INTERNATIONAL INSTITUTE OF TECHNOLOGY & MANAGEMENT, MURTHAL SONEPAT

E-NOTES , Subject : Environmental Engineering-2 , Subject Code: CE-312B , Course: B.tech, Branch: CIVIL Engineering , Sem-6th ,

( Prepared By: Ms Kajal, lecturer , CE)

# E-NOTES OF ENVIRONMENTAL ENGINEERING – 2

### BTECH 6th SEM

## UNIT-1 :

- SEWARAGE SYSTEM
- CHARACTERIZATION OF SEWAGE

## UNIT – 2 :

- TREATMENT OF SEWAGE

## UNIT – 3 :

- SEWAGE TREATMENT UNITS DESIGN
- TREATED EFFLUENT DISPOSAL

## UNIT – 4 :

- LOW COST SANITATION SYSTEM
- PLUMBING

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# UNIT-1

# SEWARAGE SYSTEM & CHARACTERIZATION OF SEWERS

# General Consideration

Generally, sewers are laid at steeper gradients falling towards the outfall point with circular pipe cross section. Storm water drains are separately constructed as surface drains at suitable gradient, either rectangular or trapezoidal section. Sewers are designed to carry the maximum quantity of sanitary sewage likely to be produced from the area contributing to the particular sewer. Storm water drains are designed to carry the maximum storm runoff that is likely to be produced by the contributing catchment area from a rain of design frequency and of duration equal to the time of concentration.

## Requirements of Design and Planning of Sewerage System

The sewerage scheme is designed to remove entire sewage effectively and efficiently from the houses to the point of treatment and disposal. Following aspects should be considered while designing the system.

- The sewers provided should be adequate in size to avoid overflow and possible health hazards.
- For evaluating proper diameter of the sewer, correct estimation of sewage discharge is necessary.
- The flow velocity inside the sewer should neither be so large so as to require heavy excavation and high lift pumping, nor should be so small causing deposition of the solid in the sewers.
- The sewers should be laid at least 2 to 3 m deep to carry sewage from basement.
- The sewage in sewer should flow under gravity with 0.5 to 0.8 full at designed discharge, i.e. at the maximum estimated discharge.
- The sewage is conveyed to the point usually located in low-lying area, where the treatment plant is located.
- Treatment plant should be designed taking into consideration the quality of raw sewage expected and to meet the discharge standards.

**( Prepared By: Ms Kajal, lecturer , CE)**

# Difference Between Water Supply Pipes and Sewer Pipes :

The major difference between the water distribution network and sewerage system is presented in the table :

Table : Comparison between the water distribution network and sewage collection system

| Water Supply Pipes | Sewer Pipes |
|---|---|
| • It carries pure water | It carries contaminated water containing organic or inorganic solids which may settle in the pipe. It can cause corrosion of the pipe material. |
| • Velocity higher than self-cleansing is not essential, because of solids are not present suspension. | To avoid deposition of solids in the pipes self-cleansing velocity is necessary at all in possible discharge. |
| • It carries water under pressure. Hence, the laid up and down the hills and valieys within certain limits. downward direction towards outfall point . | It carries sewage under gravity.pipe can be Therefore it is required to be laid at a the continuous falling gradient in the downward direction towards outfall point . |
| • These pipes are flowing full under pressure. | Sewers are design to run partial full at maximum discharge. This extra space ensures non-pressure gravity flow. This will minimize the leakage from sewer, from the faulty joints or crack, if any. |

# Provision of Freeboard in Sewers

**Sanitary Sewers**

Sewers with diameter less than 0.4 m are designed to run half full at maximum discharge, and sewers with diameter greater than 0.4 m are designed to flow 2/3 to ¾ full at maximum discharge. The extra space provided in the sewers provides factor of safety to counteract against the following factors:

1. Safeguard against lower estimation of the quantity of wastewater to be collected at the end of design period due to private water supply by industries and public. Thus, to ensure that sewers will never flow full eliminating pressure flow inside the sewer.
2. Large scale infiltration of storm water through wrong or illegal connection, through underground cracks or open joints in the sewers.
3. Unforeseen increase in population or water consumption and the consequent increase in sewage production.

**Storm Water Drains**

Storm water drains are provided with nominal freeboard, above their designed full supply line because the overflow from storm water drains is not much harmful. Minimum of 0.3 m free board is generally provided in storm water drains.

# Hydraulic Formulae for Determining Flow Velocities

Sewers of any shape are hydraulically designed as open channels, except in the case of inverted siphons and discharge lines of pumping stations. Following formulae can be used for design of sewers.

1. **Manning's Formula :**

This is most commonly used for design of sewers. The velocity of flow through sewers can be determined using Manning's formula as below:

**2. Chezy's Formula**

### Chezy's and Manning's Equations in SI and BG System

- Chezy's Equation

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

$$Q = CA\sqrt{RS_o}$$

Value of C is determine from respective BG or SI Kutter's formula.

$V$ = mean velocity (m/s, ft/s)
$R$ = hydraulic radius (m, ft)
$S$ = friction slope (m/m, ft/ft)
C= Chezy's Constant
A= Cross-sectional area of flow

- Manning's Equation

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

$$Q(m^3/s) = \frac{1}{n}AR^{2/3}S_o^{1/2}$$ SI

$$Q(cfs) = \frac{1.486}{n}AR^{2/3}S_o^{1/2}$$ BG

$V$ = mean velocity (m/s, ft/s)
$n$ = Manning's roughness value
$R$ = hydraulic radius (m, ft)
$S$ = friction slope (m/m, ft/ft)
A= Cross-sectional area of flow

19

**3. Crimp and Burge's Formula**

$$V = 83.5\ R^{2/3}\ S^{1/2}$$

**4. Hazen- Williams Formula**

# Pipe Flow

- Hazen William greatly depends upon Roughness of pipe.
- Basic Hazen William Eq is

$$V = 0.849C\,R^{0.63}S^{0.54}$$

- Where,

V= velocity ,m/s

C=Hazen William co-efficient

R=Hydraulic radius or hydraulic mean depth

R=A/P(A=Area, P= Wetted Perimeter)

S= Hydraulic gradient=$H_L$ / L

The Hazen-Williams coefficient 'C' varies with life of the pipe and it has high value when the pipe is new and lower value for older pipes. For example for RCC new pipe it is 150 and the value recommended for design is 120, as the pipe interior may become rough with time. The design values of 'C; for AC pipes, Plastic pipes, CI pipes, and steel lined with cement are 120, 120, 100, and 120, respectively. Modified Hazen-William's equation is also used in practice.

## Minimum Velocity: Self Cleansing Velocity

The velocity that would not permit the solids to settle down and even scour the deposited particles of a given size is called as self-cleansing velocity. This minimum velocity should at least develop once in a day so as not to allow any deposition in the sewers. Otherwise, if such deposition takes place, it will obstruct free flow causing further deposition and finally leading to the complete blocking of the sewers. This minimum velocity or self-cleansing velocity can be worked out as below:

## Self cleaning velocity

$$Vs = \sqrt{\frac{8K}{f'}(Ss - 1)g.d'}$$

K= constant, for clean inorganic solids = 0.04 and for organic solids = 0.06

f' = Darcy Weisbach friction factor (for sewers = 0.03)

Ss = Specific gravity of sediments
g = gravity acceleration
d' = diameter of grain, m _x0000_

- Hence, for removing the impurities present in sewage i.e., sand up to 1 mm diameter with specific gravity 2.65 and organic particles up to 5 mm diameter with specific gravity of 1.2, it is necessary that a minimum velocity of about 0.45 m/sec and an average velocity of about 0.9 m/sec should be developed in sewers.
- Hence, while finalizing the sizes and gradients of the sewers, they must be checked for the minimum velocity that would be generated at minimum discharge, i.e., about 1/3 of the average discharge.
- While designing the sewers the flow velocity at full depth is generally kept at about 0.8 m/sec or so. Since, sewers are generally designed for ½ to ¾ full, the velocity at designed discharge' (i.e., ½ to ¾ full) will even be more than 0.8 m/sec. Thus, the minimum velocity generated in sewers will help in the following ways:
- Adequate transportation of suspended solids,
- Keeping the sewer size under control; and
- Preventing the sewage from decomposition by moving it faster, thereby preventing evolution of foul gases.

## Maximum Velocity or Non-scouring Velocity

The interior surface of the sewer pipe gets scored due to the continuous abrasion caused by suspended solids present in sewage. The scoring is pronounced at higher velocity than what can be tolerated by the pipe materials. This wear and tear of the sewer pipes will reduce the life span of the pipe and their carrying capacity. In order to avoid this, it is necessary to limit the maximum velocity that will be produced in sewer pipe at any time. This limiting or non- scouring velocity mainly depends upon the material of sewer. The limiting velocity for different sewer material is provided in Table.

Table ; Limiting or non-scouring velocity for different sewer material

| Sewer Material | Limiting velocity, m/sec |
|---|---|
| Vitrified tiles | 4.5 – 5.5 |
| Cast iron sewer | 3.5 – 4.5 |
| Cement concrete | 2.5 – 3.0 |
| Stone ware sewer | 3.0 – 4.5 |
| Brick lined sewer | 1.5 – 2.5 |

The problem of maximum or non-scouring velocity is severe in hilly areas where ground slope is very steep and this is overcome by constructing drop manholes at suitable places along the length of the sewer.

### Effect of Flow Variations on Velocities in a Sewer

The discharge flowing through sewers varies considerably from time to time. Hence, there occur variation in depth of flow and thus, variation in Hydraulic Mean Depth (H.M.D.). Due to change in H.M.D. there occur changes in flow velocity, because it is proportional to $(H.M.D.)^{2/3}$. Therefore, it is necessary to check the sewer for minimum velocity of about 0.45 m/sec at the time of minimum flow (1/3 of average flow) and the velocity of about 0.9 to 1.2 m/sec should be developed at a time of average flow. The velocity should also be checked for limiting velocity i.e. non-scouring velocity at the maximum discharge.

For flat ground sewers are designed for self-cleansing velocity at maximum discharge. This will permit flatter gradient for sewers. For mild slopping ground, the condition of developing self-cleansing velocity at average flow may be economical. Whereas, in hilly areas, sewers can be designed for self-cleansing velocity at minimum discharge, but the design must be checked for non-scouring velocity at maximum discharge.

## Hydraulic Characteristics of Circular Sewer Running Full or Partially Full :

(i) A circular section gives the least perimeter for a given area, and therefore has the maximum hydraulic mean depth for running full and half full conditions. It is therefore the most efficient section at these flow conditions.
(ii) It is the most economical section since it requires minimum quantity of material for its construction.
(iii) The section has uniform curvature and hence prevents the possibility of deposits anywhere within the section.
(iv) These can be easily manufactured.

A circular sewer may run either full or partially full.
**The hydraulic elements of circular sewers for both the conditions viz., running full and running partially full are indicated below:**

**(a) Circular Sewers Running Full:**

Let D be the internal diameter of the sewer.

(1) *Area of flow section*

$$A = \frac{\pi D^2}{4} \qquad \ldots(4.10)$$

(2) *Wetted perimeter*

$$P = \pi D \qquad \ldots(4.11)$$

(3) *Hydraulic mean depth*

$$R = \frac{A}{P} = \frac{D}{4} \qquad \ldots(4.12)$$

(4) *Velocity of flow* (Manning's formula)

$$V = \frac{1}{n} R^{2/3} S^{1/2} \qquad \ldots(4.13)$$

or

$$V = \frac{1}{n}\left(\frac{D}{4}\right)^{2/3} S^{1/2} \qquad \ldots(4.13\ a)$$

or

$$V = \frac{0.3968}{n} D^{2/3} S^{1/2} \qquad \ldots(4.13\ b)$$

where

$n$ is Manning's roughness coefficient at running full condition ; and

$S$ is slope or gradient of the sewer.

(5) *Discharge*

$$Q = A \times V$$

or

$$Q = \frac{1}{n} A R^{2/3} S^{1/2} \qquad \ldots(4.14)$$

or

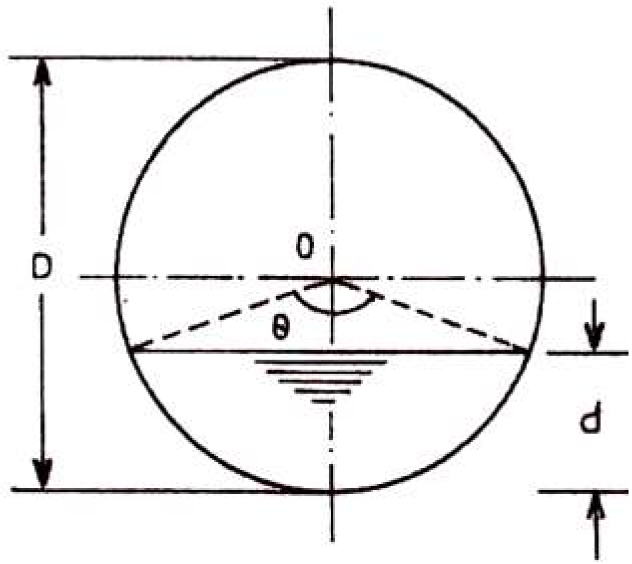
$$Q = \frac{1}{n}\left(\frac{\pi D^2}{4}\right)\left(\frac{D}{4}\right)^{2/3} S^{1/2} \qquad \ldots(4.14\ a)$$

or

$$Q = \frac{0.3116}{n} D^{8/3} S^{1/2} \qquad \ldots(4.14\ b)$$

## (b) Circular Sewers Running Partially Full:

Fig. 4.2 shows a circular sewer running partially full.




Let D be the internal diameter of the sewer, d be the depth of flow, and θ be the angle subtended by the wetted perimeter at the centre of the sewer.

Let a be the area of flow section;

p be the wetted perimeter;

r be the hydraulic mean depth, i.e., r = (a/p); and

v and the velocity of flow

Central angle θ is given by the expression

$$\cos\frac{\theta}{2} = \left(1 - \frac{2d}{D}\right)$$

(1) *Depth of flow*

$$d = \frac{D}{2} - \frac{D}{2}\cos\frac{\theta}{2}$$

or

$$d = \frac{D}{2}\left(1 - \cos\frac{\theta}{2}\right)$$

∴ *Proportional depth*

$$\frac{d}{D} = \frac{1}{2}\left(1 - \cos\frac{\theta}{2}\right)$$

(2) *Area of flow section*

$$a = \frac{\pi}{4}D^2 \times \frac{\theta}{360°} - \frac{D}{2}\cos\frac{\theta}{2}\frac{D}{2}\sin\frac{\theta}{2}$$

or

$$a = \frac{\pi D^2}{4}\left[\frac{\theta}{360°} - \frac{\sin\theta}{2\pi}\right]$$

∴ *Proportional area*

$$\frac{a}{A} = \frac{a}{\left(\frac{\pi D^2}{4}\right)} = \left[\frac{\theta}{360°} - \frac{\sin\theta}{2\pi}\right]$$

(3) *Wetted perimeter*

$$p = \pi D \times \frac{\theta}{360°}$$

∴ *Proportional perimeter*

$$\frac{p}{P} = \frac{p}{\pi D} = \frac{\theta}{360°}$$

(4) *Hydraulic mean depth*

$$r = \frac{a}{p} = \frac{\frac{\pi D^2}{4}\left[\frac{\theta}{360°} - \frac{\sin\theta}{2\pi}\right]}{\pi D \times \frac{\theta}{360°}}$$

or
$$r = \frac{D}{4}\left[1 - \frac{360° \sin\theta}{2\pi\theta}\right]$$

∴ *Proportional hydraulic mean depth*

$$\frac{r}{R} = \left[1 - \frac{360° \sin\theta}{2\pi\theta}\right]$$

(5) *Velocity of flow* (Manning's formula)

$$v = \frac{1}{n_d} r^{2/3} S^{1/2}$$

where $n_d$ = Manning's roughness coefficient at depth $d$; and

$S$ = slope or gradient of the sewer which is assumed to be same as for running full

∴ Proportional velocity

$$\frac{v}{V} = \frac{n}{n_d}\left(\frac{r}{R}\right)^{2/3}$$

where

$V$ = Velocity of flow at running full condition ; and

$n$ = Manning's roughness coefficient at running full condition

Introducing equation 4.23 in equation 4.25, we obtain

$$\frac{v}{V} = \frac{n}{n_d}\left[1 - \frac{360° \sin\theta}{2\pi\theta}\right]^{2/3}$$

Further if $(n/n_d) = 1$, we have

$$\frac{v}{V} = \left(\frac{r}{R}\right)^{2/3} = \left[1 - \frac{360° \sin\theta}{2\pi\theta}\right]^{2/3}$$

(6) *Discharge*

$$q = a \times v$$

or
$$q = \frac{1}{n_d} a r^{2/3} S^{1/2}$$

∴ *Proportional discharge*

$$\frac{q}{Q} = \frac{n}{n_d}\left(\frac{a}{A}\right)\left(\frac{r}{R}\right)^{2/3}$$

or
$$\frac{q}{Q} = \frac{n}{n_d} \times \left[\frac{\theta}{360°} - \frac{\sin\theta}{2\pi}\right] \times \left[1 - \frac{360° \sin\theta}{2\pi\theta}\right]^{2/3}$$

# Waste Water Engineering

**Qualities of waste water/Sewage:**

Waste water is the combination of water and liquid waste originated from locality after different activities.

Sewage can be classified into three categories:

- Domestic waste
- Industrial waste
- Drainage discharge/storm water/drainage

**1.Domestic Sewage:**It is mixer of water and liquid waste originated due to domestic activities like washing,cooking, bathing.

**2.Industrial Sewage:**Waste water originated due to industrial activities is termed as industrial sewage.

1. Combination of domestic and industrial waste water is termed as Sanitary Sewage.
2. Combination of Kitchen and bathroom waste is termed as Sullage.

**3.Storm water/drainage:** It is sewage that is originated due to rainstorm water.

**Sewers:** Pipes used for carrying sewage from one point to another are called sewers.

**Sewarage System:**

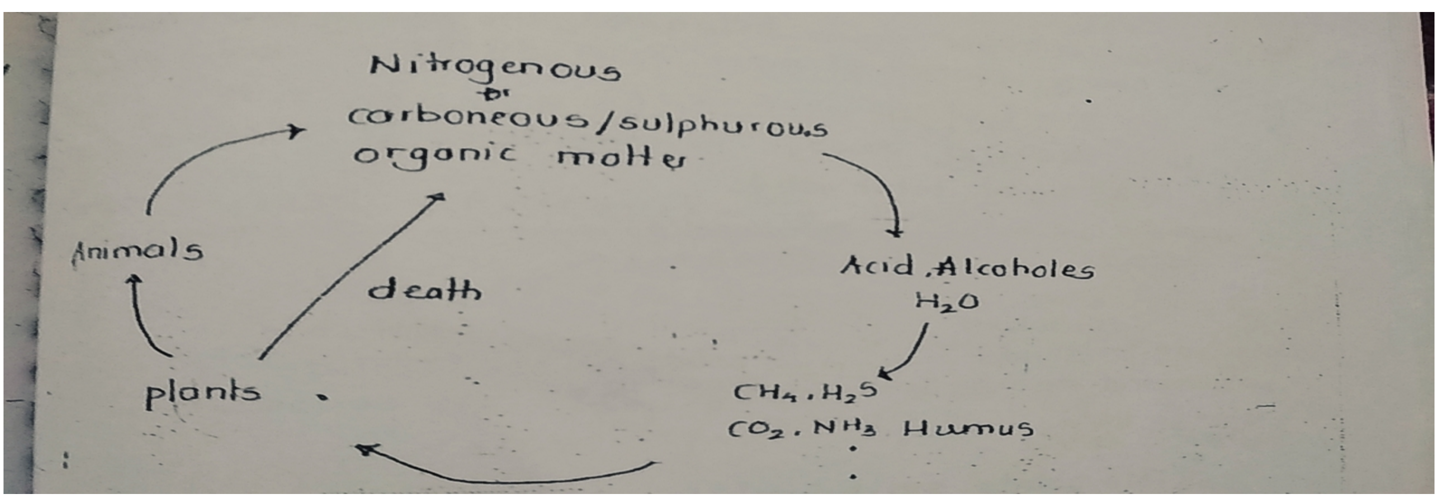
1. It is method of collection, treatment and disposal of the treated sewage.
2. Sewerage system is generally of three types:
    1.1.1.Seperate sewerage system
    1.1.2.Combined sewerage system
    1.1.3.Partially seperate

**1.Physical Waste water parameters:**

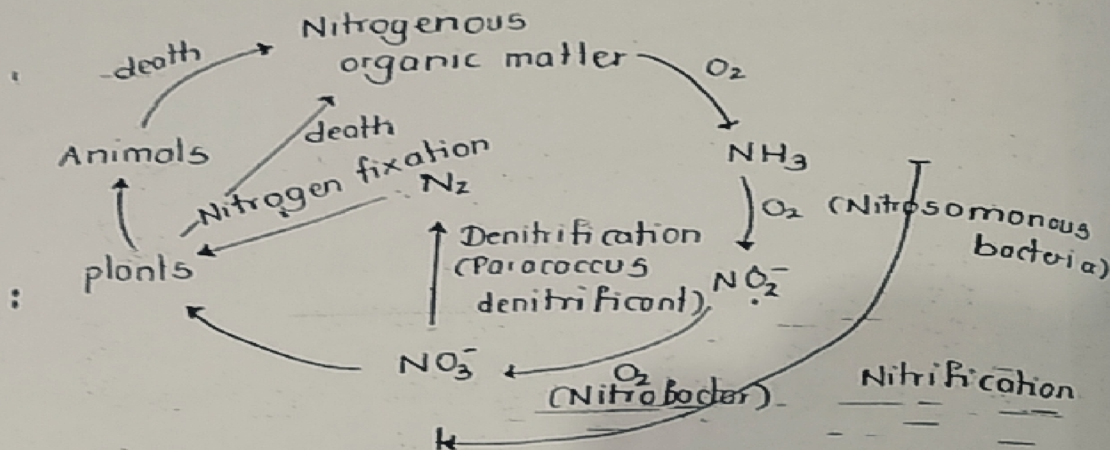
All physical WQ parameters are applicable here also.

