 m³/day of air per kg of BOD removal with respect the BOD removal. Since only about 5% of oxygen in the air is actually involved in the biochemical action.

Extend of BOD removal desired in ppm	Quantity of returned sludge as percentage of sewage flow.
150	25
250	30
300	35
400	40
500	48
600	53

The volume of returned activated sludge from secondary clarified to the aeration tank, mainly depends upon the extend of BOD desired to be removed.

② Mechanical Aeration.

⇒ In the air - diffusion method as pointed out above a lot of Compressed air (90 to 95%) gets wasted, as it simply escapes through the tank without giving oxygen to the sewage; although it helps in bringing about the required agitation of sewage mixture.

⇒ The only sewage so as to bring it in intimate contact with the atmosphere. The aeration period depend on the mechanical process adopted for agitation. It generally varies between 6 to 8 hours. The quantity of the returned sludge is usually about 25 to 30 percent of the flow of sewage in mechanically aerated aeration tank.

⇒ Types of Surface Aeration.

(i) Haworth system.
(ii) Sheffield system.
(iii) Hartley system.
(iv) Simplex aeration method.

(I) Haworth system and Sheffield system.

⇒ 1m deep aeration tank is divided by thin walls in a series of long and Comparatively narrow channel (70m x 1.5m) and given a total travel of about 1.5 km. At about midway

4.

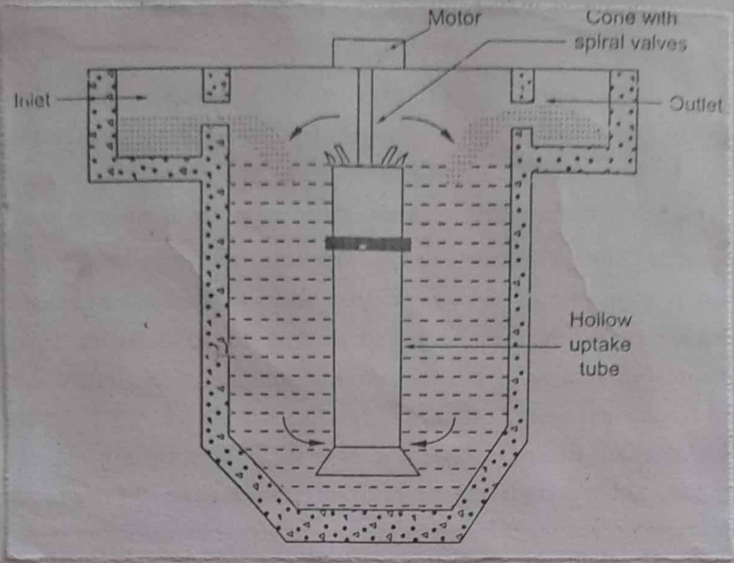
of its length, two rows of paddles, revolving at 1.5 rpm are provided with a horizontal shaft crossing each channel for the aeration of sewage. The liquid is imparted a velocity sufficient to keep the sludge in suspension the detention period of these tank is about 15 hours, and the returned sludge ranges between 15 to 20% of the sewage flow. This method is generally used at Sheffield in England. and hence also known as Sheffield system of mechanical aeration.

③ Hartley System:-

It is similar to the above Haworth system with the modification that here the paddles are kept inclined at some angle with the vertical and are fixed at the end of the channel the diagram baffles are provides across the channel to maintain spiral flow.

④ Simplex Aeration method:-

A tank square in plain with hopper bottom is generally used. Sometimes a rectangular tank may also be used, but in that case, it must be divided suitably into square unit.

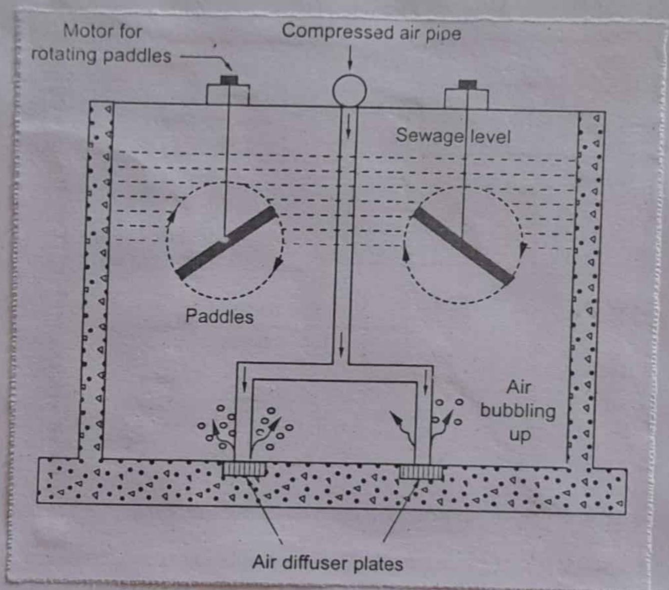


A short Cone with Spiral vanes is provided at the top of the uptake tube and it is driven by a motor placed at the top of the tank. The Cone is revolved at a high speed (60 rpm) which sucks the mixed Liquor through the uptake tube by creating suction at the bottom and formed in this process, which bring about satisfactory aeration of Sewage. Sewage also get thoroughly mixed up with the activated sludge during its downwards Journey.

5.

3. Combined Aeration

In this the diffused air aeration as well as the mechanical aeration are Combined together in a single unit. A well known type of such an aeration unit is Called Dorron aerator.



In this type of an aerator, the aeration of Sewage is achieved by diffusing air through bottom diffuser plate as well as by rotating paddles at 10 to 12 rpm. Spiral motion.
So set up bring about the required aeration. such an aeration is very efficient detention period is smaller (3 to 4 hours) and require less amount of Compressed air as Compared to the diffused air aeration.

Secondary Sedimentation Tank:

The sewage flow to the final sedimentation tank from the aeration tank there are no floating solids here, providing for the removal of scum (or) floating are not needed. The suspended particle in the aeration tank effluent are light in weight and are thus markedly influenced by current.

Therefore, in these secondary settling tanks, a considerable length of overflow weir is desirable, to reduce the velocity of approach. A good design should provide a weir overflow rate not exceeding 150 m³/day per lineal metre of weir. This value is based on average flow of sewage and not to the mixed flow.