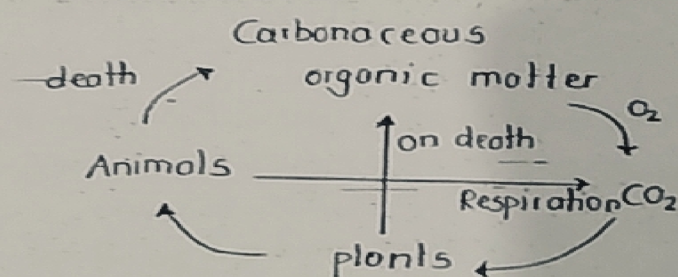
1. Total solids
2. Settalable solids
3. Dissolved solids
4. Suspended solids
   - 80% of water supplied goes into the sewage.
   - Sewage consist of both organic and inorganic particles.
   - Organic particles are decomposed by the chemical and the biological actions.
   - Organic particles are decomposed by the biological action are termed as biodegradable organic matter.
   - This biological decomposition can be carried out either in the presence or absence of oxygen. If it is carried out in the presence of Oxygen is termed as aerobic & if carried out in absence of Oxygen are called anaerobic.
   - The end products obtained depends upon the method by which decomposition is carried out.

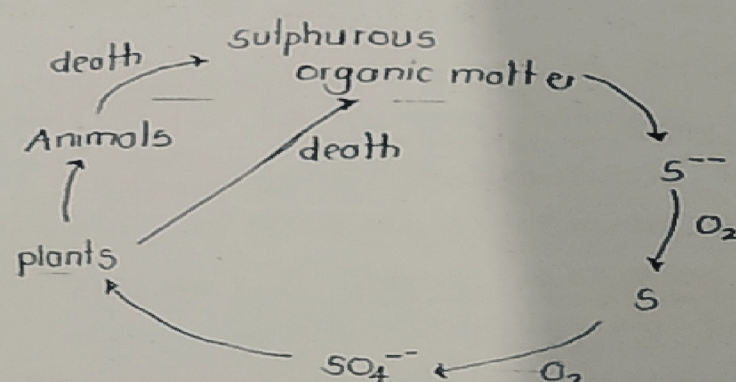
**Aerobic decomposition:**



## Aerobic decomposition



The method of treatment employed for sewage depends on condition whether it is carried out anaerobically or aerobically.

**Method based on Anaerobic condition:**

- Trickling filter(TF)
- Activated sludge process(ASP)
- Oxidation pond(OP)
- Rotating biological contractor(RBC)

**Methods based on aerobic conditions:**

- Septic tank
- Inhoff tank
- Anaerobic lagoons
- Upflow Anaerobic sludge blanked reactor(UASBR)
  - Sewage consist of more than 99.9% of solids.(0.1%)
  - If 1000kg of sewage is considered it consists of only 0.45kg of total solids.
    Total solids=organic solids(45%)+dissolved solids(0.225kg)+suspended solids (0.125kg)+settalable solids (0.125kg)+inorganic solids(55%)

**Settalable solids:**The solids settled at the base of the Inhoff come when sewage is allowed to stand in this cone for 120minutes are termed as settalable solids.

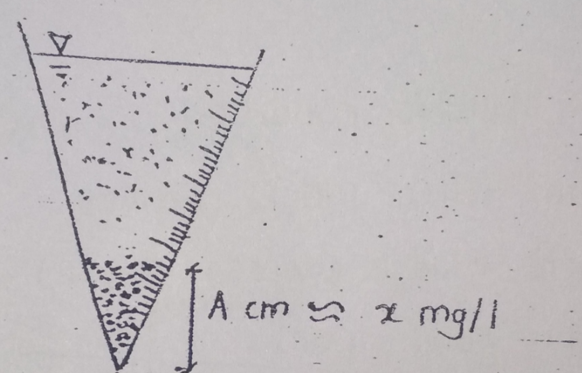



Fig. Emhoff cone for measuring settlable solids

## 2.Chemical waste water quality parameters:

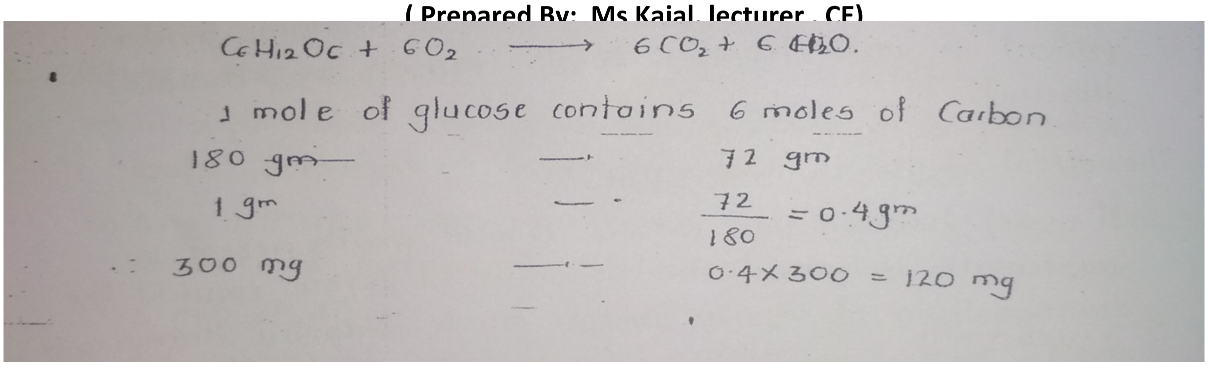
**Dissolved oxygen:**

- At a particular temperature max quantity of Oxygen present in water is termed as Saturation dissolved oxygen.
- Any deficiency observed in value of DO indicates the presence of biological activity in water.
- A min of 4ppm DO is required at all the temperature for survival of fishes in water.(effluent)
- DO in water can be computed using wrinkler's method:
  Sample $+MnSO_4+NaOH+KI=Mn(OH)_{2}/MnO_2$
  If $Mn(OH)_2$[white ppt. form]then it means NO DO.
  If $MnO_2$[Red ppt.form]then it means DO is present.
  Now
  MnO2+2I+ O2= I2
  $I_2$+ I=$I_3$(blue complex)
  Now this blue complex titrate against std Na2S2O3 gives volume of 0.01 N Na2S2O3 ( to decolourised blue solution).

**2. Chemical waste water quality parameters-chemical oxygen demand (COD):**

- It is amount of oxygen required to decompose both biodegradable and non biodegradable organic matter.
- It can be calculated by adding potassium dichromate (K2Cr2O7) along with Sulphur acid(H2SO4) and noting down the amount of oxygen consumed for decomposition of organic matter.
  Note: As potassium dichromate is strong oxidizing agent,it carries out decomposition of some of inorganic matter present in water, hence it is also known as dichromate demand.

**3. Theoretical Oxygen Demand(TOD):**



$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$.

1 mole of glucose contains 6 moles of Carbon

180 gm —— 72 gm

1 gm —— $\frac{72}{180} = 0.4$ gm

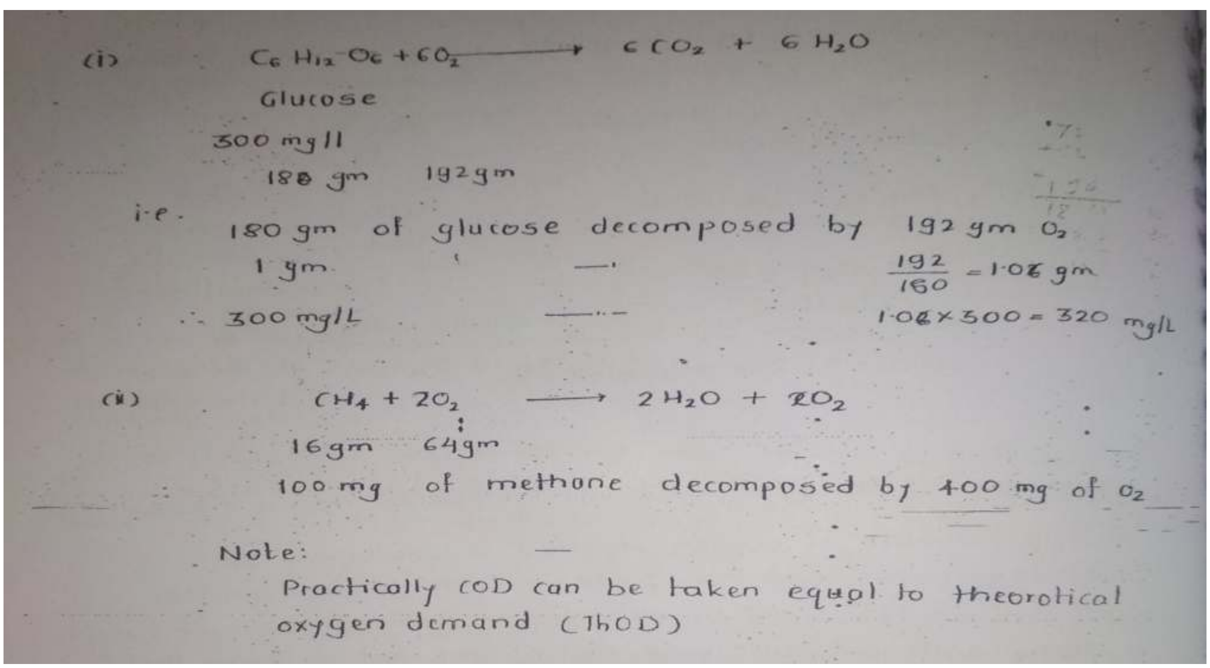
∴ 300 mg —— $0.4 \times 300 = 120$ mg

- If exact formula and conc. of organic matter present in waste water is known then quantity of Oxygen required for decomposition of organic matter can be computed theoretically and is termed as Theoretical oxygen demand.

**4.Total Organic Carbon (TOC):**

- Total organic carbon is just another method for expressing organic matter present in the water in the form of its carbon content.

**5. Biological Oxygen Demand (BOD):**



(i) $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$

Glucose

300 mg/l

180 gm 192 gm

i.e. 180 gm of glucose decomposed by 192 gm $O_2$

1 gm —— $\frac{192}{180} = 1.06$ gm

∴ 300 mg/L —— $1.06 \times 300 = 320$ mg/L

(ii) $CH_4 + 2O_2 \longrightarrow 2H_2O + CO_2$

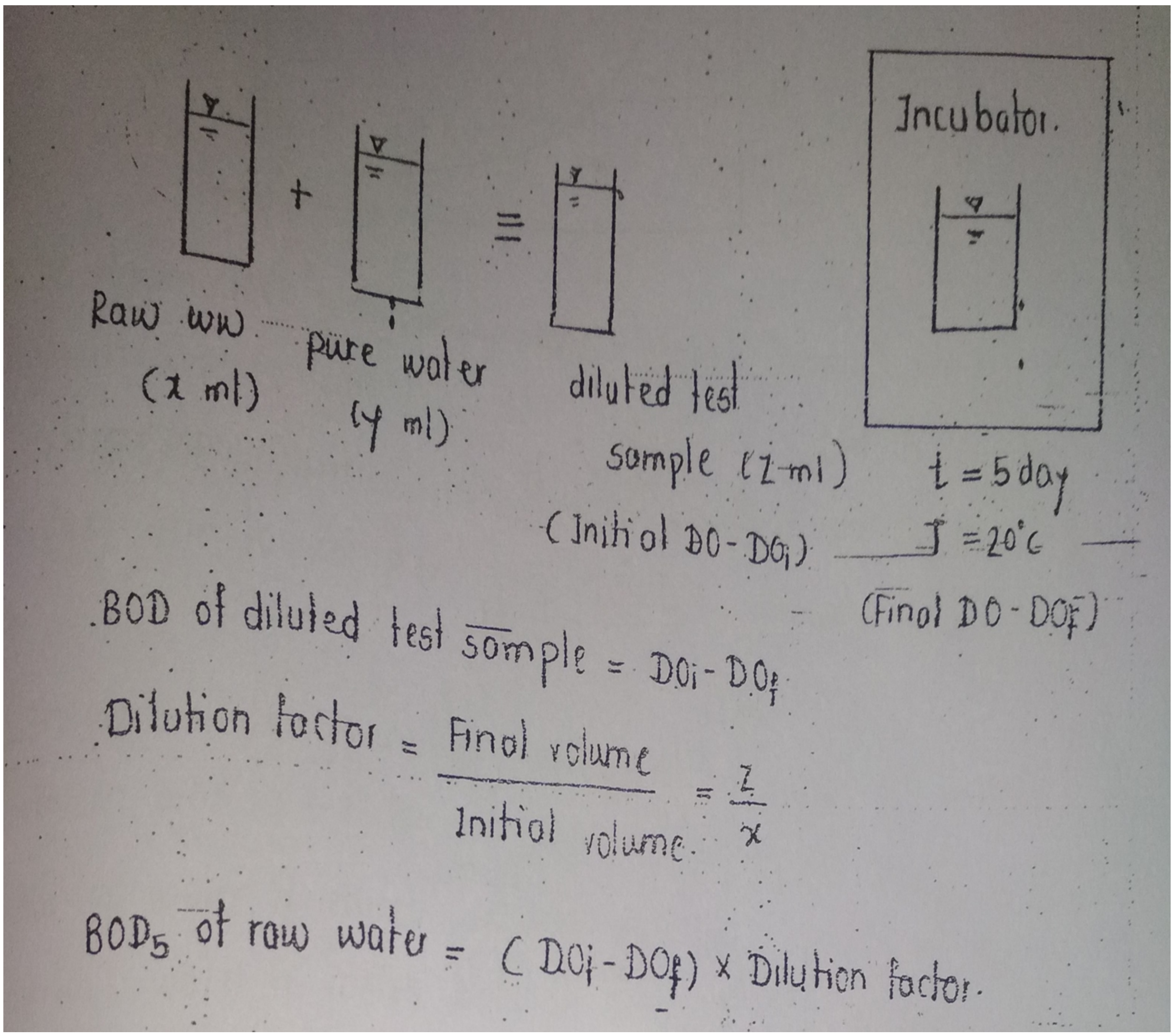
16 gm 64 gm

∴ 100 mg of methane decomposed by 400 mg of $O_2$

Note:

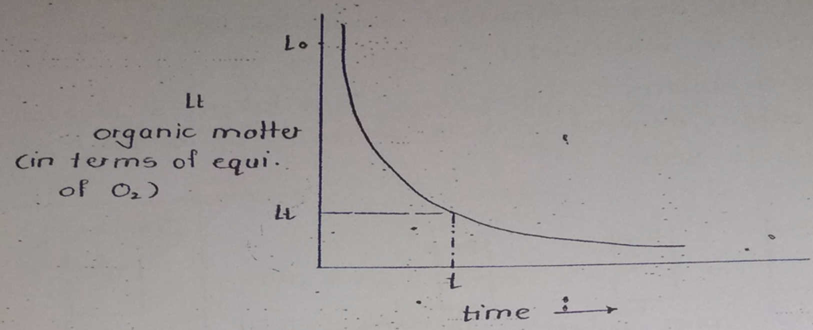
Practically COD can be taken equal to theoretical oxygen demand (ThOD)

- It is the amount of oxygen required by the micro organisms to carry out the decomposition of biodegradable organic matter present in waste water.




- BOD of water during 5 days at 20°C as taken as standard biological Oxygen demand and is approximately equals to 68% of ultimate BOD.
- BOD is determined by diluting known volume of waste water sample with known volume of aerated water sample and calculating DO of diluted sample ,before and after incubation of 5days and at 20°C.
- Normally 300ml sized bottles are used and all sources of light must be excluded from incubator in

order to prevent the growth of algae (performs photosynthesis and release oxygen adding to calculated DO). which results in decreased value of BOD in comparison to actual value of




At t = t. $\frac{dL_t}{dt} \propto -L_t$ organic motter decreases.

$$\frac{dL_t}{dt} = -k \cdot L_t$$

$$\int_{L=L_o}^{L=L_t} \frac{dL_t}{L_t} = -k \cdot \int_{t=0}^{t=t} dt$$

$$\ln|L_t|_{L_o}^{L_t} = -k\,(t)_0^t$$

$$\ln\left(\frac{L_t}{L_o}\right) = -kt \quad \text{or} \quad 2.303 \log\left(\frac{L_t}{L_o}\right) = -kt$$

$$\frac{L_t}{L_o} = e^{-kt} \quad \text{or} \quad \frac{L_t}{L_o} = 10^{\frac{-kt}{2.306}}$$

$$L_t = L_o \cdot e^{-kt} \quad \text{or} \quad \frac{L_t}{L_o} = 10^{-K_D \cdot t}$$

k- deoxygenation constant. $K_D = \frac{K}{2.306}$

BOD required for any time t $= L_o - L_t$

$$= L_o - L_o \cdot e^{-kt}$$

$$= L_o (1 - e^{-kt})$$

or

$$BOD_t = L_o - L_o \cdot (10^{-K_D \cdot t})$$

$$= L_o (1 - 10^{-K_D \cdot t})$$

BOD.calculated DO). which results in decreased value of BOD in comparison to actual value of BOD.

- Here K or $K_D$ are deoxygenation constants at base e and base 10 respectively.KD=0.434K
- The deoxygenation constant represents rate at which BOD reaction takes place without affecting ultimate BOD.

  For ultimate BOD

  $UBOD=L_o(1-10)^{(-KD\times infinity)}$

  $UBOD=L_o$

  - De-oxygenation constant for given sample depends on type of impurities present in it .
  - For simple impurities deoxygenation constant will be more e.g. sugar and for complex compounds like phenols it will be less.
  - In general deoxygenation constant at base 10(KD) varies between 0.05 to 0.2,for municipal sewage per day.
  - For tap water it varies between 0.01-0.05 per day. For the surface water it varies between 0.05-0.1 per day at 20°C.
  - For untreated sewage it varies between 0.1-0.15 Per day & for treated sewage it has value 0.05-0.1per day at 20°C.
  - With increase in temperature of system biolo activity increases and so does deoxygenation constant.

$K_D$ at t°C = $K_D$ at 20°C $[1.047]^{(T-20°C)}$

NOTE :

2. Wastewater sample consists of different types of organic matters, hence requires different microorganisms.
3. Micro organisms obtain carbon for their self growth either from the organic carbon or from molecular carbon like $CO_2$.
4. Microorganisms which utilizes organic carbon for their growth are heterotrophs and those utilising $CO_2$ are termed as autotrophs.
5. Conversion of carbon from $CO_2$ to cellular carbon requires production process which is energy consumpted hence autotropic microorganisms utilizes more of their energy to extract carbon from $CO_2$ resulting into lower cell mass growth.
6. Nitrogenous BOD is satisfied by autotrophs, while the carbonaceous BOD is by heterotrophic.
7. For Municipal sewage BOD is in the range of 100 to 500 milligram perr leter.

## UBOD / COD :

$$UBOD / COD \leq 1$$

5. This ratio represents quality of sewage entering in the treatment plant, hence decides the method of treatment adopted for removal of organic impurities.

   $BOD5 / COD \leq 0.68$

6. this ratio is less than 0.8 or this ratio is less than 0.5 it is assumed to be treated non biologically.

## COD / TOC :

$$COD / TOC = 0 \text{ to } 5.33$$

It is zero for those organic compounds which cannot be oxidised by $K_2 cr_2 O_7$. Thus giving COD equal to zero.

This ratio also signifies quality of sewage and the method of treatment.

## Population Equivalent (PE) :

- Average standard BOD of domestic sewage is 80 gram per capita per day.
- **the number of persons producing the amount of BOD at a rate of 80 milligram per capita per day equal to that produced in industrial sewage is termed as population equivalent.**
  **DOD 5 of industrial is equal to BOD5 of a domestic × potential equivalent.**
- **This parameter is used to find strength of industrial sewage and its corresponding cost of treatment.**

## Relative stability :

- **It is defined as the ratio of oxygen available** in the effluent to the total oxygen required of 1st Stage building , it is denoted by S.
  S = oxygen in effluent ( in form of DO - $NO^{3-}$, $NO^{2-}$, $SO^{4-}$, $CO^{3-}$ )/ Total oxygen required for first stage BOD.
- Here t20 and t37 are times in days required by wastewater samples to decolorize the standard methylene blue solutions at 20 degree Celsius and 37 degree Celsius respectively.
- Decolorization of methylene blue is caused by enzymes released due to Anaerobic microorganisms.

- If decolorization takes place is less than 4 days at 20 degree Celsius at effluent is considered as unstable and if it takes place more for more than 4 days effluentis considered as stable.

NUMERICAL :

Que 1.) Following observations permit was made for 4% dilution of waste water . Dissolve oxygen of aerated water sample used for deletion is 3 milligram per later . Dissolved oxygen of original sample is 0.6 milligram per later. Calculate BOD5 and BODu the oxygenation cost at at 20 degree celcius is 0.23 per day . Dissolve oxygen of diluted sample after 5 days of incubation is 0.8 milligram per liter.

Que 2.) Calculate 1 day 37 degree Celsius body for sewage sample whose 5 day 20 degree Celsius BOD is 100 milligram per Liter. Assume deoxygenation constant at 20 degree Celsius at base 10 to 20 0.1 for a day.