The another important factor is solid loading which governs the design of secondary basin. This is because of the fact that in the secondary tank hindered settling occurs, and hence the settling velocity of discrete particle may not govern its design as in the case of the primary sedimentation tank. The solid loading rate based on mixed liquor flow to the settling tank may be kept at about 100-150 kg/m² per day at average flow. and should not exceed 250 kg/m² per day at peak flow. such rate ensure adequate sludge thickening and concentrated sludge returns.

The surface area for activated sludge settling tank should be designed for both overflow rate and solid loading rate and large value adopted.

The detention period for such a sedimentation tank may be kept between 1½ - 2 hr. as the same is usually found to give optimum results.

The length of depth ratio of these tank may be kept at about 5 for circular tank and 7 for rectangular ones. The depth may be kept in the range of 3.5 to 4.5 m.

Final settling is always required in an activated sludge plant, so as to provide the return activated sludge.

Trickling filter

⇒ These files also called as percolating filters (or) sprinkling filters, Consists of tanks of Coarser filtering media, over which the sewage is allowed to sprinkle (or) trickle down by means spray nozzles (or) rotating distribution. The percolating sewage is collected at the bottom of the tank through a well designed under drainage system.

⇒ Organic matter from the sewage influent is also absorbed on the biological film, which is formed by micro-organisms around the filtering media particles. In the outer portion of this film of biological mass (or) slime layer, the organic matter is degraded by the aerobic bacteria. As the micro-organisms grow, the thickness of slime layer increase. and the diffused oxygen is Consumed by the upper portion of the slime layer, thereby Creating an anaerobic environment near the surface of the media particle. As the slime layer increases the thickness,

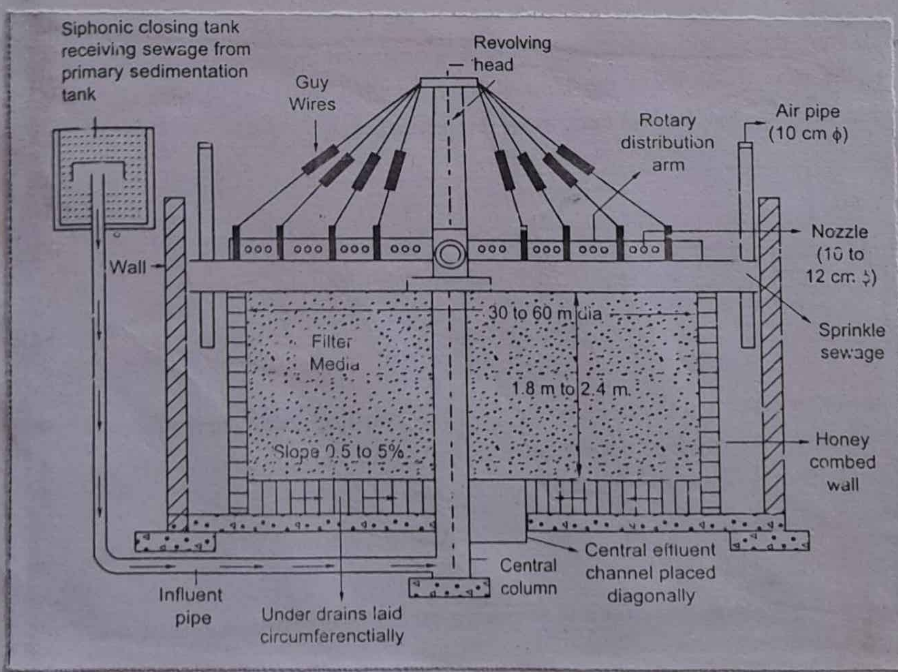
⇒ In order to ensure the large scale growth of the aerobic bacteria in the biofilm. sufficient quantity of oxygen is supplied by provided suitable ventilation facilities in the body of the filter and also to some extent by the intermittent functioned of the filter.

7.

Construction and operation :-

→ Trickling filter tank are generally constructed above the ground. They may either be rectangular (or) more generally circular. Rectangular tank filters are provided with a network of pipes having fixed nozzles, which spray the incoming sewage into the air, which then falls over the bed of the filter under gravity.

→ The circular filter-tanks on the other hand are provided with rotary distributory having a number of distributing arms. These distributor rotate around a central support either by an electric motor. (or) more generally by the force of reaction on the spray.



Such self-propelled reaction type of distributor are now a day preferred and used. The rate of revolution vary from 2 RPM for small distributor to less than ½ RPM for large distributors.

⇒ The advantage of having two or more arm is not only to get reaction sufficient to rotate the entire mechanism but is also to pass the fluctuating demands by taking low flow in two arm and the remaining two arms should come into operation only at the time of higher flows. The distributing arm should remain about 15 to 20 cm above the top surface of the filtering media in the tank.

⇒ These block laid on the reinforced concrete floor which is slope at 0.5 to 5% towards the main effluent channel. The main effluent channel may be provided diagonally adjoining the central column of the distributor or may be provided along the circular periphery of the filter.

⇒ The flow in the channel has characteristics similar to the flow in a wash-water through a rapid sand filter used in water supplies. The slope of the channel should be sufficient to ensure a minimum flow of velocity about 0.9 m/sec.

Types of Trickling Filter

(i) Conventional Trickling Filter.

⇒ It is also known as ordinary trickling filter (or) standard rate (or) Low rate trickling filter:

(ii) High rate trickling filter

→ The high rate filter have some modern advancement also function with same lines & same Construction detail. But with the difference that provision is made in them for recirculation of sewage through the filter, by pumping a part of filter - effluent to primary settling tank.

Sequencing Batch Reaction process :- (SBR)

The sequencing batch reactor (SBR) process utilizes a fill and draw reactor with Complete mixing during the batch reaction step (after filling) and where the subsequent steps of aeration and clarification occur in the same tank. All SBR system have five step in common,

① fill ② react (aeration) ③ Settle (sedimentation/ clarification) ④ Draw (decant) ⑤ idle.

Each of these steps is illustrated on figure and table. For Continuous flow applications at least two SBR tank must be provided so that one tank receives flow.

Sludge wasting in SBR

→ Sludge wasting is another important step in the SBR operation that greatly affect performance. waste is not included as one of the five basic process step because there is not set time period within the cycle dedicated to wasting.

→ The amount and frequency of sludge wasting is determined by performance requirement as with a Conventional

9.

Continued flow system. In an SBR operation, sludge wasting usually occur during the react phase so that a uniform discharge of solid (including fine material and large floc particles) occur.