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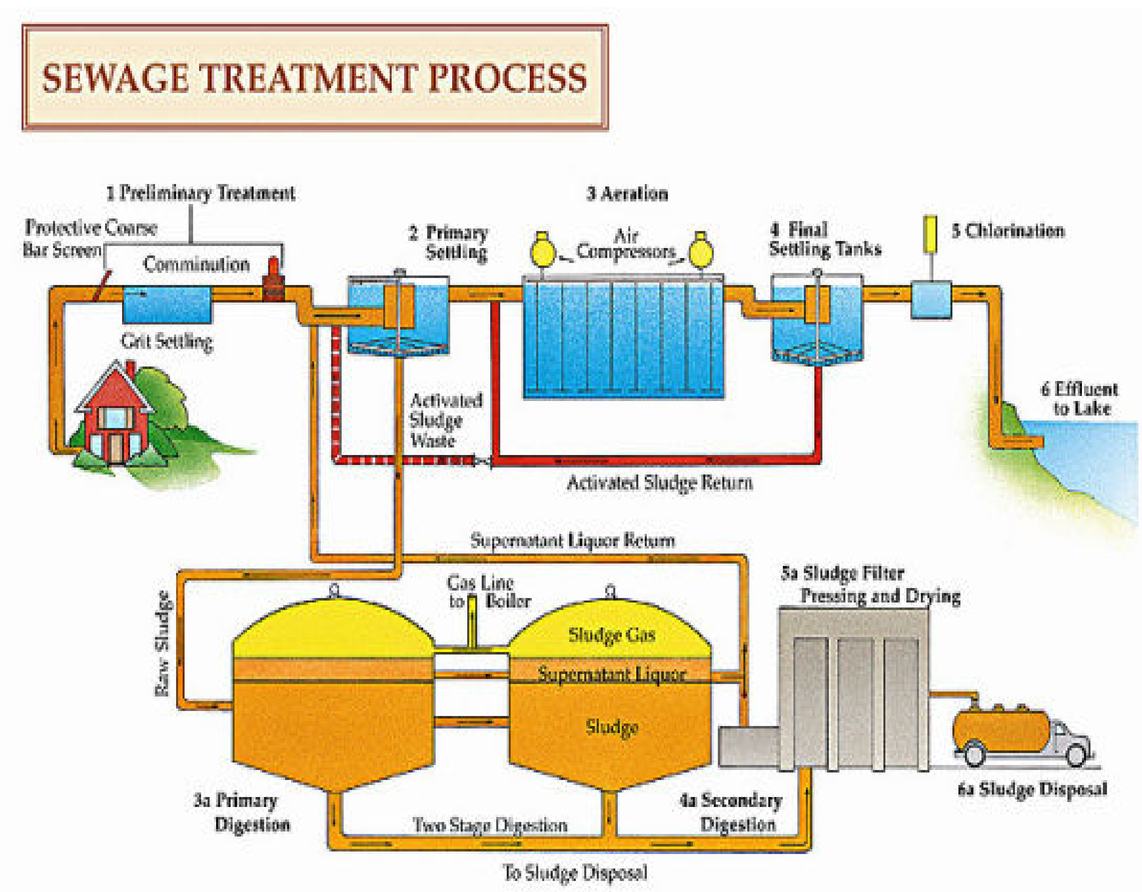
E-NOTES , Subject : Environmental Engineering-2 , Subject Code: CE-312B , Course: B.tech, Branch: CIVIL Engineering , Sem-6th ,

( Prepared By: Ms Kajal, lecturer , CE)

# UNIT - 2

## SEWAGE TEATMENT



1. First degree treatment is provided to remove the suspended impurities both organic and inorganic from wastewater.
2. Screens are used to remove heavy suspended impurities present in wastewater.
3. Grit chamber remove the inorganic suspended solids and PST removes organic suspended matter in sewage.
4. Disposal of inorganic matter is much convenient in comparison to that of organic matter, hence these are being removed separately in the treatment plant.
5. biological treatment remove the organic matter present in sewage, by indusing the biological activity in its which is being carried out by bringing the contact between microorganisms and the organic matter.
6. This contact can be brought by any of the following mechanism:

- By suspending Biomass in wastewater
  Suspended growth system - ASP, OP, ST
- Bypassing wastewater over the Biomass layer which is attached to medium
  Attached growth system - TF, RBC

1. first degree treatment normally removes 60% of suspended impurities and also satisfied 30 to 40% be associated with it.
2. Secondary treatment satisfies 85 to 95% BOD associated with the waste water.
3. Anaerobic sludge / first degree sludge / raw sewage /primary sludge is treated anaerobically in aerobic digester and secondary or biological sludge is treated aerobically in Arabic digester.
4. The concentration of organic matter in PST is more than SST, thus the growth of microorganisms may be uncontrollable in PST. To avoid this the first degree sludge is treated anaerobically.

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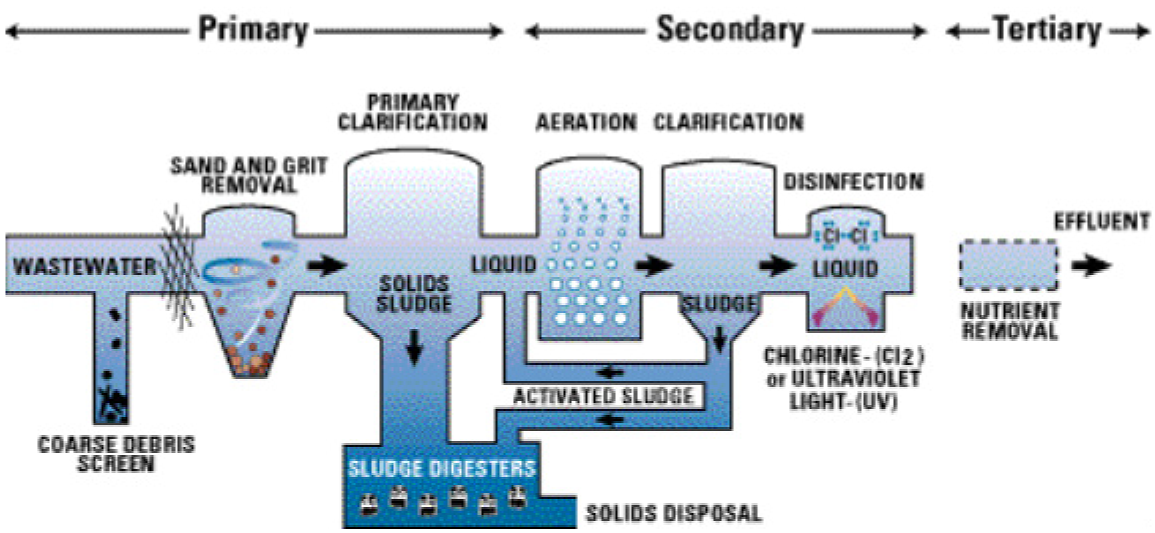
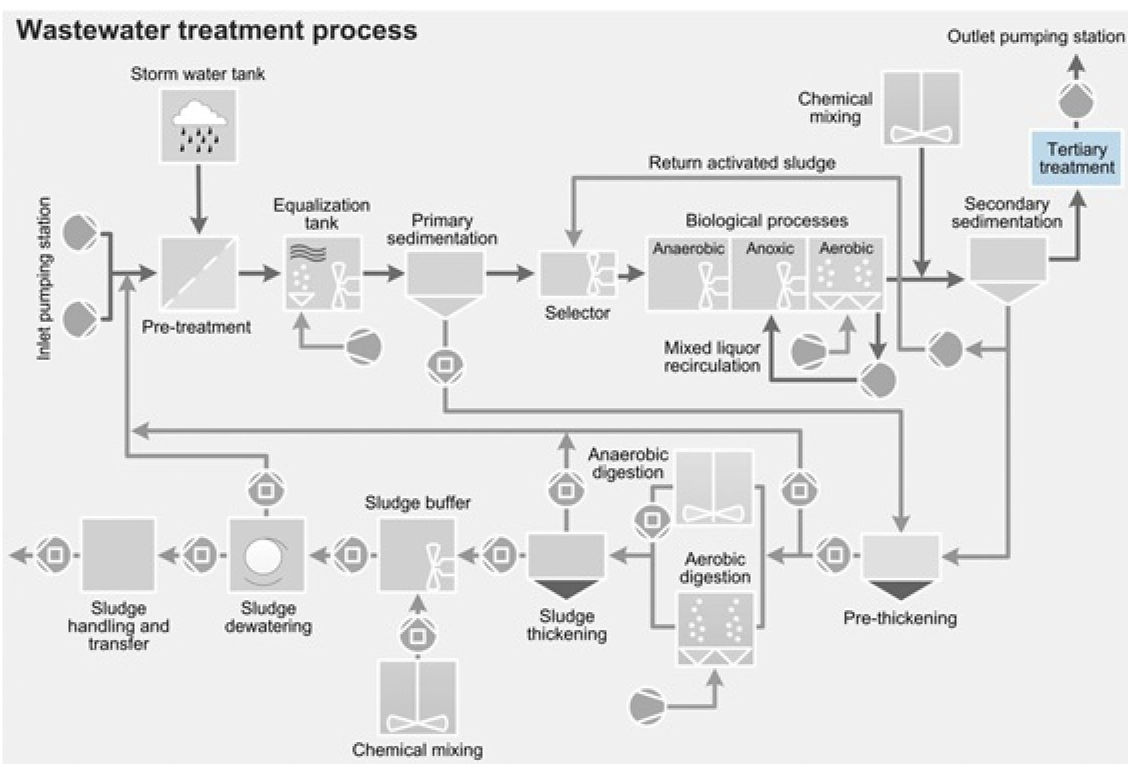
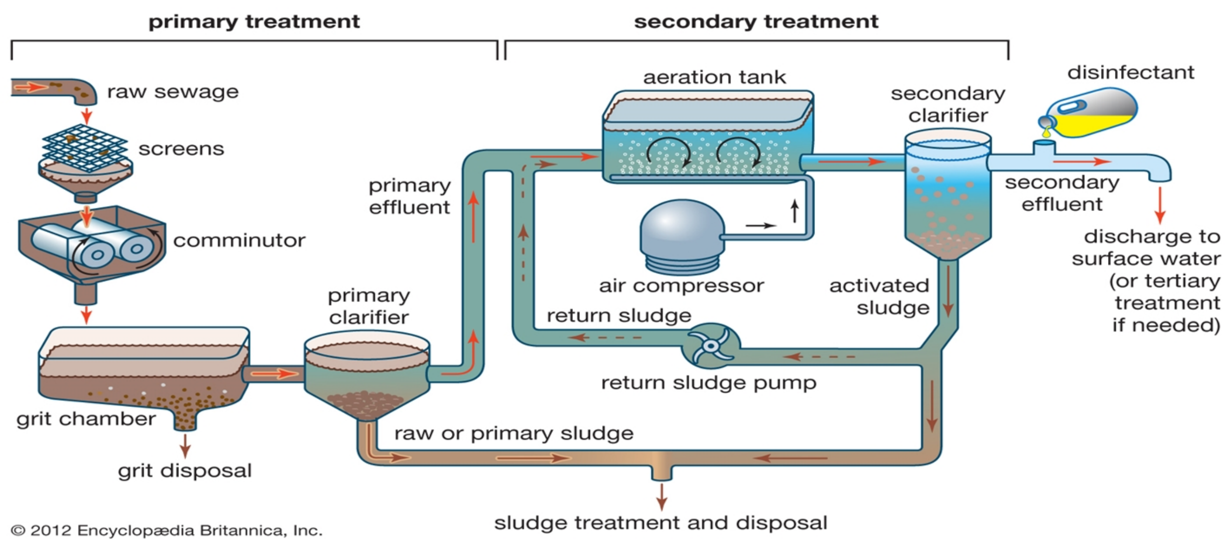


# Primary treatment :




Primary waste water treatment is the physical or chemically enhanced settling of suspended particles. It includes:

1. Aeration of the waste to remove odors and to oxidize Fe(II) to Fe(III). Many compounds with intense odors, such as sulfides and thiols, can be oxidized in air to compounds that don't have a bad smell.

2. The addition of $Al_2(SO_4)_3$, $Fe_2(SO_4)_3$, and $Ca(OH)_2$. These materials precipitate as a flocculant material that traps the suspended particles in the waste water.

3. The waste goes into a tank where the undissolved solids fall to the bottom.

Primary treatment removes only one-third of the BOD and virtually none of the dissolved minerals. This doesn't remove soluble materials or toxic chemicals. The water retains a high BOD.

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**( Prepared By: Ms Kajal, lecturer , CE)**

## Screening :

It removes large floating matters like Polythene bags it has of two type: fine screen and course screen, it is placed in inclined way against the flow of water , Reasons : the floor area increases, velocity reduces, larger floating matters could be collected.

Usually , we prefer coarse screen because fine screen get cloged frequently, so we avoid fine screen.

### Grit Chamber :

3. Grit Chambers are used to remove the inorganic suspended particles like clay, silt, sandd, glass, and egg shelves and to pass forward organic suspended particles present in it for the removal in primary settling tank.
4. These tanks are in the form of long narrow channels which may be rectangular or parabolic in shape.
5. Velocity control devices such as proportional Weir and parshall flume are employed at the end of this chambers.
6. Proportional Weir is used if rectangular section is adopted and partial flume is used if parabolic section of grit chamber is adopted, in general partial flume is favoured over proportional Weir as Head loss is similar in this case.
7. These units are designed generally in the form of two chambers one to carry average discharge and 2nd to carry variation of the discharge in average discharge.
8. The septic tanks are designed to settle inorganic particles of size greater than 0.2 mm and passed away organic particles, for removal of these particles the overflow rate is approximately 2160 metre cube per metre square per day which is calculated using translation law.
9. Detention time is normally in the range of 30 to 60 second generally 60 sec. adopted.
10. Horizontal velocity of flow is in the range of 0.15 to 0.3 metre per second.
11. Depth of tank is approximately 1 to 1.8, freeboard of 0.3 m is divided over district.(to avoid overflow ) .
12. The length of tank is increased approximately by 25 to 30% in order to consider the turbulence of inlet and outlet of Chamber.

# Sedimentation :

Depending upon tendency of suspended particles to interact with each other and concentration of particles, following types of settling may be observed in sedimentation tank :

1. **Discrete settings (type 1 settling) :**
- Shape, size and mass of particles remains same
- Setting is independent of another particle
- Stokes law is applicable
- Settling velocity can be also calculated using transition law example setting in grit chamber.
2. **Flocculating settling (type 2 settling ) :**
- Size, shape and mass changes during settling
- Theoretical settling velocity cannot be calculated
- Flocs are formed
- This occurs when concentration of particles in water is very less
- Examples of primary settling tank where organic particles settle.
3. **Zone of Hindered settling (type 3 settling )** :
- This type of settling is observed when concentration of the particles in water is in medium range such that velocity fields of the particles during their settling settlement overlaps each other.
- Particle settles in form of zone in order to maintain their relative position with respect to each other.
- Example settling in secondary settling tank followed by activated sludge process in this type of settling.
4. **Compression settling (type 4 settling ) :**
- The concentration of particles is very high such that they are in physical contact with each other.
- Bottom layers of these particles support the weight of top players of particles due to which any father settling results by compression of entire particles in the medium, accompained by squeezing out of water from voids of particles.

**Note** :

Sedimentation tank is in which Type III and type IV of settling takes place are designed for solid loading rate and are checked for surface flow rate.

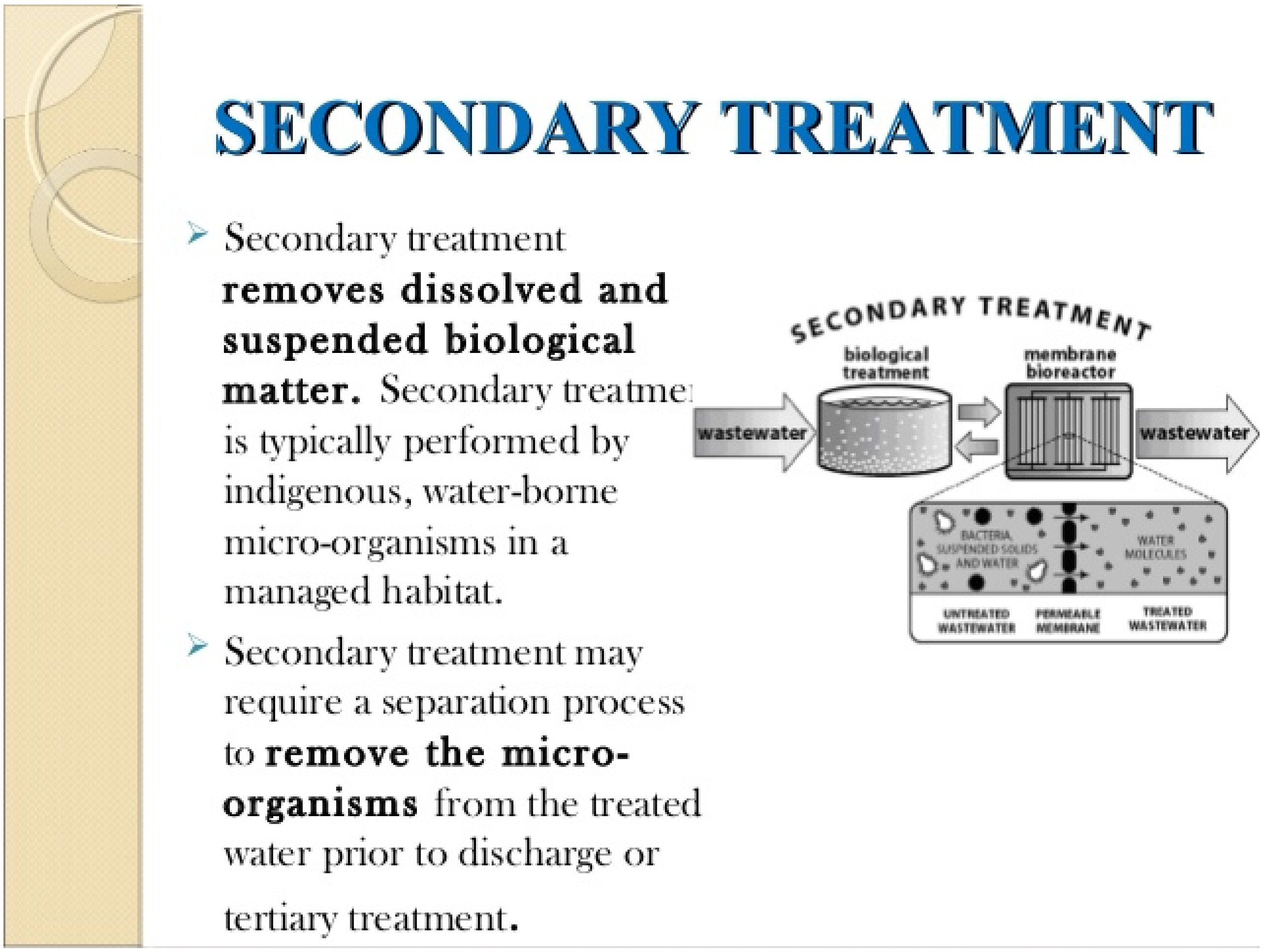
## Primary Settling tank (PST) :

- Overflow rate of the PST varies between 25 to 30 metre cube per metre square per day and 50 to 60 metre cube per metre square per day.(peak)
- Plan area of tank is computed using both the rates and maximum value is adopted,Qavg = 1/3 of Qpeak.
- Depth of tank is in the range of 2.5 to 3.5 metre.
- Detention time is to 2 to 2.5 hours.
- Horizontal velocity of flow is 0.3 metre per minute.
- Rate of tank is kept to be approximately 6 metres and length per width ratio is in the range of 4 to 5 ratio 1.

## Coagulation aided sedimentation :

- Coagulation aided sedimentation is mostly avoided in the treatment of sewage.
- It is avoided because :
  - Coagulant added may destroy microorganisms required
  - Flocs formed may increase volume of sludge formed
  - The cost of coagulant used is more in this case as SS concentration is more in wastewater than raw water.
- It may have ever may be adopted in hilly areas where the availability of areas is less(thus increase in s-o-r is done by coagulation aided sedimentation to reduce plan area).
- Coagulation removes nutrients from water and wastewater also helps thus helps in preventing eutrofication of lakes.

## Secondary treatment :




- Secondary treatment involves biological treatment call the activated sludge process.
- Waste water is mixed with bacteria lead and sludge and oxygen which allowed the bacteria to break down organic matter.
- The water is passed into a sedimentation tank where the activated sludge is collected and removed.
- Aerobic process is a biological treatment process in presence of oxygen , the species of bacteria which require oxygen for their survival , growth and for the process of

reproduction are called aerobic bacteria or aerobs. In wastewater treatment plants ,in aeration tank, microorganism needs Oxygen for respiration and organic material as food. In this way microorganisms biodegrade the organic material and treat the wastewater . Type of some aerobic processes are suspended growth process, attached growth process and hybrid or combined suspended attached growth process. where activated sludge process, leggings and aerobic digestion are part of suspended growth process. Trickling filter, rotating biological contactor and, packed bed reactor( like mbbr,fbr) are common name of attached growth process, and trickling filter combine with growth process.

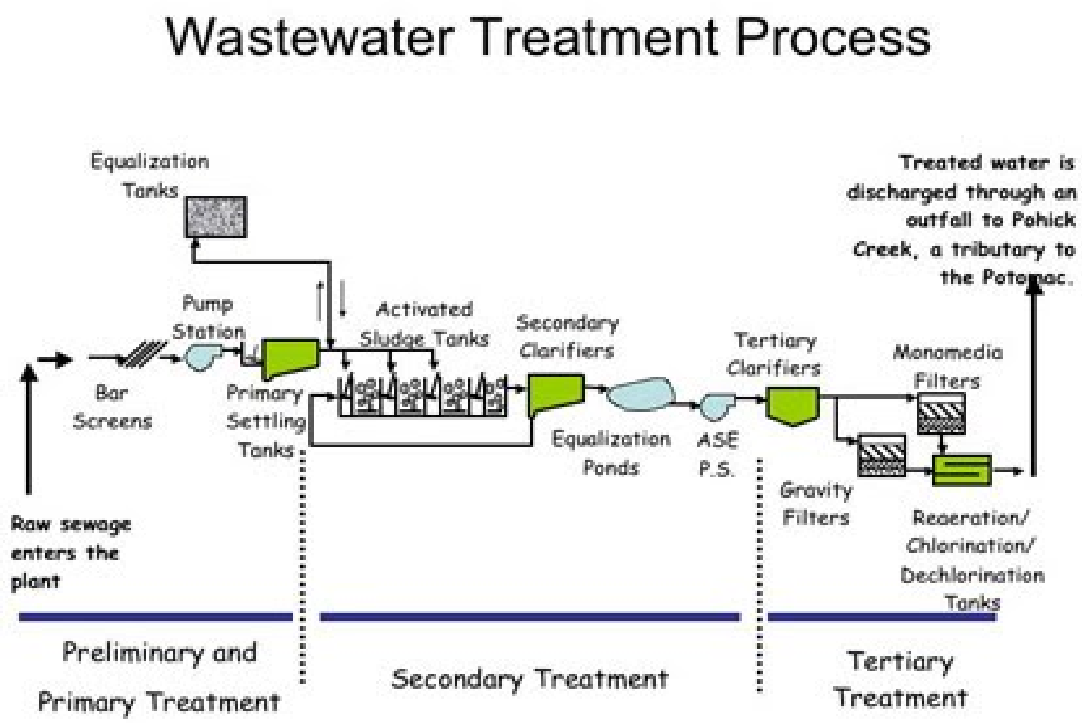
- Secondary treatment is the second wastewater treatment stage which involve the use of microorganisms to remove high level of biodegradable organic pollutants present in the water source . Now there are numerous process in secondary treatment, there are aerobic or anaerobic and pond process now in both aerobic and anaerobic, there are divided into two classes which are suspended and attached.

  Attached growth system : it is the process in which microorganisms responsible for the conversion of organic matters or other constitutes in the wastewater which microorganisms are attached to some inert materials.

  Basic principle of attached growth system: the attached growth system is the simple system we have a solid media and then Biomass layer and also the water that will flow through the system. Basically , the Biomass layer for the bacteria state and grow to the solid media, the liquid waste water will pass through the Biomass layer forming a liquid layer, the biochemical reactions such as organic matter oxidation. Nitrification is the biological process where the conversion of Nitrogen to form nitrogen compounds such as Ammonia nitrate or nitrite under aerobic condition. So, the end products such as carbon dioxide, wastewater, nitrate flow will flow out with the water , leave the biofilm layer back to the liquid layer and move out with the liquid flow into the applicant's stream, meaning that all of those compounds will flow out . Denitrification can only be achieved where anoxic condition axists. Denitrification means of biological process where bacteria convert nitrogen nitrate and nitrite into nitrogen. Where anoxic means a condition in which oxygen available only in a combined for such as nitrate and nitrite, and sulphate in an aquous environment. So, the dead bacteria will be then removed by sedimentation in a final sedimentation tanks.

Examples of Attached growth system : the first one is trickling filter, also known as biological Tower. Next we have rotating biological contactor, packed bed reactors and last but not least, we have Fluidized bed Biofilm reactors.

## Tertiary treatment :




1. Nitrates are highly soluble in water so that they cannot be removed by precipitation.
2. Ion exchange is used to remove nitrates from wastewater.
3. Nitrates can also be removed by biological method that is anaerobic organisms turn the nitrogen in nitrates into atmospheric nitrogen.
4. Heavy metal ions such as cadmium, lead and mercury can be removed by precipitation as their solubility in water is very low.
5. Phosphate ions can be removed by the addition of calcium and Aluminium.

Tertiary treatment includes a range of processes that improve the water quality of the effluent before it is released into a lake, river, or into the ground. Not all sewage treatment plants use any type of tertiary treatment.


*Waste Chlorinator*

These processes include:

1. Filtration

    (a) sand (for particulates)
    (b) activated carbon (for organic compounds)

2. Lagooning
3. Constructed wetlands
4. Biological nitrification/denitrification (removal of ammonia)
5. Chemical precipitation of phosphorus with Fe(III) or Al(III) salts
6. Disinfection (removal of microorganisms)

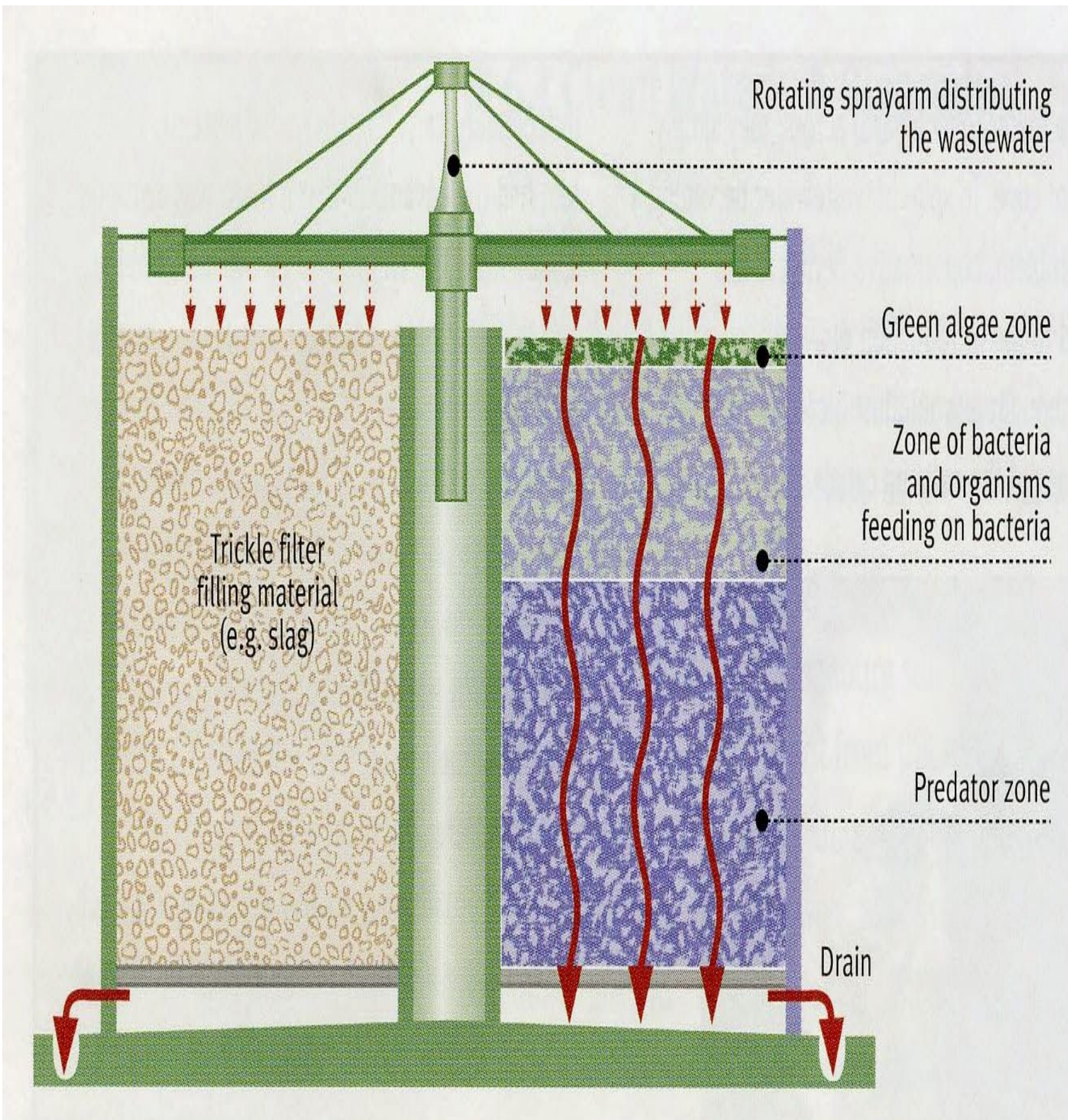
    (a) chlorination
    (b) UV light
    (c) ozonolysis

( Prepared By: Ms Kajal, lecturer , CE)

# Unit – 3

# SEWAGE TREATMENT UNITS DESIGN :

# TRICKLING FILTER (Aerobic attached growth system) :



3. As the wastewater trickles filter medium, Biomass layer grows and attaches to the medium surface making filter ready for operation within two to three weeks.
4. When the ww (waste water) flows through this Biomass layer organic matter present in it, comes in contact with the microorganisms present in the Biomass layers, which carries out oxidation of organic matters resulting in formation of biomass which gets attached over filter medium.
5. The layer in which this process takes place is termed as a Slime layer.
6. The thickness of Slime layer varies from 0.1 to 2mm.
7. In the top surface of this layer aerobic process take place and in remaining anaerobic process takes place.
8. Over a period of time Scarcity of food and oxygen takes place in bottom layers due to increase in thickness of Slime leading to androgynous respiration in bottom layers which leads to increase in concentration of Dead cell mass in layer.
9. The presence of Dead cell mass weakens bond between medium particles and Biomass layer, resulting in its sloughing (removal) due to continuous flow of waste water through filter.
10. This Sloughed Biomass is finally taken to SST for removal.
11. The rate of removal of organic matter in system depends upon following factors:

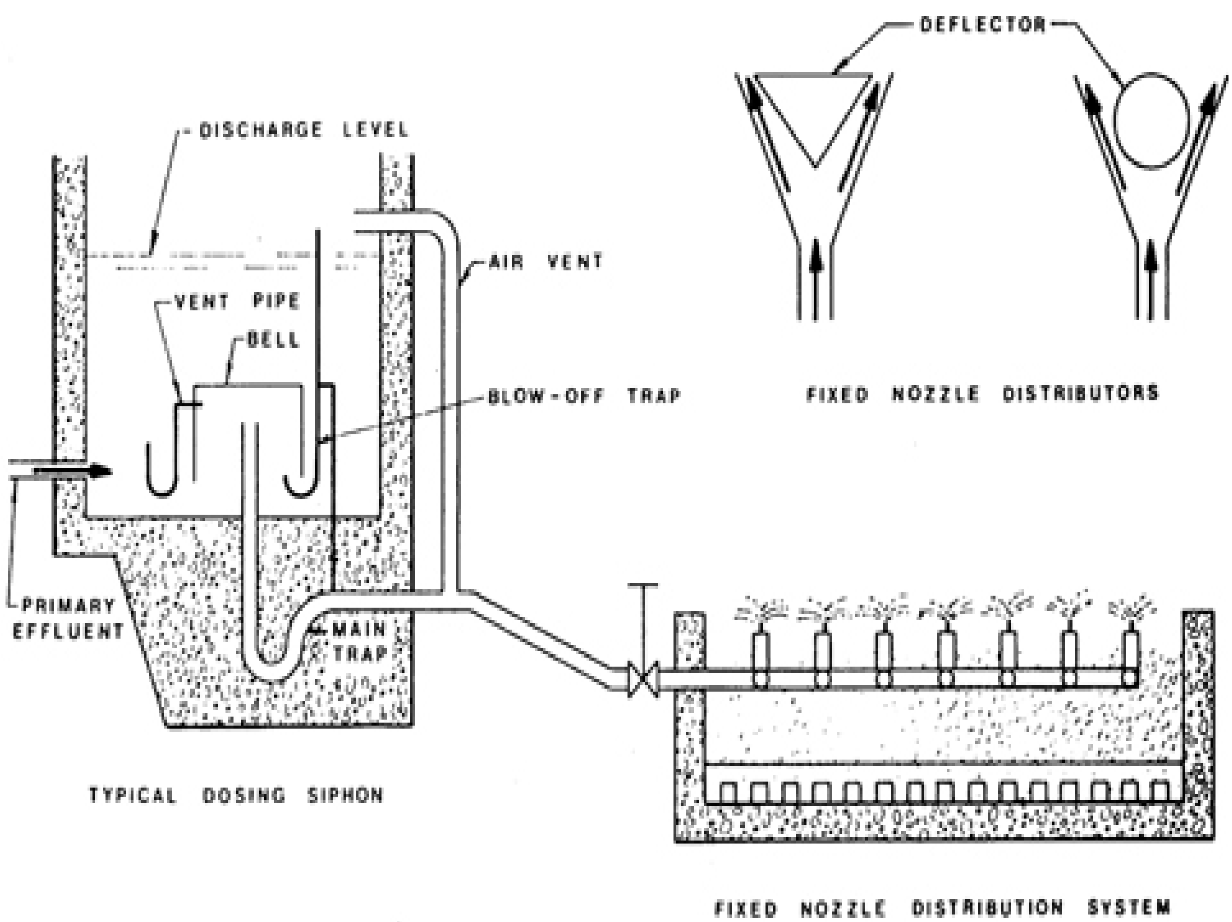
- Hydraulic loading rate
- organic loading rate
- temperature (high temperature increases rate of removal of organic matter).

12. Large organic loading rate will produce more amount of organic matter removed by more microorganisms. Thus Biomass formed will clog the filter does reducing rate of removal of organic matter.
13. Hydraulic loading at high rate will cause sloughing of biomass layers thus increase in rate of removal of organic matter.
14. Trickling filter used to carry out removal of organic matter is generally at two types:

13. Standard rate trickling filter (above discussed)
14. High rate trickling filter

## A.) Standard rate trickling filter:

8. in these types of trickling filter hydraulic loading rate is less as there is no provision of recirculation in this case. ( we can manipulate hydraulic loading rate not organic loading rate).
9. Distribution of wastewater on the filter in wastewater is done by the rotatory distribution method or by spray nozzle method.
10. Rotatory distribution system is more effective source of no orderous gas forms in the system.




## Operational trouble in Standard rate trickling filter :

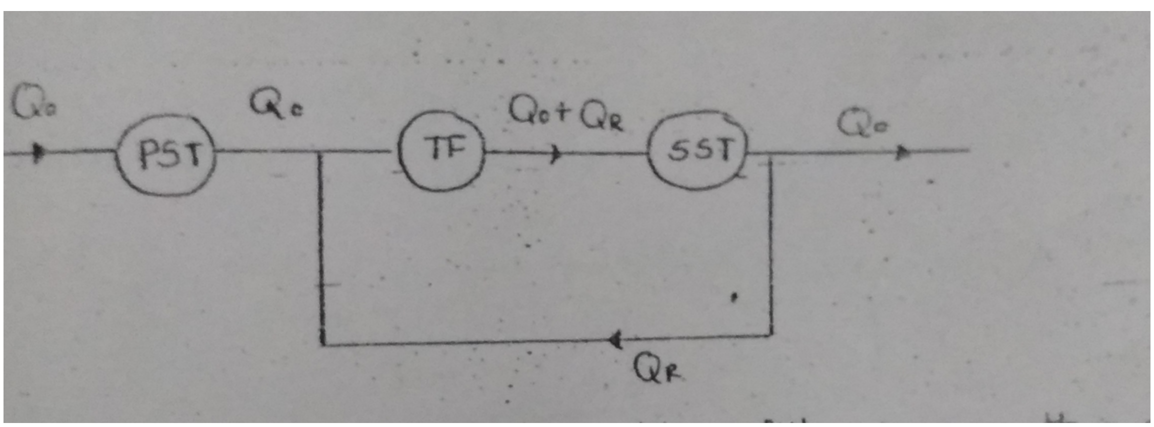
## 7. Fly nuisance:

- As TF is open to atmosphere, insects are generated over its surface which attracts hies.
- This problem can be avoided by spraying is insecticides like DDT over surface of TF ( dichloro diphenyl trichloroethane-DDT).

8. **Odour problem :**
   - As the hydraulic loading rate is less in case of SRTF. The decomposition of organic matter takes place for longer duration leading to evolution of order of gases.
   - To avoid this, hydraulic loading rate is increased.
9. **Ponding problem :**
   - Due to the growth of fungi and algae in the trickling filter, chocking of voids takes place leading to standing or ponding of wastewater above trickling filters.
   - It can be overcome by addition of any oxidizing agent like lime, copper sulphate etc.

     In standard rate trickling filter, oxidation of organic matter upto nitrate level takes place ( nitrification) as hydraulic loading rate is less in this case which provide sufficient time for nitrifying bacteria (autotrophs )for satisfying nitrogenous BOD.

## B.) High rate trickling filter :



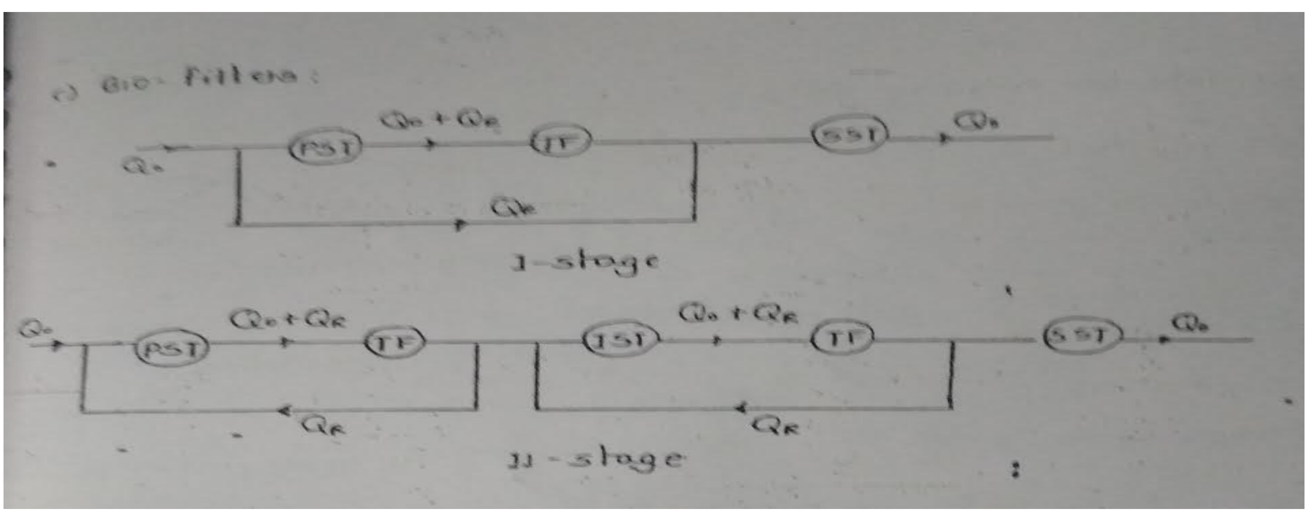

- In high rate trickling filter hydraulic loading rate is increased by recirculating the portion of the treated wastewater discharge.

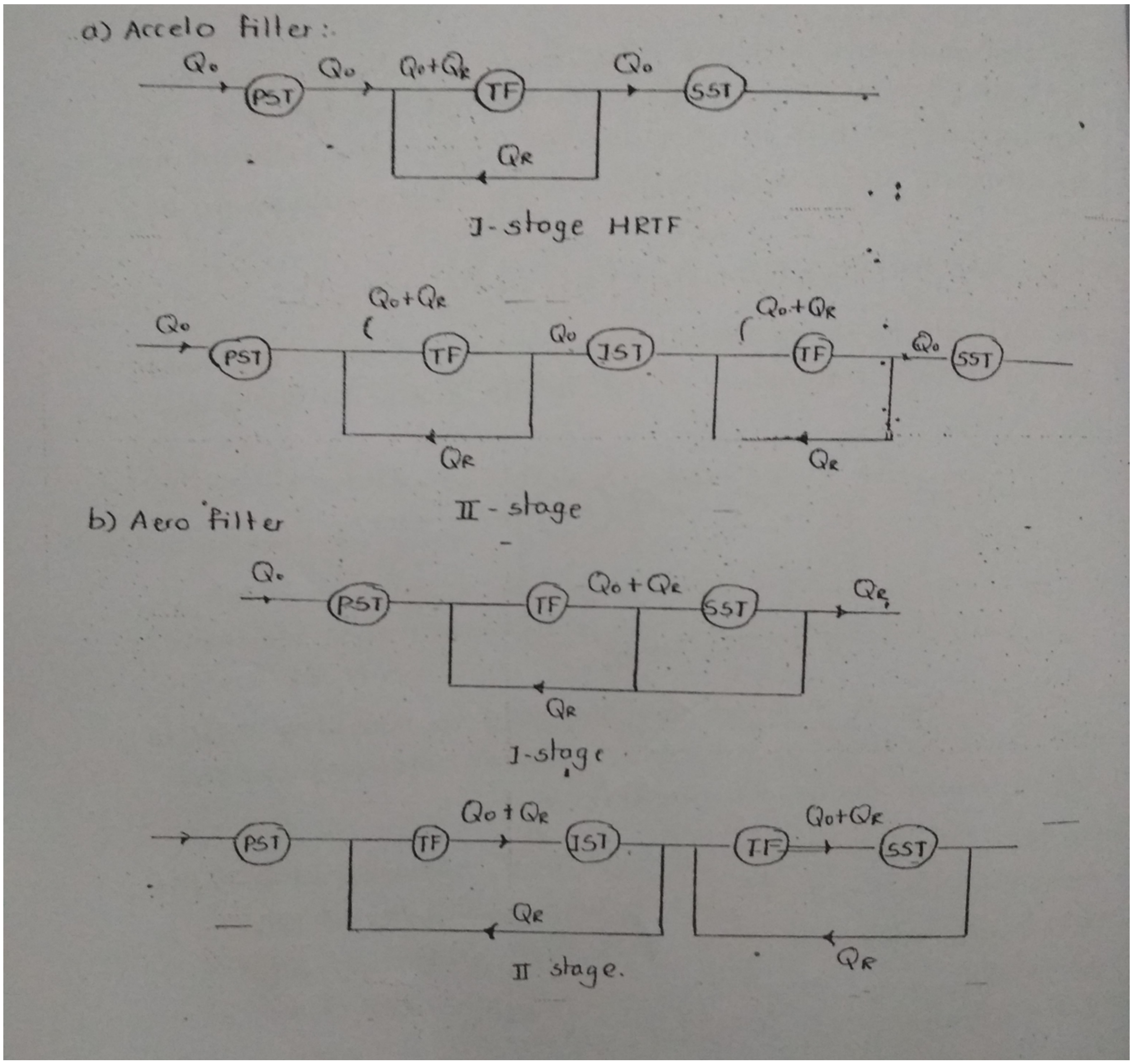
- The efficiency of high rate trickling filter is more than standard rate trickling filter as the contact between micro organisms and organic matters is brought more than once.
- In HRTF, fly nuisance, odour and ponding problem is not formed due to high loading hydraulic rate and reduces coaching of filter. It increases sloughing of biomass layer and keeps filter ventilated .
- Body fluctuations and shock loadings are also dampness in HRTF due to mixing of recirculated ww.
- In HRTF, nitrogenous BOD is not satisfied as sloughing takes place before the action of autotrops.
- The recirculation of sewage in HRTF can be performed in various stages.
- Classification of high rate trickling filter on the basis of method of recirculation of wastewater.