→ Unique feature of the SBR system is that there is no need for a return activated sludge system.

Application of process kinematics.

The change in substrate concentration with time can determine by starting with the substrate mass balance for a continuous flow complete-mix reactor.

$$\frac{ds}{dt}V = QS_0 - QS + r_{su}V.$$

where $$r_{su} = -\frac{\mu_m X S}{Y(K_s + S)}$$

Other term as defined previously. Because Q = 0 for the batch reaction, the substrate concentration

$$\frac{ds}{dt} = -\frac{\mu_m X S}{Y(K_s + S)}$$

Integration of above equation with respect to time yields.

$$K_s \ln \frac{S_0}{S_t} + (S_0 - S_t) = X \left(\frac{\mu_m}{Y}\right) t.$$

where S_0 ⇒ Initial substrat Concentration @ $t = 0$ mg/l.

t ⇒ time, d

S_t ⇒ Substrate Concentration @ t mg/l.

The same kinetic expression applies for nitrification where $X = X_n$ the nitrifying bacteria Concentration, $S = N$, the $NH_4 - N$ Concentration and the monod model kinetic Co-efficient are submitted.

$$K_n \ln \left(\frac{N_0}{N_t}\right) + (N_0 - N_t) = X_n \left(\frac{\mu_{mn}}{Y_n}\right) t.$$

where, $N_0 = NH_4 - N$ Concentration @ $t = 0$, mg/l.

$N_t = NH_4 - N$ Concentration @ time t, mg/l.

X_n = nitrifying bacteria Concentration, mg/l.

The maximum Specific growth rate for nitrifying bacteria is affected by the DO Concentration

$$K_N \ln \frac{N_0}{N_t} + (N_0 - N_t) = X_n \left(\frac{\mu_{mn}}{Y_n}\right)\left(\frac{DO}{K_0 + D_0}\right) t.$$

The above batch kinetic equation can be used to determine of the react period aeration time selected for SBR design is sufficient to provide the desired amount of degradation.

⇒ The overall amount balance can be done first, assuming a certain amount of substrate is remove to determine the biomass concentration (x and X_n) for use in equation.

⇒ The time needed for dissolved BOD removal is relatively short (less than 1h) due to batch kinetics for treating domestic waste water, resulting in a relatively low initial dissolved BOD concentration.

⇒ For nitrification, SBR aerobic react time may range from 1.0 to 3.0 h.

Process Design of SBR

⇒ The following SBR design example requires selecting key design condition and evaluated the results to determine if design is appropriate

⇒ The key design condition selected are

① The fraction of the tank content removed during decanting.

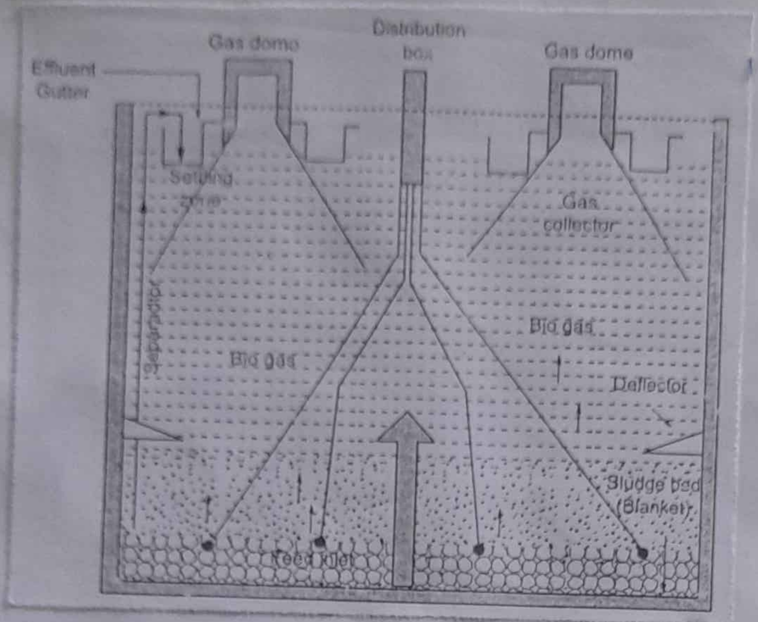
② The settle, decant and aeration and times.

USAB Reactor:

The upflow anaerobic sludge blanket reactor maintain a high concentration of biomass through the formation of highly settleable microbial sludge aggregates. The waste water flow upwards through a layer of very active sludge to cause anaerobic digestion of organics of the waste water. At the top of the reactor. three phase separation between gas - solid liquid take place. The process is suitable for both soluble waste water as well as waste water containing particular matter

The large scale adoption of this technique for teaching municipal waste water is comparatively of recent origin, although the system was developed as late as in the year 1979 by a. Netherland Scientist Mr. Gatze Lettinga. The system, however has proved very promising and several such treatment plants have comes into existence in countries like simple technique was first of all adopted in the year 1989, when a demonstration sewage treatment plant (STP) of 5 MLD capacity was initially installed at 36 MD plant at Kanpur, 14 MLD plant at Mirzapur (U.P).

The reactor consist of an upflowing treatment tank, provided with a feed inlet distribution system at the tank bottom A gas solid liquid separation (GSS) device is provided at the top to help provide a quiescent zone at the top of the reactor.



The waste water enter the tank from the bottom, and flow upward through the sludge bed, which get formed during the process itself. The sludge bed develop micro-organisms capable of flourishing in an oxygen deficient environment. The sludge bed traps the suspended organisms of the upmoving waste water. The suspended solid trapped in the sludge bed are degraded by the anaerobic and anaerobically working facultative bacteria, producing methane and Carbon-di-oxide. The bio gas produce during the anaerobic decomposition helps in providing gentle mixing and stirring of the biomass, thereby increasing the efficiency of decomposition, reducing the BOD and suspended solid of the waste water.

The methane (or) bio gas is collected at the top of the tank in a gas collector, from where it can be withdrawn.

for use as a by-product; while the water supply sludge mixture is made to enter a settling tank where the Sludge Settling down and flows back into the bottom of the reactor.

The UASB evidently operates as a suspended growth system, with no packing material in the reactor. In this system the microbes attach themselves to each other, (or) to small particles of the suspended matter of sewage to form granules (or) agglometerates and ultimately the sludge bed.