Accelo filter :

Aero filter :

Bio filter :






- The efficiency of second stage HRTF is more than that of first stage HRTF.
- 2nd stage HRTF is generally used when influent BOD is very large. It is also used when effluent BOD desired is 30 milligram per later.

- Nitrogenous BOD is also satisfied in two stage high trickling filter.

$$\eta_{II\,HRTF} > \eta_{I\,HRTF} > \eta_{SRTF}$$

$$\eta_{N\,II\,HRTF} > \eta_{N\,I\,HRTF}$$

$$\eta_{N\,SRTF} > \eta_{N\,I\,HRTF}$$

where,

$\eta_{I\,HRTF}$ - efficiency of Ist stage HRTF

$\eta_{II\,HRTF}$ - efficiency of II stage HRTF

$\eta_{SRTF}$ - efficiency of SRTF

$\eta_{N\,I\,HRTF}$ - nitrogenous efficiency of I stage HRTF

$\eta_{N\,II\,HRTF}$ - nitrogenous efficiency of II stage HRTF

$\eta_{N\,SRTF}$ - nitrogenous efficiency of SRTF

( Prepared By: Ms Kajal, lecturer , CE)

## Design date for trickling filter :

| Design parameters | SRTF | HRTF | SUPER HRTF |
|---|---|---|---|
| Hydraulic loading rate (m3/m2/day)(including recirculation) | 1-4 | 10-40 | 40-200 |
| Organic loading rate (Kg/m3/day)(excluding recirculation) | 0.08-0.32 | 0.32-1 | 0.6-0.8 |
| Depth(m) | 0.8-2.5 | 0.9-3 | 4.5-12 |
| Recirculation ratio ($R=Q_r/Q_o$) | 0 | 0.5-3 | 1-4 |

Surface area = $Q_o$/HLR (excluding recirculation)

Or

Surface area = $(Q_o+Q_r)$ /HLR (including recirculation)

Volume = $Q_o.S_o$/OLR (excluding recirculation)

Or

Volume = $(Q_o.S_o + Q_r.S_o)$ /OLR

( Prepared By: Ms Kajal, lecturer , CE)

## Efficiency of trickling filter :

Efficiency of Trickling Filter:

As per GOI manual.

a) For SRTF.

$$\eta(\%) = \frac{100}{1 + 0.0044\sqrt{u}}$$

where u - unit organic loading rate (kg/Ha.m/day)

$$\eta(\%) = \frac{100}{1 + 0.44\sqrt{u}}$$

- u - kg/m³/day

b) HRTF

for stage I.

$$\eta_I = \frac{100}{1 + 0.0044\sqrt{\frac{W_1}{V_1 F_1}}}$$

where $W_1$ - amount of BOD entering into stage I (kg/day) - $Q_0 \cdot S_0$

$V_1$ - volume of filter in stage I (Ha·m)

$F_1$ - recirculation factor for stage I

$$F_1 = \frac{(1+R)}{(1+0.1R)^2} \qquad R = \frac{Q_R}{Q_0}$$

for stage II.

$$\eta_{II} = \frac{100}{1 + \frac{0.0044}{1-\eta_I}\sqrt{\frac{W_2}{V_2 F_2}}}$$

$W_2$ - BOD entering into stage II

$W_2 = W_1 (1-\eta)$

overall efficiency of biological process

$$\eta = \eta_I + (1-\eta_I)\cdot\eta_{II}$$

Numerical 1 :

Population of 30,000, domestic sewage produced is 120 lpcd having BOD of 200 milligram per leter. Industrial sewage produced is 3 into 10 ki power 5 litre per day having BOD 800 gram per later. Design HR single stage TF with following data:

BOD removed in PST - 35%

Organic loading rate - 10,000kg/ha.m/day ( exclu.recirculation)

Hydraulic loading rate - 170×106 lit/ha/day (inclu. recirculation)

Recirculation ratio - 1

Find efficiency of TF and BOD of effluent .

Answer :

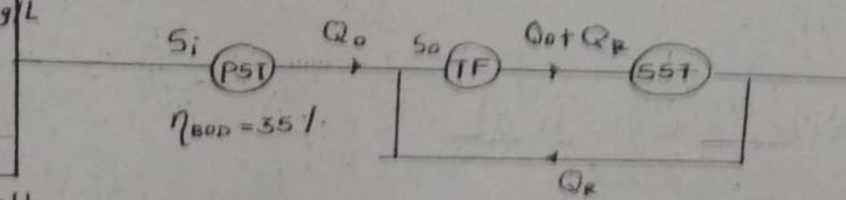
$Q_{IS} = 3\times10^5$ L/d

$BOD_{IS} = 800$ mg/L

$Q_{DS} = 120$ lpcd

$P = 30,000$

$BOD_{DS} = 200$ mg/l




$$Q_o = Q_{IS} + Q_{DS}$$
$$= 3\times10^5 + 120 \times 30,000$$
$$= 3.9 \times 10^6 \text{ l/day}$$

Influent HuenBOD

$$S_i = \frac{Q_{IS}\cdot BOD_{IS} + Q_{DS}\cdot BOD_{DS}}{Q_o}$$
$$= \frac{3\times10^5 \times 800 + 3.6\times10^6 \times 200}{3.9\times10^6}$$
$$= 246.1 \text{ mg/l}$$

∴ Influent BOD in TF

$$S_o = 0.65 \times 246.1$$
$$= 160 \text{ mg/l}$$

$$\text{Surface area of TF} = \frac{Q_o + Q_R}{\text{HLR (including R}}$$
$$= \frac{2\times3.9\times10^6}{170\times10^6} \times 10^4 \text{ m}^2$$
$$= 458.8 \text{ m}^2$$

$R = \frac{Q_R}{Q_o} = 1$

$Q_R = Q_o$

$$\frac{\pi D^2}{4} = 458.8$$

$$D = 24.17\ m^2$$

$$\text{volume of TF} = \frac{Q_0 \cdot S_0}{\text{OLR (excluding R)}}$$

$$= \frac{3.9\times10^6 \times 160\times10^{-6} \times 10^4}{10000}$$

$$= 624\ m^3$$

$$\text{depth (H)} = \frac{\text{volume}}{\text{surface area}}$$

$$= \frac{624}{458.8}$$

$$= 1.36\ m$$

iency of trickling filter

$$\eta_1 = \frac{100}{1 + 0.44\sqrt{\frac{W_1}{V_1 F_1}}}$$

$$W_1 = Q_0 \cdot S_0$$

$$= 3.9\times10^6 \times 160\times10^{-6}$$

$$= 624\ kg/day$$

$$V_1 = 624\ m^3$$

$$F_1 = \frac{1+1}{(1+0.1\times1)^2} \qquad R = 1$$

$$= 1.65$$

$$\eta_1 = \frac{100}{1 + 0.44\sqrt{\frac{624}{624\times1.65}}}$$

$$= 74.25\ \%$$

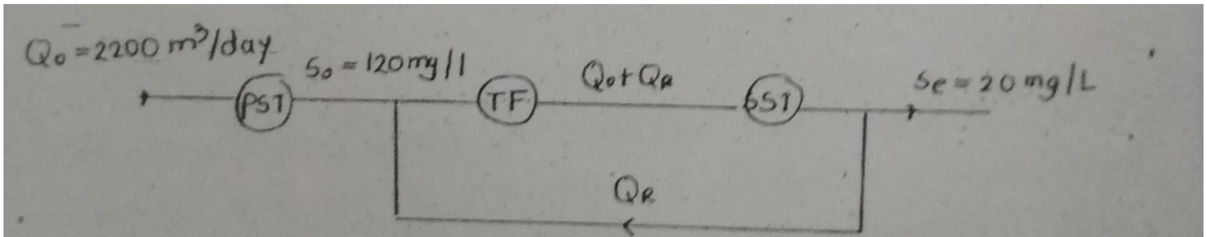
$$\eta_1 = \frac{Q_0 \cdot S_0 - Q_0 \cdot S_e}{Q_0 \cdot S_0} \times 100$$

$$74.25 = \left(\frac{160 - S_e}{160}\right)\times100 \qquad S_e = 41.20\ mg/l$$

Numerical 2 :

Calculate the diameter required for single stage TF which is to yield effluent BOD of 120mg/L. When treating settled domestic sewage of BOD 120mg/L. Waste water flow is 2200 metre cube per day and recirculation discharge is 4000 metre cube per day, depth of tank is 1.5 metre.

ANSWER :




Efficiency of treatment.

$$(\eta) = \frac{Q_0 \cdot S_0 - Q_0 \cdot S_e}{Q_0 \cdot S_0} \times 100$$

$$= \frac{120 - 20}{120} \times 100$$

$$= 83.3\ \%$$

Or

$$\eta = \frac{100}{1 + 0.0044\sqrt{\frac{H_1}{V_1 F_1}}}$$

Amount of BOD entering.

$$W_1 = Q_0 S_0$$

$$= 2200 \times 10^3 \times 120 \times 10^{-6}$$

$$= 264 \text{ kg/day}$$

$$F_1 = \frac{1+R}{(1+0.1R)^2}$$

$$R = \frac{Q_R}{Q_0} = \frac{4000}{2200}$$

$$= 1.81$$

$$F_1 = \frac{1+1.81}{(1+0.1\times1.81)^2}$$

$$= 2.01$$

$$83.3 = \frac{100}{1 + 0.44\sqrt{\dfrac{264}{V_1 \times 2.01}}}$$ in kg/m³/day

$$V_1 = 637 \text{ m}^3$$

Depth = 1.5 m.

$$\text{Plan area} = \frac{637}{1.5}$$

$$\frac{\pi D^2}{4} = 425$$

$$D = 23.3 \text{ m}$$

ote:

The diameter of trickling filter is limited upto 60 m, as it is the maximum available size of rotatory distribution. (if more than 60 m, steel truss will bend at its ends due to self weight)

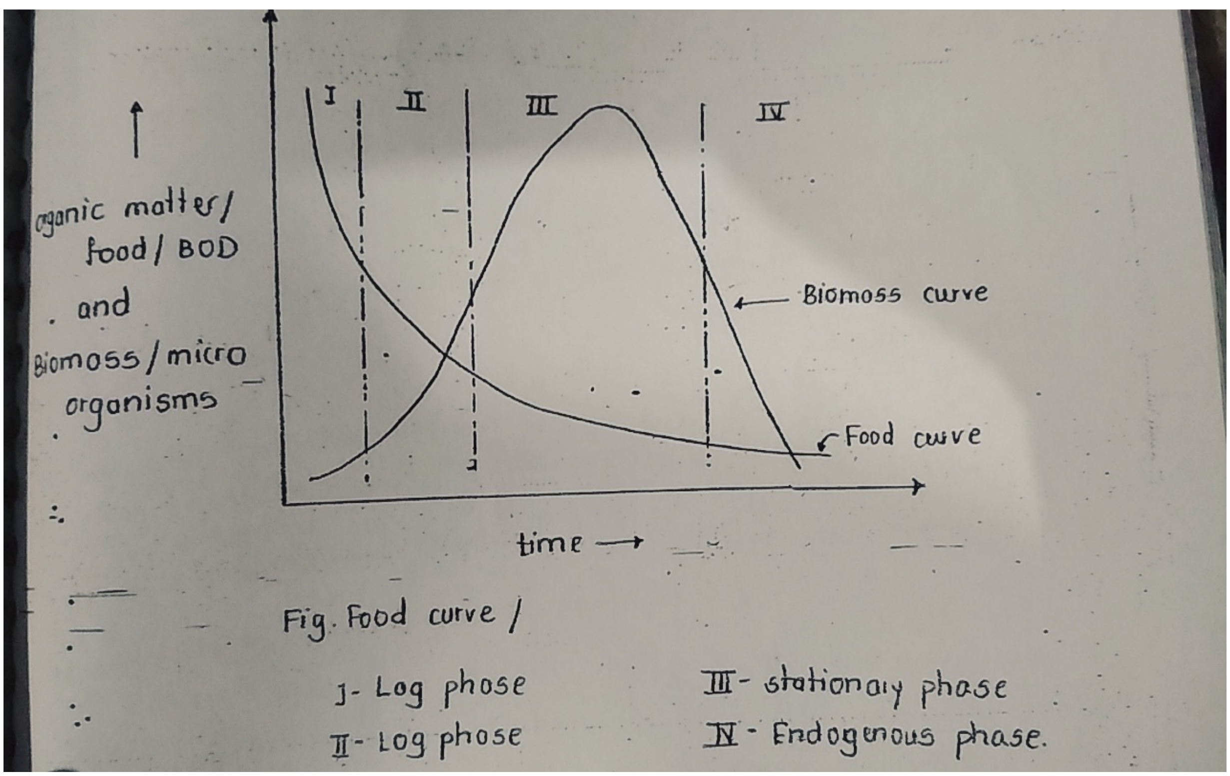
# Activated Sludge Process (ASP):

### (Aerobic Suspended Growth System)

**The entire process of biological decomposition is believed to takes place in four phases.**

**1. First Log phase**

15. In the phase micro organisms get accumulated to food and environment given to them.
16. If the micro organisms are already familiar with the environment and food given to them then duration of log phase is less.
17. The growth of biomass in the phase is very less hence it is termed as Log phase.



**2. Second Log phase**

- In log phase micro organisms reproduce rapidly by cell division leading to the rapid increase in the growth of biomass at corresponding decrease in the organic matter in waste water.
- In ASP, we try to maintain system in log phase .

**3. Third Stationery phase**

**15.** In this phase growth of biomass is slightly obstated due to endogenous respiration resulting from scarctity of food.

**4. Fourth Endogenous phase**

11. In this phase endogenous process of respiration starts due to depletion of organic matter from system.

## A.) For biomass:

- dx/dt is directly proportional to X. (without considering endogenous respiration stage fourth)

  Where dx/dt= rate of biomass formation

  X=biomass present at time ( MLSS/MLVSS)

  dx/dt=kx. -------(I)

  k=overall gri rate constant (depends on type of micro organism )

- **MLSS ( Mixed liquor suspended solids)is generally taken as index for** active micro organisms present in waste water but it also comprises of dead cell mass and other inorganic impurities considered in MLSS, the MLVSS is used to represent active micro organisms in the system ( Mixed liquor volatile suspended solids)

Considering endogenous respiration

dx/dt is directly proportional to -x

dx/dt= -Ker.x. ---------(ii)

Where Ker= endogenous decay rate constant ( 0.06 per day for municipal sewage)

From I and ii

dx/dt = (K-Ker).x

## B.) For organic matter /BOD/FOOD:

ds/dt is directly proportional to s

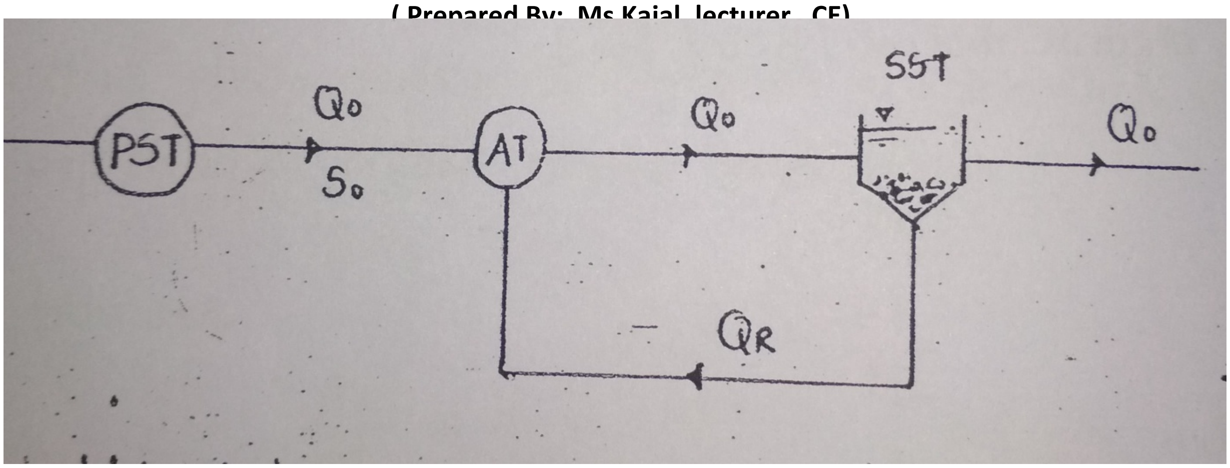
da/dt= -Kd.s

Some fraction of organic matter is reduced by consumption of carbon by micro organisms.

-y(ds/dt)= dx/dt

Where y= organic matter fractionconverted into biomass.

This portion of organic matter converted to biomass is more for aerobic process and less for anaerobic process because



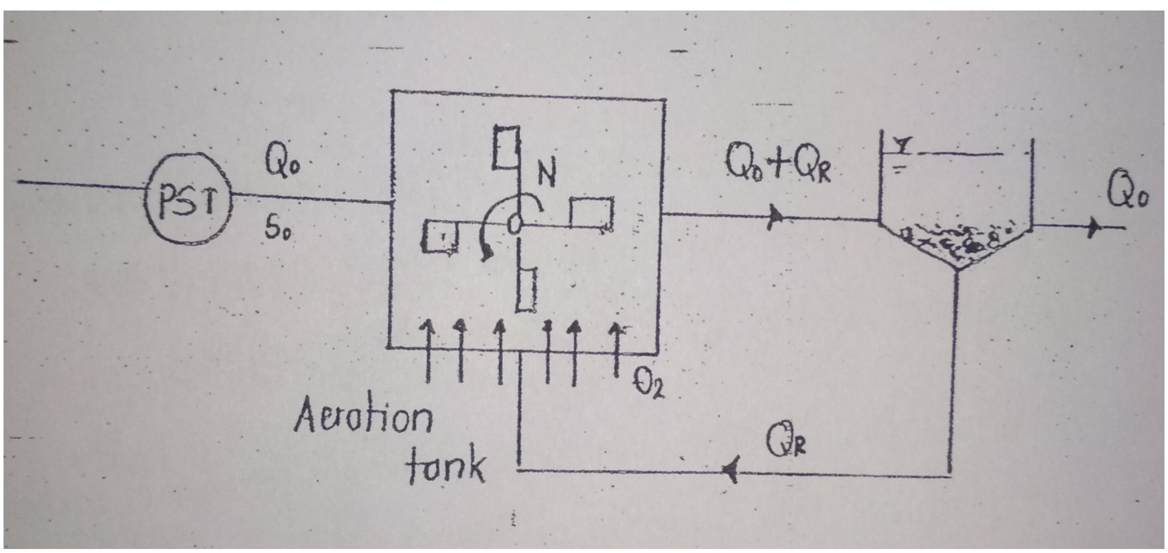

- microorganisms converted the organic matter into the large quantity of biomass ds they consume less quantity of carbon and produce other products.
- In anaerobic process microorganisms consume carbon and produce less quantity of biomass.

**#####£####£######**

- In activated sludge process secondary or biological sludge (sludge coming from SST) which mostly comprises of living microorganisms also termed as active microorganisms is recirculated back to aeration process to carry out oxidation of organic matter. Hence process is termed as activated sludge process.
- Activated sludge process is suspended growth culture in which sludge return is done by following any of the flow regime.

## A.) Complete mix process:

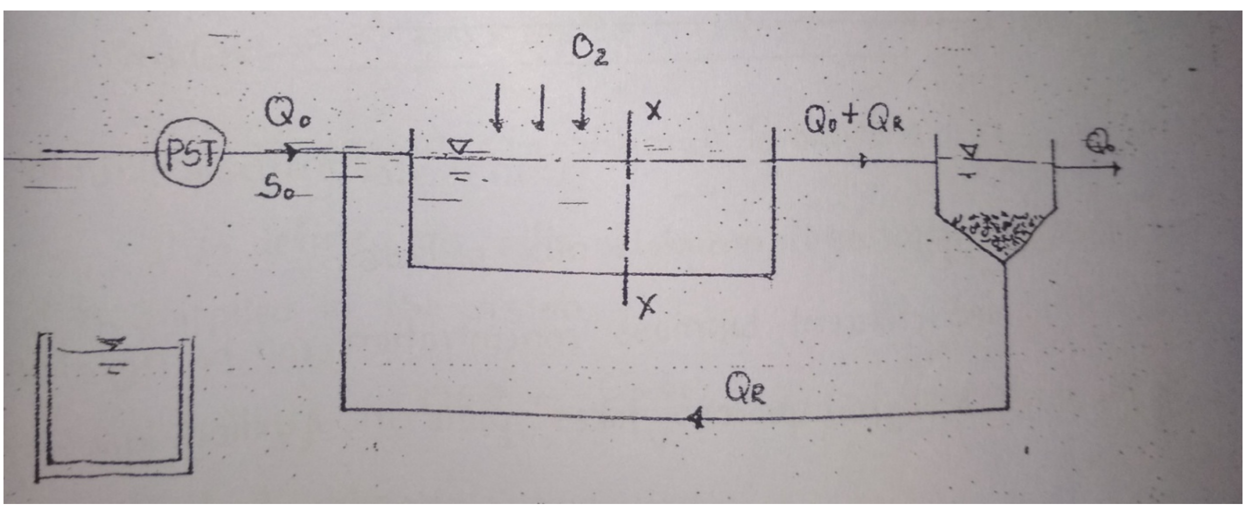
- It is adopted for plants having capacity less than 25 MLD.
- in this process incoming wastewater is completely makes with activated sludge by inducing mixing in aeration tank.
- In complete mix process square or circular tanks are used provided with mechanical aerators.
- Operational stability of this process with regard to shock loading is very high as complete mixing is indused in the aeration tank.
- F/M ratio and oxygen demand is uniform to out the tank in this system (due to mixing).




- This system is capable of holding high MLSS.

## B.) Plug Flow Process:

- It is conventional method used for plants of capacity more than 300 mld.
- Plug flow process represent the gradual flow of wastewater along the length of tank in which activated sludge is mixed at the inlet.
- Long narrow channels are adopted in plug flow process.
- In this system F/M ratio and oxygen demand gradually decreases along the length of tank.
- This process lacks operational with respect to shock loadings.



- In plug flow process decomposition of organic matter upto the nitrate levels takes place as sufficient time is provided for nitrifying bacteria which satisfies nitrogenous BOD.
- More efficiency of complete mix process than this method.

## C.) Extended Aeration :

- Flow regime in extended aeration process is completely mixed.

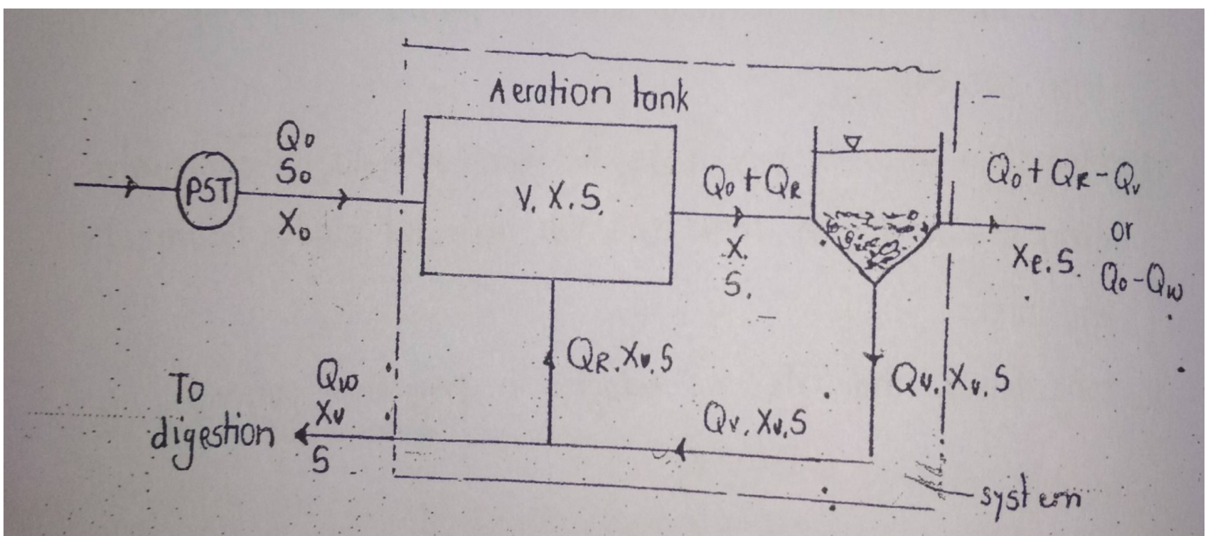



Fig. Analysis of Complete mix process

- In this process primary sedimentation tank is avoided and at employs low organic loading rate , high MLSS conc. resulting in low F/M ratio corresponding increased efficiency.

- The entire process is carried out in long narrow channels and system in this case is maintained in endogenous phase, resulting in high concentration of dead cell mass in the sludge formed which does not requires digestion and can be disposed directly on drying beds.

## Assumptions in analysis of complete mix process :

- In fluent and effluent biomass concentration can be neglected.
- The entire biological process takes place in aeration tank only

Biomass entered + biomass grown=biomass out

QoXo +. V.dx/dt = (Qo-Qw)Xc + Qw.Xu

V(K-Ker).X =Qw.Xu

Nn K =Qu.Xu/V.x. + Ker .......(I)

Food entered - Food content =Food out

Qo.So - (-Y.ds/dt) = (Qo-Qw).S + Qw.S

Qo.So -. (dx/dL)V =Qo.S

Qo.So - (K-Ker)XV = Qo.S

Qo(So-S)/VX = K .......(ii)

From I and ii

Ker + We.Xu/VX =Qo.(So-S)/VX

## Design parameters used in ASP :

1. **Hydraulic retention time (HRT) :**

   **It** is defined as volume of aeration tank to the rate of flow of waste water excluding recirculation.

   HRT = V/Qo (Hours)

2. **Organic loading rate (OLR) :**

   It is defined as ratio of BOD applied to the mass of BOD applied to the system.

   OLR = Qo.So/V (kg/$m^3$/day)

3. **Specified food utilisation / substrate rate (U) :**

   It is defined as ratio of BOD removed in the system to the mass of biomass in the aeration tank.

   U = Qo(So-S)/VX ( Kg/kg/day)

4. **Sludge age (Qc) :**

   It is the average time for which sludge remains in the system . It is defined as ratio of mass of MLSS leaving the system per day.

Qc=Vx/[(Qo-Qw)Xc + We.Xu]

Qc=Vx/We.Xu

Sludge age determines the occurrence of nitrification in the system . More is sludge age more are the chances for nitrification to takes place.

To avoid the nitrification , the wasted sludge discharge can be increased 2 decrease sludge age.(because nitrification consumes oxygen required for carbonaceous.)

In the case, where Qc is reduced efficiency of system reduces to Less MLSS in tank.(Q.Vu)

5. **F/M ratio :**

It is define as ratio of BOD applied to systemto the mass of biomass in aeration tank. Efficiency of tank depends on F/M ratio.

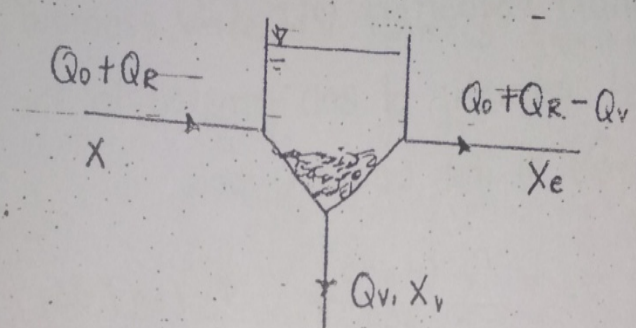
-F/M = Qo.So/V.X

U = Lee+1/Qc

**( Prepared By: Ms Kajal, lecturer , CE)**

## 6.**Re-Circulation ratio :**

(vi) Re-circulation ratio (R)




Mass conservation, on biomass.

$$(Q_0+Q_R)X = Q_u \cdot X_u + (Q_0+Q_R-Q_u)\cdot X_e \quad (X_e \to 0)$$

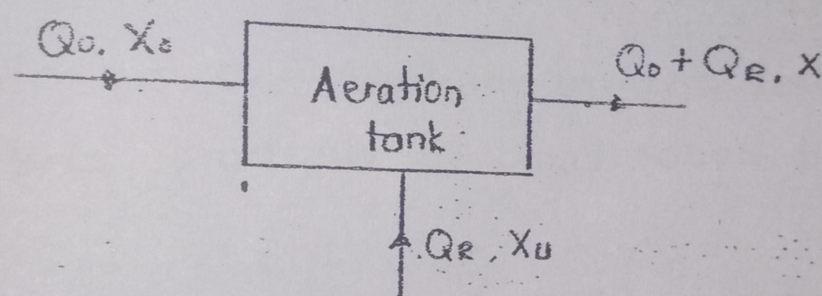
$$\left(1+\frac{Q_R}{Q_0}\right)X = \frac{Q_u}{Q_0}\cdot X_u$$

$$R = \frac{Q_u \cdot X_u}{Q_0 \cdot X} - 1$$

**INTERNATIONAL INSTITUTE OF TECHNOLOGY & MANAGEMENT, MURTHAL SONEPAT**

**E-NOTES , Subject : Environmental Engineering-2 , Subject Code: CE-312B , Course: B.tech, Branch: CIVIL Engineering , Sem-6th ,**

**( Prepared By: Ms Kajal, lecturer , CE)**




Mass conservation on biomass

$$Q_0 \cdot X_0 + Q_R \cdot X_u = (Q_0 + Q_R) \cdot X$$

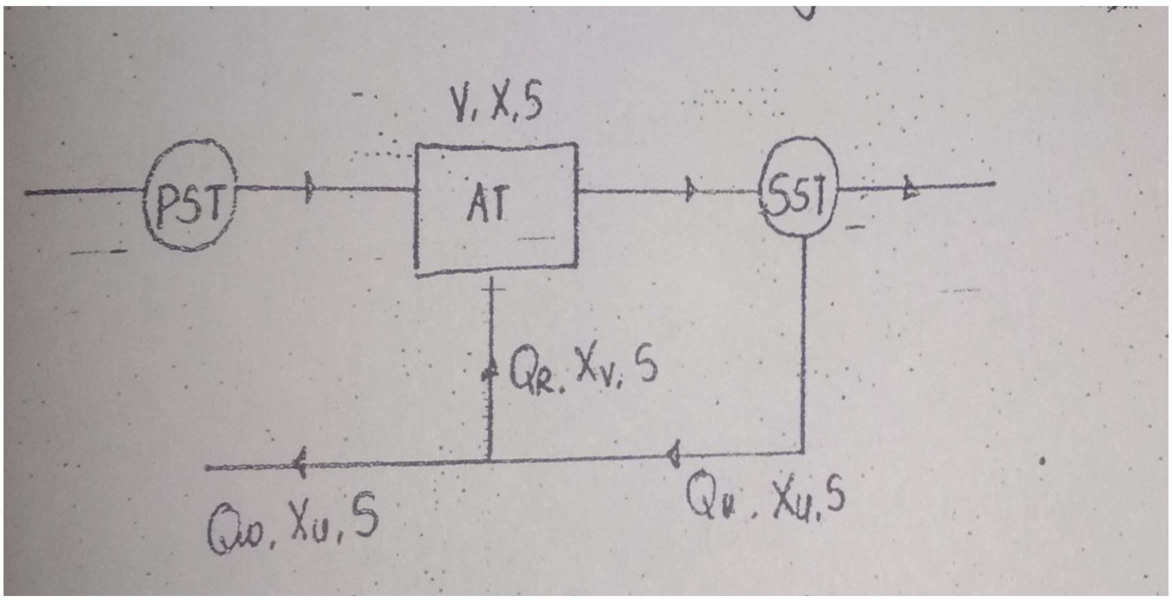
$$Q_R (X_u - X) = Q_0 \cdot X$$

$$R = \frac{Q_R}{Q_0}$$

$$R = \frac{X}{X_u - X}$$

## 7. Sludge volume index (SVI) :

Mass conc. In aeration tank is dependent on circulation ratio in which is determined on the basis of sludge volume index.




Sludge volume represents physical state of sludge and signifies concentration of sludge in aeration rate to obtain the desired MLSS and F/M ratio for the given degree of treatment .

Sludge volume index is defined as volume occupied in ml by one gram of solids when allowed to settle for 30 minutes.

( Prepared By: Ms Kajal, lecturer , CE)

## Determination of sludge volume index (SVI) :

- The standard test involved to find SVI in laboratory collection of 1 litre of mixed liquor from discharge end of the aeration tank.
- This mixed liquor is allowed to settle in graduated containers for 30 minutes and volume occupied by solid in ml settled in container after 30 minutes is noted.
- Let the observed volume be Vob,which represents the volume of solids settled in graduated container in 30 minutes someone liter of mixed liquor.
- The settled solids are again remixed in mixed liquor and standard test is performed to find concentration of the ss in mixed liquor.

Let the observed concentration of ss be Can (mg/l)

Sludge volume index (SVI) = Vob/Xob

=(ml/l)/(mg/l)

= ml/mg

= 1000*Can/Xab

Concentration of solids aeration tank (Xu) = $10^6$/SVI

R= Qr/Qo = X/(Xu-X) = X/($10^6$/SVI - X)

- Sludge volume index normally veries between 80-150 ml/ gm.

**Numericals :**

**INTERNATIONAL INSTITUTE OF TECHNOLOGY & MANAGEMENT, MURTHAL SONEPAT**

**E-NOTES , Subject : Environmental Engineering-2 , Subject Code: CE-312B , Course: B.tech, Branch: CIVIL Engineering , Sem-6th ,**

**( Prepared By: Ms Kajal, lecturer , CE)**

Q. A complete mix process is designed with the following data.

Initial discharge $(Q_0)$ = 10,000 $m^3/d$

BOD after primary sedimentation = 150 mg/l

effluent BOD = 5 mg/l

Fraction of organic matter converted into biomass = 0.5

Endogenous decay rate constant $(K_{ER})$ = 0.05 /day.

MLSS = 3000 mg/l

underflow concentration $(X_u)$ = 10,000 mg/l

Determine the reactor volume, mass and volume of sludge wasted per day & recycle ratio.

Assume $\theta_c = 6$ days

(i) ∴

$$VX = \frac{Y \cdot Q_0 (S_0 - S) \cdot \theta_c}{1 + K_{ER} \cdot \theta_c}$$

$$V \times 3000 = \frac{0.5 \times 10000 \, (150-5) \times 6}{1 + 0.05 \times 6}$$

$$V = 1115.38 \, m^3$$

(ii) Mass of sludge wasted per day $= Q_w \cdot X_u$.

$$\theta_c = \frac{VX}{Q_w \cdot X_u}$$

$$Q_w \cdot X_u = \frac{VX}{\theta_c}$$

$$= \frac{1115.38 \times 3000 \times 10^{3} \times 10^{-6}}{6}$$

$$= 557.65 \text{ kg/day}.$$

volume of sludge wasted per day. $= Q_w$.

$$= \frac{Q_w \cdot X_u}{X_u}$$

$$= \frac{557.65}{10,000} \times 10^{6} \times 10^{-3}$$

$$= 55.76 \text{ m}^3/\text{day}.$$

(iii)

$$R = \frac{Q_R}{Q}$$

$$= \frac{X}{X_u - X}$$

$$= \frac{3000}{10000 - 3000}$$

$$R = 0.428$$ (Assumed sludge age is ok)

Q. For a conventional treatment plant flow of wastewater is 50,000 m³/day. Endogenous decay rate constant is 0.06 day⁻¹. Raw ww BOD is 250 mg/l. Fraction of organic matter converted to biomass is 0.5. Raw ww SS conc. is 400 mg/l. Efficiency of PST for removal of BOD is 35%. & for removal of suspended solids is 75%. ASP of efficiency 90% -

1° & 2° excess sludge SS conc. is 40 & 10 kg/m³ respectively. Sludge-age is 6.5 days. Determine.

(i) Volume of aeration tank.

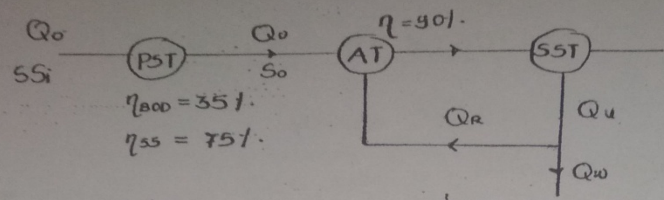
(ii) mass & volume of excess sludge wasted day⁻¹

(iii) Recirculation ratio.

(v) Sludge recirculation

(vi) $O_2$ required.

vii) Total sludg in treatment plant.




$$S_o = 0.65 \times 250$$
$$= 162.5 \text{ mg/l}$$

$\theta_c = 6.5$ days, $K_{ER} = 0.06 \text{ day}^{-1}$ $y = 0.5$

Assume $X = 2000$ mg/l

$$\eta = \frac{Q_o (S_o - S)}{Q_o \cdot S_o} \times 100$$

$$90 = \frac{162.5 - S}{162.5} \times 100$$

effluent BOD $S = 16.25$ mg/l

(i) volume of tank.

$$XV = \frac{y \cdot Q_o (S_o - S) \theta_c}{1 + K_{ER} \cdot \theta_c}$$

$$VX(2000) = \frac{0.5 \times 50000 (162.5 - 16.25) \cdot 6.5}{1 + 0.06 \times 6.5}$$

$$V = 8548.7 \text{ m}^3$$

(ii) Mass of sludge wt. per day = Qw

$$\theta_c = \frac{VX}{Q_w \cdot X_u}$$

$$Q_w \cdot X_u = \frac{VX}{\theta_c}$$

$$= \frac{8548.7 \times 2000 \times 10^{-6} \times 10^3}{6.5}$$

$$= 2630.4 \text{ kg/day}$$

volume of sludge wasted per day.

$$= \frac{Q_w \cdot X_u}{X_u}$$

$$= \frac{2630.4}{10}$$

$$= 263.04 \ m^3/day$$

(iii) To calculate R.

$$R = \frac{Q_R}{Q_o}$$

$$= \frac{X}{X_R - X}$$

$$= \frac{2000}{10 \times 10^6 \times 10^{-3} - 2000}$$

$$= 0.25$$

(iv) Pump capacity = $Q_R$

$$Q_R = R \cdot Q_o$$

$$= 0.25 \times 50,000$$

$$= \frac{12500}{24}$$

$$= 520 \ m^3/hr.$$

(v) oxygen required

$$= \frac{Q_o (S_o - S)}{0.68} - 1.42 \cdot Q_w \cdot X_w$$

$$= \frac{50,000 (162.5 - 16.25)}{0.68} \times 10^{-6} \times 10^3 - 1.42 \times 2630.4$$

$$= 7018.5 \ kg/day.$$

volume of sludge generated in treatment plant

= primary sludge + secondary sludge

volume of sludge from SST $(Q_w)$ = 263.04 $m^3/day$.

wt. of sludge in PST (solids) $= Q_0 \cdot SS_i \cdot \eta$

$= 50{,}000 \times 400 \times 10^{-6} \times 10^{3} \times 0.75$

$= 15{,}000$ kg/day.

wt. of sludge in PST, ($P = 95\%$)

$= \frac{100}{(100-95)} \times 15000$

$= 3 \times 10^{5}$ kg/day.

volume of sludge in PST $= \frac{3 \times 10^{5}}{40}$

$= 7500\ m^3/day$.

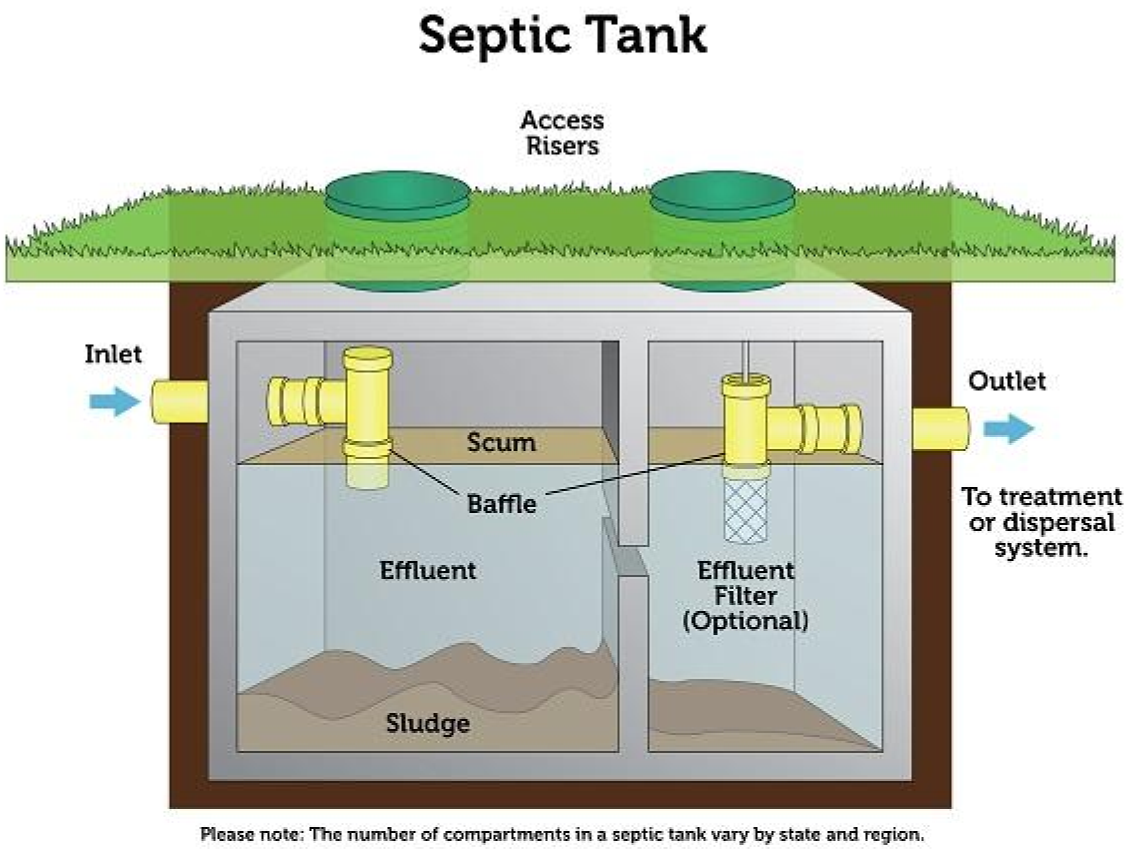
Total volume of sludg $= 7763.04\ m^3/day$.

( Prepared By: Ms Kajal, lecturer , CE)

# UNIT-4

# LOW COST SANITATION TANK :

# SEPTIC TANK(Anaerobic suspended growth system ) :




1. In septic tank designing is done similar to sedimentation tank with only difference detention time of 26 to 36 hours is provided.
2. During this period solid present in waste water settles at the bottom of tank where it is digested over period of 6 to 12 months anaerobically.
3. Additional volume is provided in septic tank for this digestion to take place.
4. to rising of oil, grease and soap to surface scum layer is formed which acts as thermal insulator and does not allow odorous gases to escape into the atmosphere.
5. The flow of sewage in tank is taken to be 40 to 70 lpcd , if sullage is also considered .The flow is taken as 90 to 150 lpcd.
6. Rate of accumulation of sludge varies between 30 to 40 litre per capita per year.