Retention of the bacteria containing Sludge in the reactor is one of the most important features of the UASB process. The bacteria in the Sludge continue to perform their function of treating the incoming effluent. The continuous bacterial presence enables retention time in the reactor to be reduced to about 6-8 hours. As compared to at least 30 hours. that is required in Conventional Sewage treatment system.

The treatment effluent is collected in gutter and discharge out of the reactor. The methane generated can be used as a gas for domestic (or) industrial use. It may also be used for generation of electricity for running the plant. after appropriate dehydration and cleaning.

This process can be reactivated even after the plant remain shut down for days (or) months, or after power breakdown and interruption in waste water supply.

Advantage of UASB system :-

1) The space requirement of the system is quite comparable to that of an activated sludge system (ie) about 0.5 acres per MLD, as compared to 2.5 acres per MLD required for oxidation ponds 1.5 acres for aerated lagoons.

2) The capital cost investment of such plant is about ₹ 20 Lakh/MLD as compared to about Rs. 35 Lakh/MLD for activated sludge plant, Rs. 7.5 Lakh/MLD for oxidation ponds and 15 Lakh/MLD for aerated lagoons.

⇒ Electricity consumption in this system is quite low, and the system is quite capable of withstanding long power failures.

⇒ The sludge production in the system is low and the produced sludge is having quick dewatering characteristics.

⇒ The system enables quicker sludge, digestion as compared to the conventional digestors.

⇒ Biogas is produced in the system as a by-product which can be used to produce electricity to run the system.

Limitation of USAB System:

1) The system help to lower only two parameter of waste water. (a) BOD (b) Suspended Solids.

Eventually the system does not help in the removal of toxic pollutant, like heavy metal which may be present in some of the waste water.

2) Like all other anaerobic high rate system, (UASB) reactor also requires Large quantity of organic matter as compared to the aerobic reactor. because the growth of anaerobic bacteria per unit of organic matter is about 10-12 times the growth of anaerobes.

3) Some of the waste may contain mineral, which may interfere with the efficiency of the anaerobic microbes.

4) The acid produced during the breakdown of organic matter in a USAB reactor, may cause corrosion of the reactor.

5) The efficiency of BOD and S.S removal is a little bit low as compared to that in an Activated sludge plant. The effluent BOD of municipal wastewater treated in UASB reactor System. will therefore be higher.

Say for eg:: The effluent BOD, may be about 50 mg/l for influent BOD of 200 mg/l. for concentrated influent, the effluent BOD may still be higher.

6) pre-treatment of waste water with Screening and grit chamber removal are usually found necessary for direct anaerobic treatment.

7) The methanogenic bacteria do require iron, Cobalt, nickel and Sulphide in addition to nitrogen and phosphorous.

13.

Aerobic Stabilisation Units.

Oxidation ponds and Stabilisation Units.

Stabilisation pond are open flow through earthen basin, specifically designed and constructed to treat sewage and biodegradable industrial waste water. Such ponds provide comparatively long detention period, extending from a few days to several days.

Stabilisation pond may be classified as anaerobic, facultative (or) anaerobic depending upon the mechanism of purification.

The stabilisation of waste is brought about by anaerobic bacteria, which flourish in the presence of oxygen. The oxygen demand of such bacteria which flourish in the presence of oxygen a combine reaction of alage and other micro-organisms called alage photosynthesis (or) alage - symbiosis.

In a facultative pond, the upper layer check under aerobic condition, while the anaerobic condition prevail in the bottom layers. The layer of the pond act as a good check against the evolution of the foul odour from such a pond.

The term oxidation pond was originally refered to that stabilisation pond which received partically treated sewage. whereas the pond that received raw sewage was used to called a sewage lagoon.

The result of the oxidation pond treatment are: the oxidation of the original organic matter and the production of algae, which are discharged with the effluent. This result is the net reduction in BOD, since the algae are more stable than the organic matter in waste water, and degrade slowly in the inner stream into which the effluent is discharged.

Constructional Detail:-

A typical plan and section of an oxidation pond is an earthen pond, dug into the ground, with shallow depth. The pond should be atleast 1.0m deep to discourage growth of ~~...~~ aquatic weed and should not exceed 1.5m (05) as otherwise the pond may turn into a deeper anaerobic pond rather than remaining facultative in character without giving foul odours. The detention time in the pond 2 to 6 weeks depending upon sunlight and temperature. Better efficiency of treatment is obtained. If several ponds are placed in series, so that the sewage flows progressively from one to another unit until of it is finally discharged.

16.

Design Criteria :-

The surface area of the tank may worked out by assuming a suitable value of Organic Loading, which may range from 300-150 kg/hectare/day. (or) So in hot tropical Countries like India to about 90-60 kg/hectare/day.

The length of the tank may be kept at about twice the width. The depth may be kept between 1 to 1.5m. A free-board of about 1m may also be provided above a Capacity Corresponding to 20-30 day of detention period. It is found that with the above assumed Organic Loading and per Capita daily BOD production of about 0.08 kg, one hectare land area will suffice for

$$\frac{300}{0.08} = 3750 \text{ , to } \frac{60}{0.08} = 750 \text{ persons.}$$

Result obtained :-

properly operated pond may be as effective as trickling filter in reducing the BOD of sewage. The BOD removal is up to 90% and coliform removal is up to 99% (or) So.

Removal of settled sludge :-

During the designed detention period in an Oxidation pond. The Organic solids will either be oxidised (or) will settle down. The average sludge accumulation observed in several.

pond is about 2 to 5 cm depth per year.

Advantage:-

→ Oxidation pond are quite suitable in hot dry Countries like India and places where 200 (or) more sunny day are expected. The biggest advantage of oxidation pond is the treatment is that it is very cheap.

→ Maintenance cost is less. no need of skilled labour.

Disadvantage:-

→ The nuisance due to mosquito breeding and bad odours.

Recent Advances in Sewage Treatment:-

1

Unit :- IV Disposal of Sewage.

Disposal of sewage

The disposal of sewage from its sources can classified as follow.

1) Disposal by dilution.

2) Disposal by Land treatment.

Disposal by dilution :-

The process of disposing raw (or) partially treated sewage into natural water bodies is called dilution. The limit of discharge and degree of treatment of sewage are determined by the capacity of self-purification of natural waters. The ratio of the quantity of the diluting water to that of the sewage is known as the dilution factor.

1.) After carried out the primary treatment of sewage i.e. removal of settleable and floating matters.

2.) Sewage should be in fresh state (Age = 4 to 5 hrs)

3) Dissolved oxygen content of diluting water should be high.