7. Detention time-12 to 36 hours
   Cleaning time-6to12hours
   L/B ratio =2 to 3
   Width(B) =0.9m
8. Volume of septic tank
   V = V1 + V2
   $V1 = Q_o.t_o$
   V2 = Rate of accumulation of sludge ×cleaning period
9. Effluent of septic tank is disposed of either in soak pits or in dispersion trenches.
10. Soak pit and dispersion trenches should possess sufficient permeability so as to allow easy percolation of the effluent into the ground.
11. Percolation rate is defined as time required in min. by the effluent to seep into the ground by the distance of 1 cm.
12. Soak pits are used if percolation rate is less than 30 min & dispersion trenches are used if percolation rate is in range of 30 to 60 min.
13. The max. rate of effluent application on ground can be calculated by following empirical relation.
14. $Q^x = 204/\sqrt{t}$ $(t/m^2/day)$
    t= percolation rate in min
    plan area of soak pit/dispersion trenches
    $= Q_o/Q^x$

## NUMERICAL

Estimate size of septic tank having length to width ratio 2.25 and liquid depth of 2 m with 300 mm board. Also compute desludging interval in years and total trench area in m square of percolation field of small colony of 300 people. Assuming water supply 100 lpcd and sludge production 0.04 m cube per capita per year.

Detention time is 3 days . Desludging is done when tank one third full of sludge . A percolation test indicates allowable hydraulic loading of 100 l/ m square/ day.

**Solution :**

volume of septic tank.

$$V = V_1 + V_2$$

$$V_1 = Q_0 \cdot t_D$$

$$= (0.8 \times 300 \times 100 \times 10^{-3}) \times 3$$

$$= 72 \ m^3$$

$$V_2 = \frac{1}{3} V_4$$

$$V = 72 + \frac{V}{3}$$

$$V = 108 \ m^3$$

$$V_1 = 36 \ m^3$$ (for sludge accumulation)

volume of accumulated sludge

= rate of accumulation × population

$$= 0.04 \times 300$$

$$= 12 \ m^3/\text{year}.$$

De-sludging intervals $= \frac{36}{12} = 3$ yrs.

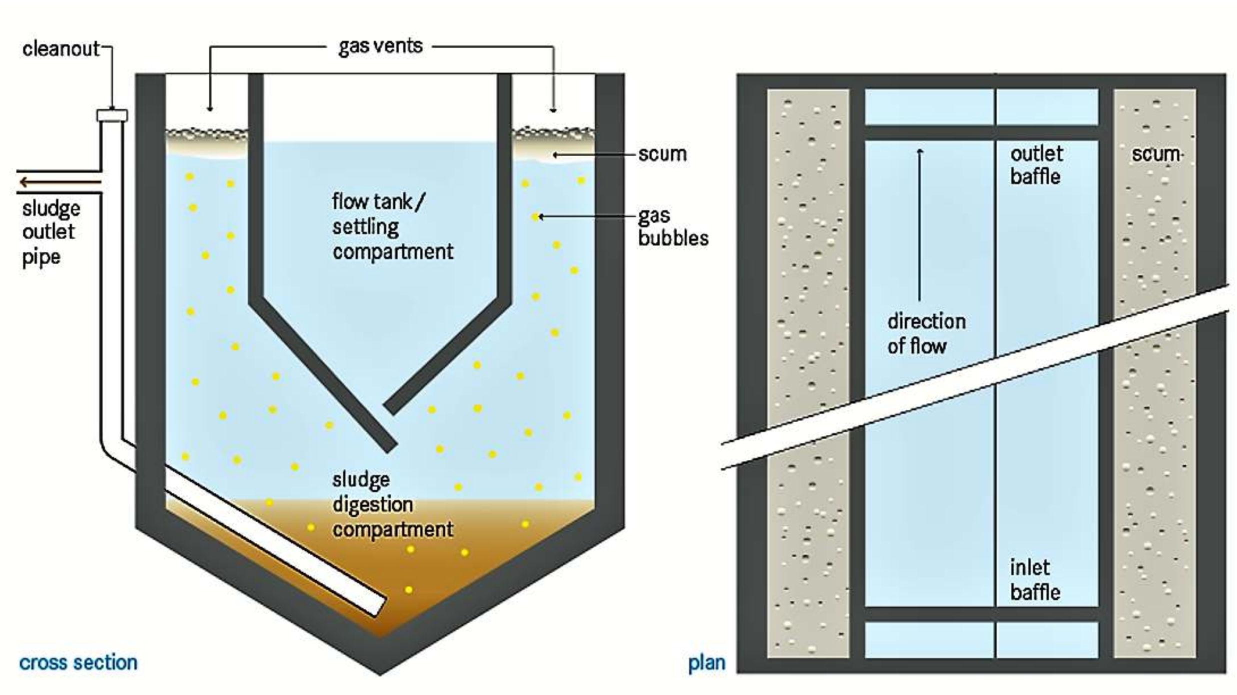
— Plan area of percolation field.

$$= \frac{Q_0^*}{Q_0^*}$$

$$= \frac{24 \times 10^3}{100}$$

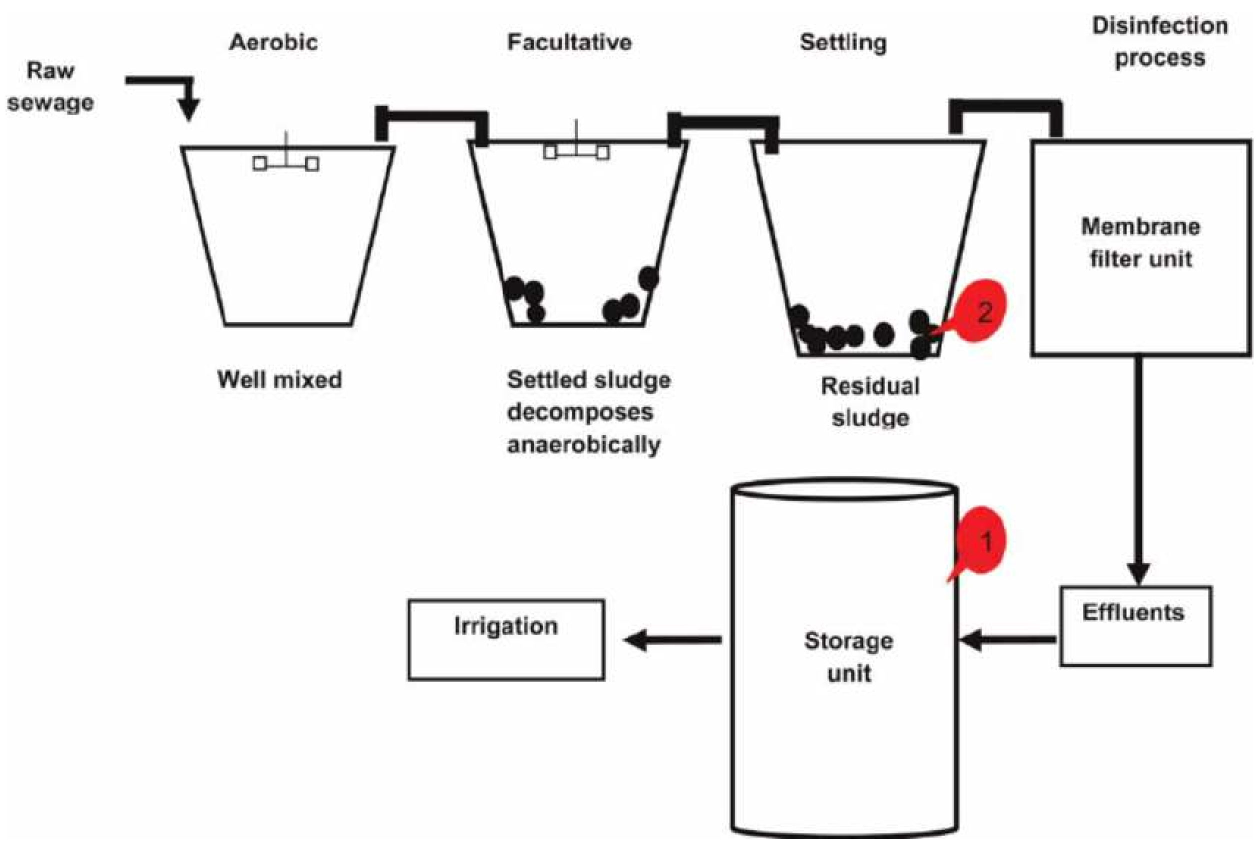
$$= 240 \ m^3$$

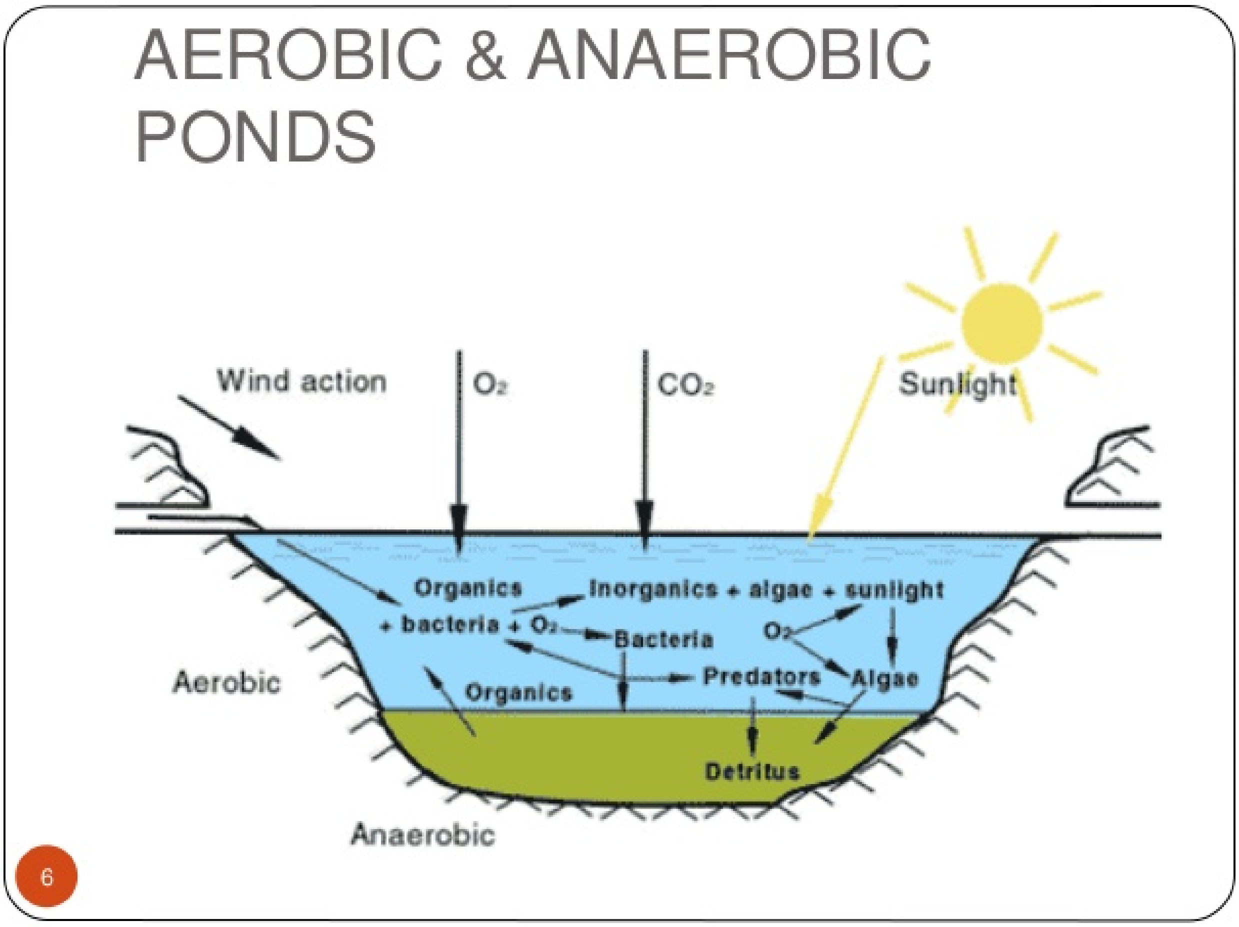
# INHOFF TANK :




- Inhoff tank is improvement over Septic tank in which the incoming sewage is not allowed to get mixed with sludge and effluent is not allowed to carry undigested sludge with it.
- It is a two storeyd tank in which sedimentation takes place in upper sedimentation chamber and digestion of sludge takes place in lower chamber.
- All parameters are same as that of septic tank.\

# OXYDATION POND(Aerobic suspended growth system):


Raw sewage
Aerobic
Facultative
Settling
Disinfection process
Membrane filter unit
Well mixed
Settled sludge decomposes anaerobically
Residual sludge
2
1
Storage unit
Effluents
Irrigation




1. Oxidation pond is in the form of long earthen channels which provides comparitively large detention time during which waste water gets oxidized by action of microorganisms.

2. In this pond special relationship exist between aerobic microorganisms and algae in aerobic zone.
3. oxygen released by algae during photosynthesis is utilised by

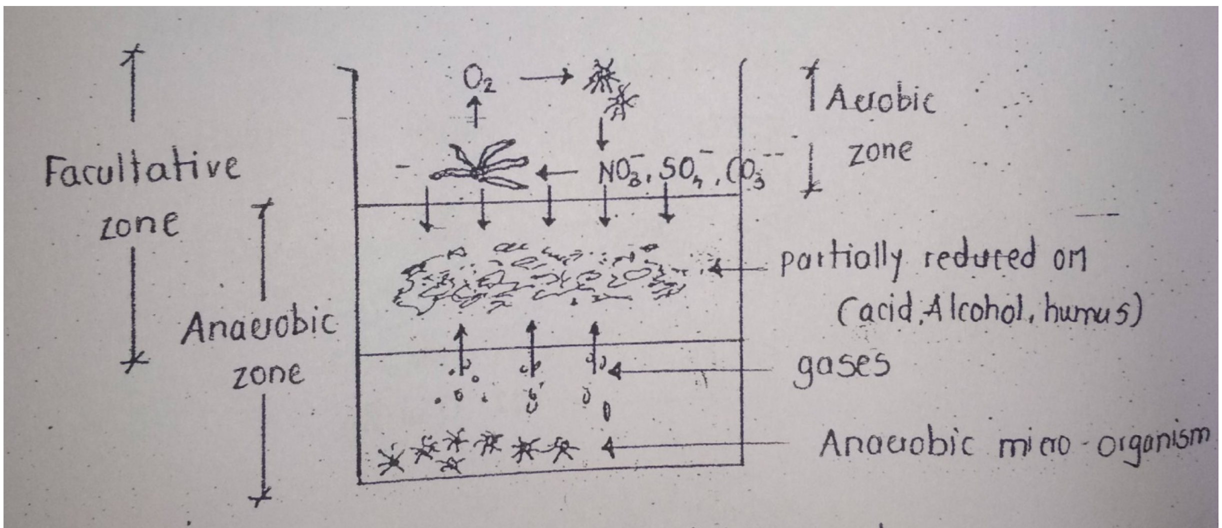



Fig. Mechanism of Oxidation pond.

microorganisms to carry out decomposition of organic matter resulting in biomass which again sewers as nutrient for algae.
4. Such mutual beneficial relationship is termed as the symbolic relationship . This type of relationship also exist between aerobics microorganisms in top zone and anaerobic microorganisms in bottom zone .
5. Gases released by anaerobic microorganisms during decomposition rise to surface and act as food for aerobic microorganisms settles down to bottom layer to act as nutrient for anaerobic microorganisms.
6. In real terms oxidation pond is facultative process (practically).

## Design parameters of oxidation pond :

- Depth of tank is in the range of 1 to 1.8 metre.
- Detention time is approximately 2 to three weeks.
- Organic loading rate depends upon temperatures of locality where pond is to be constructed and temperature of locally and turn depends on latitude.

| Latitude (N) | Organic loading rate<br>Kg/Ha/day |
|---|---|
| 36 | 150 |
| 32 | 175 |
| 28 | 200 |
| 24 | 225 |
| 20 | 250 |
| 16 | 275 |
| 14 | 300 |
| 12 | 325 |
| 8 | 350 |
| 4 | 375 |

NOTE : Latitude for India is 24 and 20.

- L/B ratio is generally taken as 2.

- Area of each unit varies from 0.5 to 1 hectare.

Plan area = BOD entering/Organic loading rate

$= Q_o.S_o/OLR$

1. Pathogenic bacteria removal efficiency is approximately 99% while BOD removal efficiency is 95%.

2. The effluent of oxidation pond are not discharged and are used for Sewage farming as it is sufficiently clarified.

3. Rate of accumulation of sludge varies between 2 to 5 centimetre per year.

4. Due to accumulation order problem may persist in pond .To avoid it sodium nitrate is headed which is strong oxidizing agent because

Removes odorous gases

Serves as nutrient for growth of algae.

5. Detention time of oxidation born can be computed empirically by following relation.

$LD = ( 1/K_d)\log(1/L-Y)$

Where. L = influent BOD in mg/l

Y = BOD removed in mg/l

11. oxidation pond is generally provided for small communities having no source of power.

**NUMERICAL :**

Population of town is 20,000 with water supply of 150 lped.BOD of wastewater is 150 milligram per litre .design the most suitable wastewater treatment system without power to the town.

**SOLUTION :**

Design discharge ($Q_o$) = $20,000 \times 150 \times 0.8 \times 10^{-3}$

$= 2400\ m^3/day$

Assume organic loading rate 200 kg/ ha/ day

plan area = $150 \times 10^{-6} \times 2400 \times 10^3/200$ ($A = Q_o.S_o/OLR$)

$= 1.8$ ha

Provide 2 units each of 0.9 Ha

$L/B = 2$

$2B \times B = 0.9 \times 10^4$

$B = 67.08m$

$L = 134.16m$

provide depth of 1.5 m ( assumed )

Detention time (Ld) = V/ Qo

$= (67.08 \times 134.16 \times 1.5) \times 2/(2400 \times 7)$

$= 1.6$ weeks $\leq 2$ weeks Not Ok

Let B = 70 m , L = 140 m , H = 1.8 m

$$Ld = (70 \times 140 \times 1.8) \times 2 / (2400 \times 7)$$

$$= 2.1 \text{ weeks} \quad \geq 2 \text{ weeks}$$

# PLUMBING :

**What is plumbing system?**

it is entire system of pipeline for providing water supply to the building or it is the system of pipe for disposal of waste water from the building.

**What is a sewage pumping station?**

**How sewage system functions?**

A sewage system is made up of a network of pipes that carry sewage from home and business to the main sewers .was ordinarily, the network of pipes relies on Gravity for the waste to flow into the main sewer.

However, in low lying Areas where the main sewer sits on higher ground than the domestic sewage pipes ,the Sewage needs to be transported to the main sewer in a different way. This is where sewage pumping stations come in.

**What is a sewage pumping station and how does it work?**

A pumping station is made up of a large tank known as a wet well that acts as the receiver for sewage from a building or a group of buildings. Sewage from individual houses flows into the wet well. The Sewage will then sit in the Well until it reaches a predetermined level . Once it is richest this level, a pump will kick in to pressurisee the Sewage so that it will travel out of the wet well, up hill, to a point where it enters the main sewer, or that it can then travels into the main sewer using Gravity.

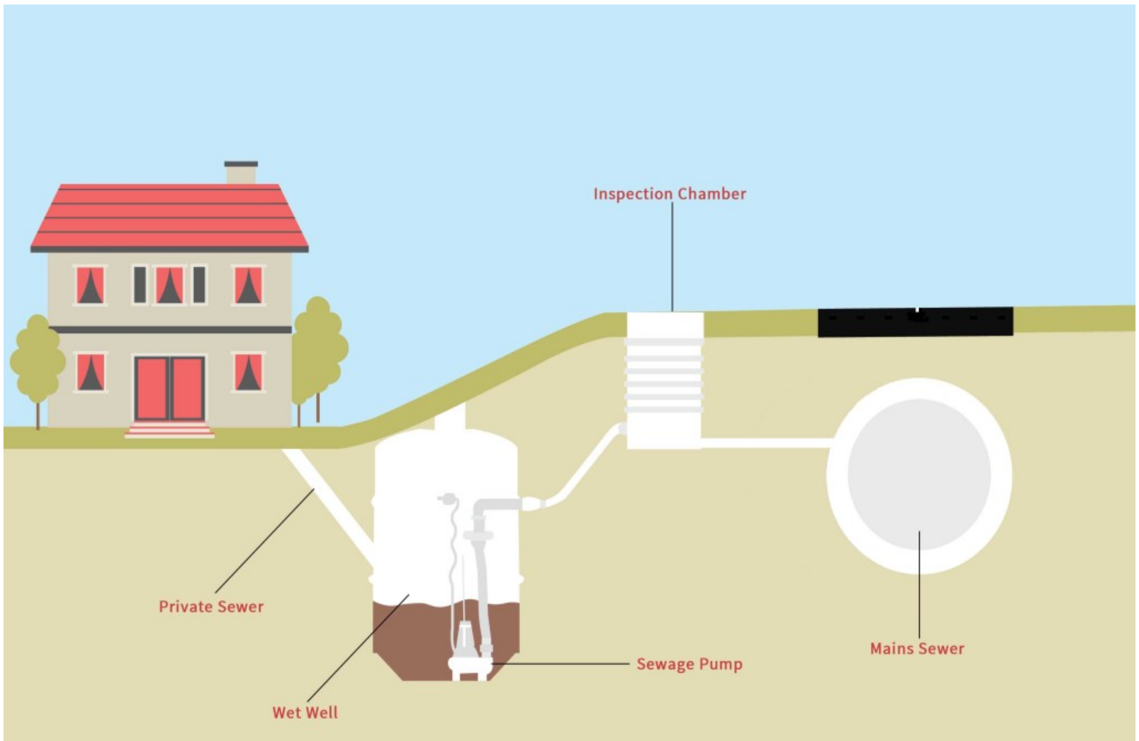
**When do you need a pump station ?**

18. when the cost of ground works to allow sewage to flow by gravity outweighs the cost of a sewage plump pumping station.
- When the sewer line passes over a ridge.
- If basement floors are too low to allow sewage flow by gravity .