4) Diluting water should not used for the domestic purpose for at least some reasonable distance on the downstream from the point of disposal.

5) A flow current of diluting water should be favourable by means of avoiding nuisance or destructing of aquatic life.

6) Outlet of sewer line of the city is situated near by the large volume of water bodies.

Mass balance principle:-

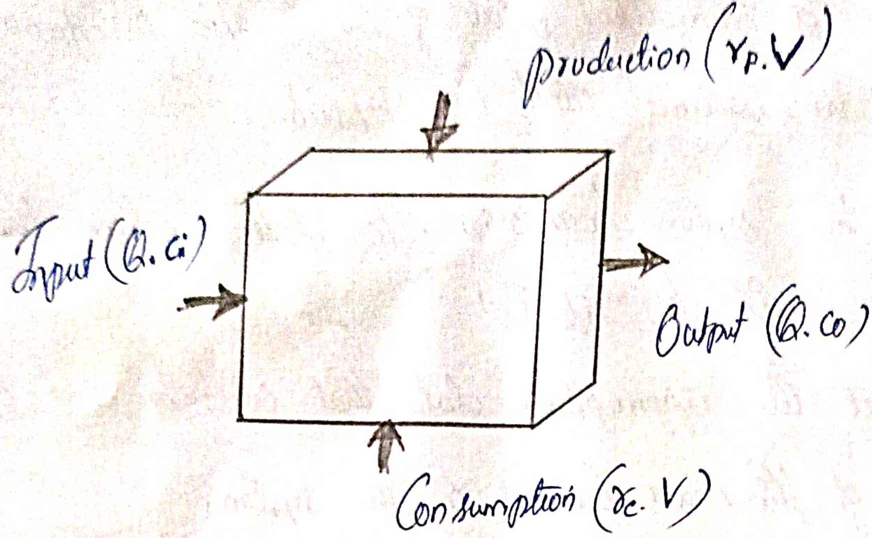
The mass balance principle describes the material that enter, leave and accumulate in a system with defined boundaries. It works based on the law of conservation of mass, that is mass is neither created nor destroyed. The important term in mass balance principle are.

- ⇒ material that enters
- ⇒ material that leave.
- ⇒ material that are generated.
- ⇒ material that are consumed.
- ⇒ material that are accumulated in a volume of tank.

Let us consider a x, y, z is a volume of tank. In a selected volume, the quantity of accumulated material must be equal to the quantity of material enter minus the quantity of material leaves, plus the quantity that is generated. Minus the quantity that is consumed.

2.

Accumulation = Input − Output + production − Consumption.



Mathematical expression for mass balance principle is

$$V.\frac{dC_o}{dt} = Q.C_i - Q.C_o + r_p.V - r_c.V$$

Where,

C_o = Concentration of the Component at a time t (ML^{-3})

C_i = influent Concentration of the Component (ML^{-3})

V = Volume of the reactor. (or) Volume element of any reactor (L^3)

Q = flow (L^3T^{-1})

t = time (T)

r_p = reaction rate of production of the Component ($ML^{-3}T^{-1}$)

r_c = reactor rate of Consumption of the Component Consumed ($ML^{-3}T^{-1}$)

Step to be followed for mass balance preparation.

1) Prepare a simplified flow of the system (or) process for which the mass balance will be prepared.

2) Draw the system boundaries, to define where the mass balance will be applied.

3) List all the appropriate data that will be used in the preparation of the mass balance of the system.

4) List all the chemical (or) biological reaction equation that are judged to represent the process.

5) Select a convenient basis on which the numerical calculations will be done.

Self-purification of River (or) Natural stream.

A river has a natural force of purification such as dilution, sedimentation, oxidation and reduction in sunlight. When sewage is discharged into a river, the water get polluted due to presence of contamination in sewage. The natural forces acting against pollutants and bring back the water into its original state. The process of purify the polluted river water by natural forces is known as self-purification of river.

The natural force of purification can be classified as follows.

physical forces:-

1.) Dilution and dispersion.

2.) Sedimentation.

3.) Sunlight.

Chemical forces:-

1.) Oxidation.

2.) Reduction.

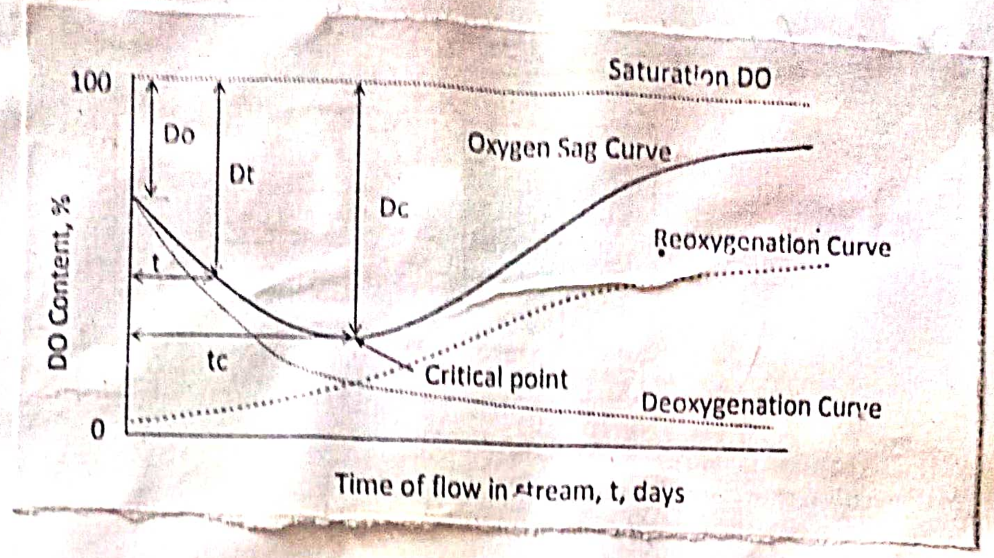
Oxygen Sag Curve:-

Deoxygenation:-

A raw sewage is disposal into natural water bodies, a decomposable organic matter get mixes up with clear water and it polluted the water bodies by reducing the dissolved oxygen content in water.

A process of decomposing organic matter with use of dissolved oxygen and amount of residual oxygen content goes on decreasing is called deoxygenation.

Deoxygenation curve goes from high to low with increasing time. it indicating reducing oxygen level after disposal of sewage into water bodies.



A process of reloaded the deficit amount of oxygen due to deoxygenation by reaeration is known as reoxygenation.

It is a slow process compare to deoxygenation. But the rate of deoxygenation slowly decrease while rate of reoxygenation increases.

Deoxygenation and reoxygenation starts simultaneously. A rate of reoxygenation depends upon the deficiency of oxygen caused by deoxygenation. The rate of deoxygenation and reoxygenation become same at a critical point.

Mathematical Analysis of oxygen Sag Curve:

Streeter-phelps derived a equation for analysis of oxygen sag curve and influence of deoxygenation and reoxygenation.

$$\frac{dD_t}{dt} = f\,(\text{deoxygenation and Reoxygenation})$$

4. Substitute eqn (2) in (1)

$$\frac{d(D_t)}{dt} = k'L_t - R'D_t$$

D_t = Do Deficit at any time "t"

L_t = Amount of first stage BOD remaining in the sample at any time "t"

k' = BOD reaction rate constant (deoxygenation constant to the base e).

R' = Reoxygenation constant to the base e

t = time (in days).

$\frac{dD_t}{dt}$ = rate of change of DO deficit.

$L_t = L_0 e^{-k't}$

L_0 = BOD remaining at time $t=0$.

Sub (3) in eqn (1)

$$\frac{dD_t}{dt} = k'L_0 e^{-k't} - R'D_t$$

$$\frac{dD_t}{dt} = k'L_0 e^{-k't} \longrightarrow (4).$$

This is the first order degree differential eqn.

Differential eqn (4) with respect to time

$$D_t = \frac{k' L_0}{k'-k'}\left[e^{-k'.t} - e^{-R'.t}\right] + D_0 e^{-R'.t}$$

Changing it to the base 10, we get.

k - BOD reaction Constant to the base 10.

R - Reoxygenation Constant to the base 10

D_0 - Initial Oxygen deficit at the point of waste discharge at time $t = 0$

$$D_t = \frac{k L_0}{R - k}\left[10^{-kt} - 10^{-R.t}\right] + D_0 \, 10^{-Rt} \quad \ldots\ldots (6)$$

Eqn (6) is the classic streeter-phelps Oxygen Sag Curve eqn.

It is most Commonly for running water analysis

Determination of D.O deficit @ Critical point (x_c) is

$$\frac{d D_t}{dt} = 0$$

$$D_c = \frac{k'}{R'} L_0 \, e^{-k'.t_c}$$

Change it to base 10

$$D_c = \frac{K}{R} L_0 (10)^{-K(t_c)}.$$

$t_c \rightarrow$ time required to reach Critical point.

5.

To find the value of t_c differentiating eqn (5) with respect to "t" and setting $\frac{dD_t}{dt}$ equal to zero.

$$t_c = \frac{1}{R' - k'} \log_e \left(\frac{R'}{k'}\right)\left[1 - \frac{D_o (R' - k')}{k' L_o}\right] \rightarrow (8)$$

$$t_c = \frac{1}{R' - k'} \log_{10} \left(\frac{R'}{k'}\right)\left(1 - \frac{D_o (R - k)}{k L_o}\right) \rightarrow (9)$$

The distance X_c is given by

$$x_c = t_c \cdot V$$

$V \rightarrow$ Velocity of flow in the river.

Deoxygenation Constant (k)

$$K_T = K_{20}\, \theta^{(T - 20^\circ)}$$

$\theta = 1.056$ for temperature range of $20^\circ C$ to $30^\circ C$

$\theta = 1.135$ for temp range for 4° to $20^\circ C$.

Reoxygenation Constant (R)

$$R_T = R_{20}\, (1.024)^{T - 20^\circ C}$$

Self purification Constant (f)

$$f_s = \frac{R}{k}$$

Land Disposal

In this method of disposal, the raw sewage (or) partly treated sewage from the industries (or) residential area is applied on the open land surface. The application of secondary effluent onto a land surface can provide an effective alternative to the expensive and complicated advanced treatment method.

A part of sewage evaporates and the remaining part percolates through the ground and is trapped by the under ground drain laid for the purpose and disposal into natural water. A sewage increase the fertility of land and cash crops can be successfully grown on it.

A sewage farming is the term used when raw (or) partly treated sewage is used for land irrigation with the object of raising crops. The sewage adds to the fertilizing value of land and crops can be profitably raised on such land.

The term sewage farming is also sometimes used for indicating disposal of sewage by land treatment. The design of a good land treatment system demand the services of environmental engineers, hydraulic engineer etc.,

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Sewage sickness:

If Sewage is applied continuously on a piece of land, pores (or) void of soil are filled up or clogged. Free circulation of air is thereby prevented and anaerobic condition develop. At this stage, the land is unable to take any further sewage load. Organic matter decomposes and foul-smelling gases are produced. The phenomena of soil is known as sewage sickness of land.

Preventive Measures:

In order to prevent sewage sickness of land, the following preventive measure may be adopted.

Alternative arrangement:

There should be ample provision of extra land so that land with sewage sickness can be given the desired rest. Alternatively, sewage should be disposal of by some other method when sewage farms are taken rest.

Depth of Sewage:

If sewage is applied in excess the chances of sewage sickness are increased. The land is unable to receive the excess sewage in a satisfactory way and it ultimately clogs up. Depth of sewage on land should be carefully decided by keeping in view the climatic conditions.

Sodium Hazard:-

In most normal soil, Calcium and magnesium are the principal Cations held by the soil in replaceable (or) exchangeable form. Sodium tends to replace Calcium and magnesium when continuously applied through irrigation water. An increase of exchangeable Sodium in the soil causes deflocculating of soil particle and promotes Compaction, thereby impairing soil porosity and the water and air relation of plants.

Sodium Content is an important factor in irrigation water quality evaluation and Excessive sodium leads to development of an alkaline soil that Can cause soil physical problem and reducing soil permeability.

$$SAR = \frac{Na}{\sqrt{(Ca + Mg)/2}}$$

Where Na^{+}, Ca^{2+} and Mg^{2+} are in meq/L.

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(7)

A city discharges 100 Cumecs of sewage into a river, which is fully saturated with oxygen and flowing at the rate of 1500 Cumecs during its lean days with a velocity of 0.1 m/s. The 5-day BOD of sewage at the given temperature is 280 mg/l. Find when and where the critical DO deficit will occur in the downstream portion of the river and what is its amount. Assume co-efficient of purification of stream (f) as 4.0, co-efficient of deoxygenation (K_D) as 0.1

Solution:

Initial D.O of water = Saturation D.O = 9.2 mg/l @ 20°C (From Table)

D.O of mix @ $t = 0$, at start

$$C = \frac{Q_s C_s + Q_R C_R}{Q_s + Q_R}$$

$$= \frac{(100 \times 0) + 1500 \times 9.2}{1500 + 100} = 8.62 \text{ mg/l}$$

($\because$ DO of sewage is nil)

Initial DO deficit of stream ($t = 0$)

$$D_o = 9.2 - 8.62 = 0.58 \text{ mg/l}.$$

BOD of mixture (Sewage and stream).

$$C = \frac{C_s Q_s + C_R Q_R}{Q_s + Q_R} = \frac{(280 \times 100) + (0 \times 1500)}{100 + 1500}$$

$$= 17.5 \ mg/l.$$

$$Y_{5d} = 17.5 \ mg/l.$$

$$Y_5 = L \left[1 - 10^{-k_D t} \right]$$

$$(t = 5d)$$

$$K_D = 0.1 \ @ \ 20^\circ c.$$

$$17.5 = L \left[1 - 10^{-0.1 \times 5} \right]$$

Ultimate BOD $L = 25.58 \ mg/l.$

$$\left(\frac{L}{D_c \cdot f} \right)^{f-1} = f \left[1 - (f-1) \frac{D_o}{L} \right]$$

$$\left(\frac{25.58}{D_c \times 4} \right)^{4-1} = 4 \left[1 - \frac{(4-1) \times 0.58}{25.58} \right]$$

Critical oxygen deficit, $D_c = 4.12 \ mg/l.$

(1) Unit: V Sludge Treatment and disposal.

Objectives:

Sludges are commonly generated from all phases of wastewater wastewater treatment facility is the suspended solid from the primary settling tank.

The removal of BOD in primary treatment unit is a difficult method and wasting energy. in secondary treatment process. high volume BOD rate can treat and efficient removed in treatment unit. The process of removal of BOD using micro organisms and it act as a decomposer in secondary treatment unit.

Characteristics of sludge:

Characteristic of sludge depends on the various treatment method, the major change in the sludge are.

(i) Thickening and dewatering. It increase the concentration of solid particle in sludge (Dry solids).

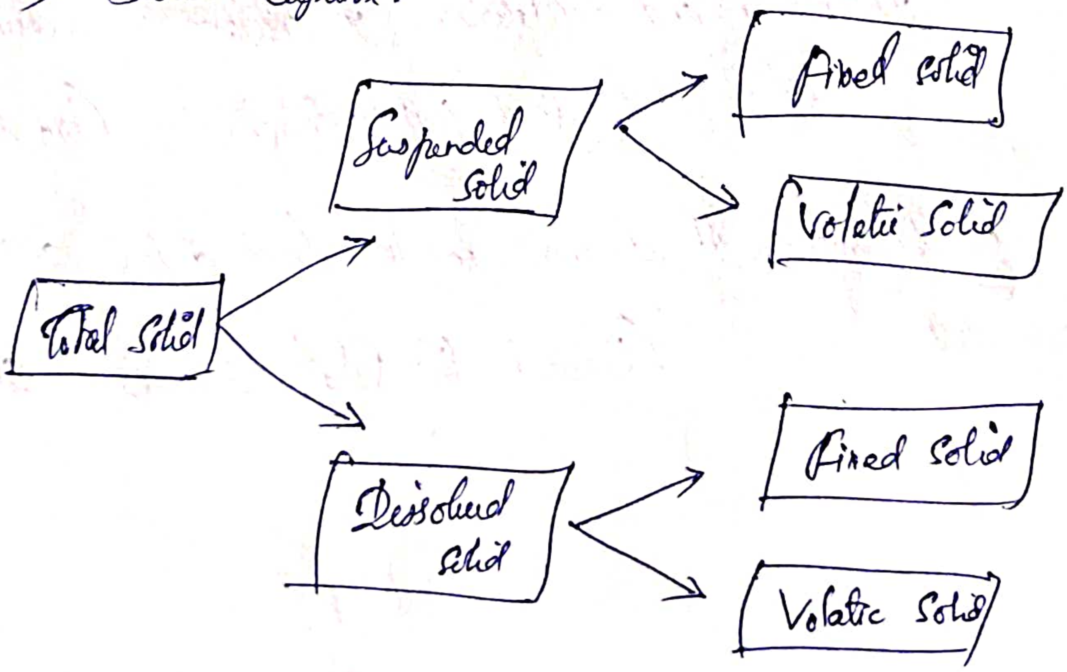
(ii) Digestion - It decreases in the Load of total solid (Reduced the volatile suspended solids).

Fundamental Relationship of sludge:-

To express the characteristic of the sludge in term of mass and volume of production, it is important to have an understanding of some fundamental relationship of mass and production.

The following important lies have been already presented.

1) Relationship between solid level and water content.
2) Expression of the concentration of dry solids.
3) Relation between flow, concentration and load.
4) Total, volatile and fixed solids.
5) Sludge density.
6) Destruction of volatile solids.
7) Solids capture.



2) ## Sludge Thickening

⇒ Sludge Thickening is a unit process and used to increase, the solid content of the sludge by removing a water content present ~~int~~ in it.

⇒ The solid content of primary, activated, trickling - filter are differ significantly depending on the characteristic of the sludge.

⇒ The process of sludge thickening is depending on the characteristic of sludge to be treated in sewage treatment plant.

⇒ A physical, chemical, Biological characteristic of sludge significantly influence the thickening process as well as operational conditions.

⇒ The major factor that influence the process of thickening ~~de~~ are.

1) ~~Major~~ Solid particle size and shape.

2) Viscosity and temperature.

3) Dissolved oxygen.

4) Bio flocculation rate.

5) Blocked water.

Sludge thickening process include.

1) Gravity thickener.

2) Flotation thickener.

3) Centrifuge.

4) Band screen filter.

5) Rotary drum screen filter.

Gravity Thickening:-

Gravity thickening is most effective way of removal of water from the sludge. It works similar to sedimentation process. The shape of the structure is circular in shape. The solid are collected from the primary and ~~sedim~~ secondary process and pumped to thickener. The solid are kept at the rest position for the long time and it get settled at the bottom of the tank.

The thickened sludge is directed to the next stage for digestion and supernatant water returned to the wastewater flow for treatment process. The behaviour of sludge during the thickening process is the principles of zone of settling and the solid flux theory.

The size of the gravity thickening tank may be calculated based on the hydraulic loading rate.

(3)

Daily operation of the thickening process include pumping observation, sample and testing, process control calculation and maintenance.

Equipment used for this process consists of a thickening tank (similar to settling tank used in primary treatment). Sludge is generated pumped continuously from the primary. activated treatment process to the thickener, which has a low overflow rate so that the excess water overflow and the sludge solid concentrate in the bottom.

In this thickener, a sludge with a solid content of 8-10% can be produced which mean four-fifth of the water has been removed. The collector mechanism uses heavier construction that in a settling tank because the solid being moved are more concentrated. The gravity thickener pumping facilities (i.e., pump and flow measurement) are used for withdrawal of thickened solid.

The performance of gravity thickening process depends on various factors including.

- ⇒ Types of sludge.
- ⇒ Condition of influent sludge.
- ⇒ Temperature.
- ⇒ Blanket depth.

⇒ Solid Loading.

⇒ Hydraulic Loading

⇒ Solid retention time.

⇒ Hydraulic detention time.

Design of gravity thickenings:

1) Computation of the required surface area:

Area = Solid Load / Solid Loading rate, &

it is expressed in m^2

2) Verification of the hydraulic Loading rate.

Hydraulic Loading rate = Flow / Area

it is expressed in m^3/m^2 day.

3) Dimension:

Dimension of the thickener using area formula depends upon the shape of the thickener.

4) Verification of the hydraulic retention time:

Hydraulic retention time = Volume / Discharge.

It is expressed in time.

(4)

Sludge Digestion :-

The purpose of sludge digestion is to reduce the volume, stabilize the organic matter and eliminate pathogenic organisms to permit reuse (or) disposal. Digestion process were developed with the purpose of stabilising the biodegradable fraction of organic matter present in the sludge. Thus reducing the risk of contamination as well as weakening the concentration of pathogens. Sludge digestion processes include the following

1) Aerobic digestion.
2) Anaerobic digestion.
3) Composing.
4) Lime stabilization.
5) Chemical oxidation (chlorine oxidation)
6) Incineration.

Aerobic digestion:-

* The aerobic digestion is a continuation of the activated sludge process to treat the biological sludge. In aerobic digestion, equipment need for the process includes an aerobic aeration tank with diffuser and solid and supernatant removal equipment is required.

Factor influencing aerobic digestion:-

The factor that influenced the aerobic digestion process are temperature, Volatile solid reduction, volume of the tank, Solid Concentration in influent, dissolved oxygen requirement and energy requirement for mixing.

Temperature:-

1) Generally, temperature play a vital role in biochemical process. High temperature lower the saturation value of dissolved oxygen in water and thus required an increase in the supply of air.

Volatile solid reduction:-

1) Around 20 - 35 % of ~~water~~ waste activated sludge from plant with primary treatment is not biodegradable.

2) To maintain the liquid temperature and solid retention time Control the degree of solid reduction.

Volume of the tank:-

The Volume of the aerobic digester tank influence the process of aerobic digestion. To estimate the tank Volume by using the following formula.

$$V = \frac{Q(X_i + F_{ps})}{X(K_d P_v + 1/SRT)}$$

(5)

Solid Concentration in influent:-

⇒ Reduction in solid content before digestion process gives more efficiency in digester. Longer sludge retention time smaller digester volume are help to improve the aerobic digestion in tank.

⇒ However, feed solid concentration greater than 3.5 to 4 percent will delay mixing and adequate dissolved oxygen levels.

Dissolved Oxygen requirement:-

⇒ The mass of oxygen required for complete oxidation process and nitrification is about 2.3 kg of cells.

⇒ Oxidation of the BOD in primary sludge varies from 1.6 to 1.9 kg of oxygen/kg of BOD oxidized.

Energy requirement for mixing:-

⇒ Air flow rate between 0.02 and 0.04 $m^3 \frac{air}{min\, m^3}$ of liquid volume ensure adequate mixing.

⇒ The amount of air required to maintain the DO level usually exceed this flow rate.

⇒ Diffused aeration has advantages over mechanical mixing in cold climates because the compressed air add heat to the system. and overall heat loss is less because of a smaller degree of surface disturbance.

Sludge Conditioning:-

⇒ Sludge is conditioned to improve dewatering characteristics of the sludge. Conditioning by the addition of chemical is the major method used in all over the world.

⇒ Sludge conditioning is carried out before dewatering and directly influences the process efficiency.

⇒ Conditioning maybe accomplished through the utilization of inorganic chemical, organic chemical (or) thermal treatment.

⇒ Chemical conditioning result in coagulation of the solid and release of the absorbed water. The most common coagulants are ferric chloride, lime or organic polymers.

⇒ Ash from incinerated sludge has also found use as a conditioning agent. Ash ferric chloride and lime in combination are effective but result in an increase of 20 to 30 % in the dry solids that must be disposal.

⇒ Application of organic polymer has become typical for sludge conditioning because they do not increase the dry solids.

⇒ They are easy to handle, require little storage space and are very effective. They also are very expensive.

⑥ ## Recent Advances of Sludge Disposal.

Gasification of Sludge

Gasification of waste water sludge is a rather new method of sludge processing and detailed information on the method is limited. However, the method is briefly described.

The Gasification process:-

Gasification is thermal process whereby a feed stock containing combustible material is converted with air to an inflammable gas. Before World war II this ~~the~~ technology was applied for the supply of local power in industry and later due to a shortage of petrol in the war, also as fuel for cars. truck etc.,

The most frequently used reactor for gasification are:

1) The fixed bed reactor.
2) The fluid bed reactor.
3) The circulating bed reactor.

Wet Oxidation Technique:-

The organic content of sludge is oxidated in specific reactor at temperature of between 200 C and 300C and at pressure level of between 20 bar and 150 bar.

The necessary pressure may be reached through high pressure pumps. (or) through specially designed reactors. tubes reaching 1,200 m deep into the underground, at the bottom of which the fluid sludge passes through a zone of high pressure and temperature before rising up again to the surface. In this application, dewatering is not necessary for the input to the sludge treatment process. The main output of the process is sludge containing more than 95% of mineral component and less than 3% of low-molecular organic substances.