16. where gravity system has not been built .

**Advantages of a sewage pump station :**

12. A pump station offers convenience when installing a sewage system, and has a potential of cutting construction cost.
13. Pump station are fitted with remote monitoring systems, which keep operators updated .
14. it is pumped automatically without any human contact, which eliminates the risk of health problems.
15. Different sizes of pumps are available for domestic applications and commercial Applications.
16. The intake of the pumps is open wide to prevent blocking.
17. Sewage pumping systems are fitted with alarms to alert you to problems with the system. This minimise the risk of sewer overflowing as you are alerted quickly.




**Disadvantages :**

10. Design and installation need to be done expertly to ensure that the system is reliable and fit for purpose. This requirement for expertise means that it can be costly.
11. Although the pump systems generally don't use much power, there is still a cost to the electricity over using a gravity system.
12. It can be difficult to source Parts for you your pump. This can be avoided by taking up a maintenance contract with pumping solutions .
13. fat and grease build up can impact reliability.
14. Although pumps are selected to minimise the risk of blockages, there is still potential for blockages to occur.

**Server connections for houses and buildings :**

( Prepared By: Ms Kajal, lecturer , CE)

- **Manholes :** these are RCC masonary/ Chambers constructed at suitable intervals along sewer lines.
- **Traps :** traps are defined as fittings at the end of soil pipes of waste pipes to prevent foul gases coming out of the soil pipe ya waste pipe.

  **Following are the main components of connections:**
  - Traps
  - Pipes
  - Sanitary fittings

**# Traps :**

Types of traps depending upon the shape :

P-trap

Q-trap

S-trap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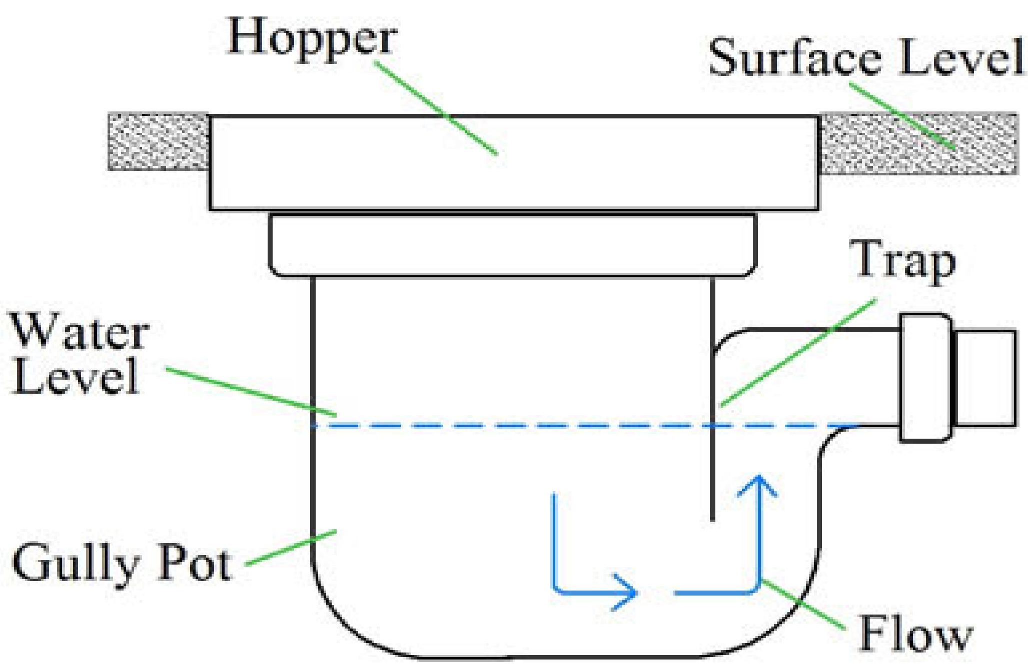
Based on the use, the traps are classified as :

- Floor traps
- Gully traps
- Intercepting traps

**Floor trap :** this trap is generally used to admit silage from the floor of rooms, bathrooms, kitchen etc Indus college pipe. This is provided with cast iron or stainless steel or galvanized gratings at it stop so that the entry of larger matter is prevented thereby chances of blockage are reduced for stop a commonly used name of trap is Nahni trap.

**Gully trap :** a gully Trap or gully is provided at a Junction of roof drain and other drain coming from kitchen aur bathroom. As figure shown Below the false alage shell enter through the side in light which is also called as back inlet or unfall rain water shell enter from the top which is covered with cast iron gratings.Gullyi traps May either have a P shaped or Q shaped water sealing arrangement for stop the water seal is normally 50mm 275 M deep.

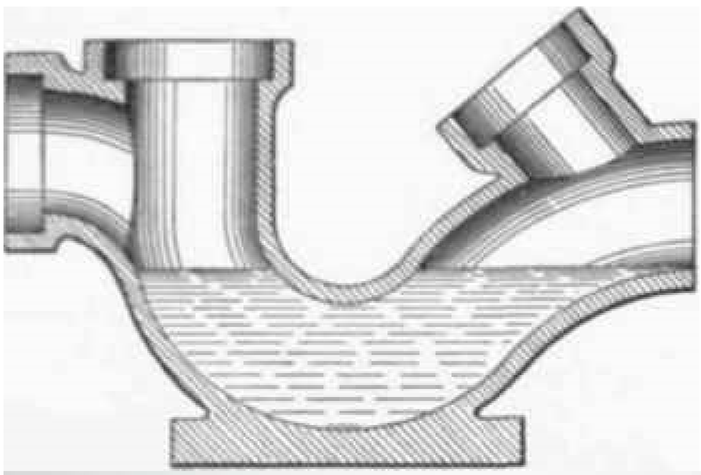



**Intercepting traps :** intercepting traps is provided at junction of a house sewer and Municipal sewer for preventing entry of foul gases of municipal sewer into the house drainage system. Intercepting trap is provided in the manhole as shown in the following figure.

**INTERNATIONAL INSTITUTE OF TECHNOLOGY & MANAGEMENT, MURTHAL SONEPAT**

**E-NOTES , Subject : Environmental Engineering-2 , Subject Code: CE-312B , Course: B.tech, Branch: CIVIL Engineering , Sem-6th ,**

**( Prepared By: Ms Kajal, lecturer , CE)**




#**PIPES :**

in house drainage system pipes maybe design nated depending upon the function have shown below :

- **Soil pipe :** A pipe carrying human extracta.
- **Waste pipe :** A pipe carrying Sullage.
- **Vent pipe :** It is a pipe installed to provide flow of air two or from the drainage system or to provide circulation of air in the drainage system to provide the circulation of air in the drainage system to provide the water sea of traps against siponage and backflow.
- **Antisiponage pipe :** It is the pipe which is installed to preserve the water seal in the trap water ventilation.
- **Rain water pipe :** A pipe carrying only rain water is called rain water pipes.

**#Sanitary fittings :**

Following sanitary fittings are used in the connections :

- Wash basins
- Sinks
- Bath tubs
- Water closets
- Urinals
- Flushing Cisterns

## Sewer Appurtenances :

### 1. Manholes :

- A manhole is defined as the construction made to connect the ground level with the hole for opening made in the sewer line so that a man can easily, conveniently and safely and through it and carry out the usual maintenance operation.
- As far as possible sewers are laid straight. At every change of alignment, gradient and diameter of the sewer, manholes are constructed for giving excess into the sewer for inspection, cleaning, repairs and maintenance. Manholes are masonary for RCC Chambers, which are constructed on the top of sewer. These are fitted with suitable cast iron covers at their top.
- A manhole essential consists of :
  - A working chamber
  - An access shaft
  - A strong cover on the top flush with the road level

- the working chamber has such a size, so that necessary examination and cleaning can be done easily.

**The minimum internal sizes of the chambers are as follows :**

- For depth of 0.8 metre or less - 0.75×0.75m
- For depth between 0.8 metre and 2.1 metre -1.2×0.9m
- For depth more than 2.1 metre-circular chambers of 1.4 metre diameter of a rectangular chamber of 1.2 multiply 0.9 metre.

  The access shaft provides an access to the working chamber. This shaft is formed by corbelling the working chamber on three sides at top as shown in figure so that cover frame can be fitted in the opening. The minimum internal dimensions of the access shaft are 0.5 by 0.5 metre.

  At the top of manhole, the manhole cover of cast iron for RCC is provided to cover the opening. The cast iron cover is placed in the cast iron frame fixed at the top of access shaft, the cast iron covers maybe light, medium or heavy waiting about 51153 or 2255 kg respectively, which are used depending on the type of traffic on the road.

  In case of RCC covers a precast RCC slab of suitable size is placed on the top of manhole opening. The manhole covers are provided flush with the road level and have such a size that men can easily enter in the working Chambers. The minimum size is 50 cm diameter.

  The bottom of the manhole is usually made of concrete slightly sloped at the top towards the open channels, which are in continuation of the sewer line. The channels are sometimes lined with half round sewer pipe section full stops that top surface of the concrete is called Benching And The Man stands on it stops during cleaning and inspection of the sewer Lines. over the cement concrete walls not less than 20 cm thickness are constructed. The actual thickness is determined by design.

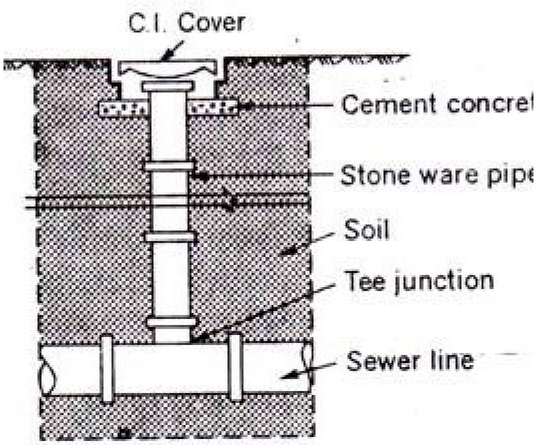
  the circular shape is structurally more stable and stronger thought it is difficult in construction. The manhole in circular shape should be at least 180 cm high and 120 cm in diameter for it may be 90 X 120 cm in plan (the longer damnation should be along the floor ).

  for sewer larger than 130 cm in diameter, the manhole walls are made two springs from the sewer walls . The straight alignment of sewer lines are also requires manhales at regular intervals. The distance between two manholes on straight alignment depends mainly on the diameter of sewer lines as below in table.

| Diameter of sewer | Distance in metres |
|---|---|
| Up to 60 cm | 75 metre |
| Above 60 cm and up to 90 cm | 120 metre |
| Above 90 cm and up to 120 cm | 150 metre |
| Above 120 cm and upto 150 cm | 250 metre |
| Above 150 cm | 300 metre |

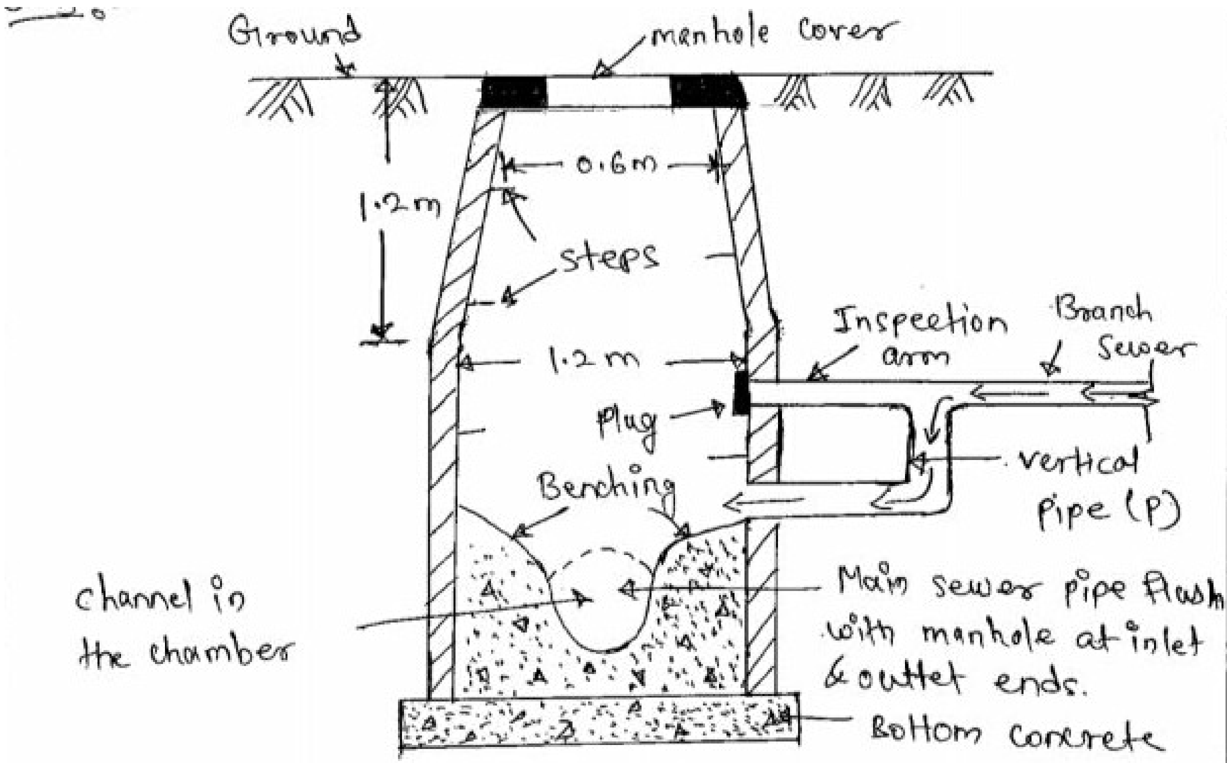
- If two or more sewers join at the same level in a manhole the branch channels should be given a smooth curve to meet the main channel. If the inlet and outlet pipes are of different diameters the crown of both the pipes should be placed at the same level and unnecessary slope should be provided in the invert of the main channel.
- very often ignored element of sewer maintenance which requires careful attention and protective measures is the manhole work. The staff should be trained for removing the manhole cover, not only to avoid smashed tours and fingers, but also to prevent more serious back injuries. The most serious hazard of manhole work are, however, flammable as and oxygen deficiency.
- The staff should be thoroughly train to carry out simple test on every man hall before entry for oxygen deficiency, combustible gases, carbon monoxide or hydrogen sulphide. If, however, and emergency demands to enter a gas tilled manhole for one there oxygen may be lacking, the work should wear a self-contained air breathing mass and a safety harness with lifetime. To other employees should be station at the main manhole opening because one individual cannot lift and unconscious person out of manhole.

## 2. LAMP - HOLES :




- In narrow lanes, change of gradient and slight curvess where space is insufficient for the construction of manholes, a vertical shaft of 20 to 30 cm diameter is connected to the sewer by a T-bend. These small size openings are covered by a cast iron for RCC cover flush with the road level at the top. Figure shows a lamp hole mostly used in Civil Lines.
  While inspecting a lamp is lowered in the vertical shaft and is seen from the man horse on either sides to find that sewer is cleaned or obstructed. The lamp holes are also provided at places when the regular manholes are placed at longer intervals.
  Actually in practice during maintenance the lamp holes are not used, therefore mostly local authorities do not recommend lamp holes in the sewer lines

## 3. DROP MANHOLES :




when it is an economical or impracticable to arrange the connections with in 60 cm of the inverse of the sewer and manhole, then a vertical shaft is constructed outside the manhole Chamber through which the Savage of branch saver is allowed to enter the manhole as shown in figure.

If the difference in level between the branch sewer and main sewer is within 60 cm and there is sufficient roof within the working chamber, the connecting pipe may be directly brought so the manhole wall by providing a ramp in the banching.

Such manholes which drop the level of invert of the incoming sewer, by providing a vertical shaft are called drop manhole, the main purpose being to avoid the splashing of sewage one of man working and on the masonry work the branch sewer line is connected to the manhole in such a way that it can be cleaned and rodded when necessary. For inspection of the incoming sewage and cleaning of vertical shaft, the vertical shaft is taken up to the ground level as shown in above figure.

## 4. STREET INLETS :

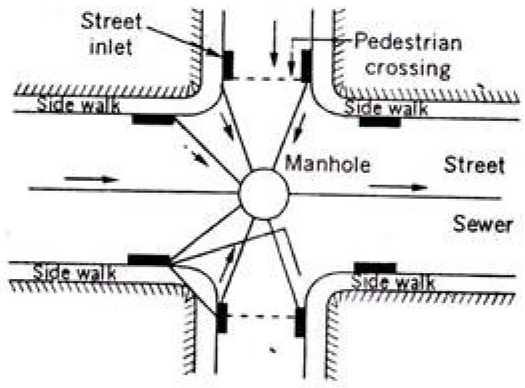



*Fig. 7.4. Street Inlets.*

Street inlets or gullies are the openings in the street curb or gutter to collect the storm water and surface wash flowing along the street , and convey it to stop or combined sewer by means of stoneware pipes 25 to 30 cm in diameter. In less are placed at the road gutters generally at Street junctions . if the streets are very long more than 200m, inlets are also provided at the intermediate points at hundred, 130m spacing. Figure shows most useful location of Street in lights at some common places. At the street junction in that should be placed in such a way that a storm water may not flow across any of the street or flood the crosswalks causing interference with the traffic.

**The inlets are of three types :**

**Curb inlets :**

In which an opening is provided in the road curb for the entrance of storm water for stop figure shows such in light. In the gutter opening bars can be fixed to prevent the passage of dry leaves, papers,etc. in the sewerl Lines.

These inlets are more suitable than Gutter inlets,because less quantity of floating solids enter in the catch pits. As the grating is fixed with the road curb, it cannot be easily stalham. Second with the grating is cheap, as it does not has to bear the traffic lord, as in case of gutter inlet.

**Gutter inlets :**

These are placed directly below the rod gutter and storm water directly enters them from the top. Such inlets catch very large volume of water and are most suitable in rods having steep slopes, because in such cases curb inlets may fail to catch all the storm water. This inlets are provided with cast iron gratings at their top to prevent the floating matters and print the sewer. That Toke rating should be sufficiently strom the bear that traffic loads.

The main difficulty with such inlets is that of the heavy cost .grating placed at the top of the inlet to collect the water, is very costly and has good scarp scrap value. Therefore, these are mostly stolen and the pit remains uncovered and becomes the source of accident. Such trouble does not arise in case of curb in lights, because there gratings is fixed with the curve. Recently to avoid thefts of gutter inlet gratings, use of RCC gratings has been started instead of C.I.

**Combined Gutter and Curb Inlet :**

Figure shows such an inlet in which the storm water enters from both the gutter and curb .

Curb inlets are preferred than gutter inlets and are mostly used in practice.

## 5. CATCH BASINS OR PITS :

Ab catch basin is a structure in the form of a chamber which is provided along the sewer line to admit clear rainwater free from silt, grit, debris, etc into the combined sewer.

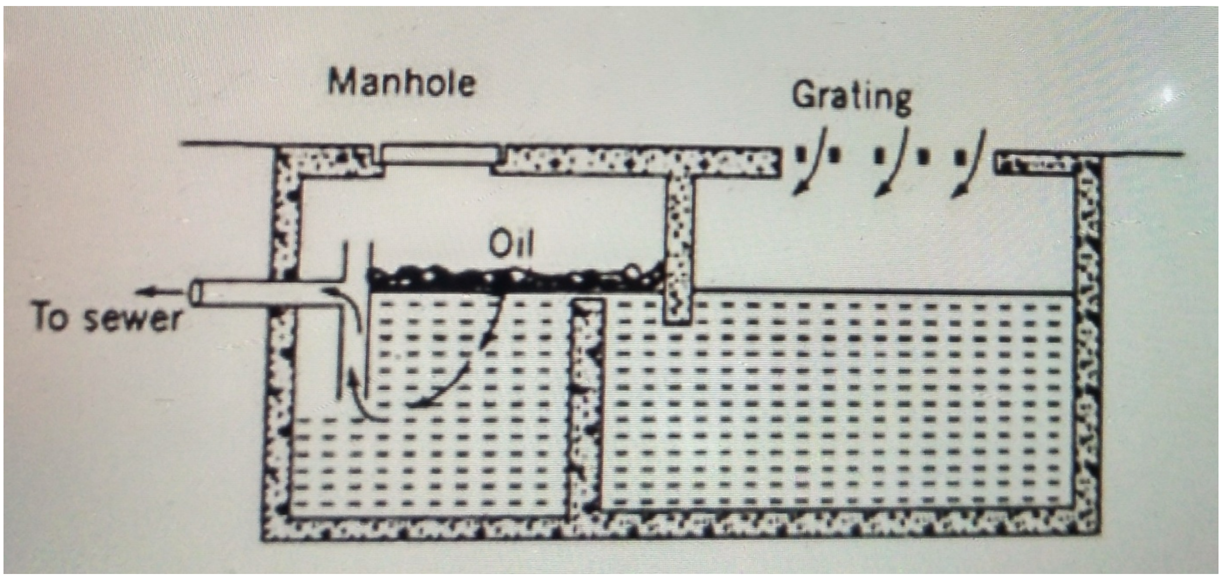
( Prepared By: Ms Kajal, lecturer , CE)

These are small masonary Chambers ( 75 to 90 cm in diameter and 75 to 90 cm deep )which are constructed below the street inlets to prevent the flow of grit, sand or debris in the Civil Lines full stops when storm water enters these basins, the grit, sand etc settle in the bed and the storm water freeze from all these enters the sewers.

## 6. SAND,GREASE AND OIL TRAPS :

The sewage from hotels, restaurants, kitchen and industries contains grease, oils and fats, which if not removed before it enters the sewers, will stick to the interior surface of the sewer conduit and will become hard and cause obstruction in the movement of the sewage. To check them, grease traps are required, which are placed in the pipe connecting the kitchen with sewer line. Fig. shows the section through a grease.

Sewage from garages and service stations contains sand, mud, oils and grease which should also be removed before the sewage enters sewer line. Fig. 7.10 shows the section through a combined silt and oil trap which is used at such places. Such traps also prevent gasoline from

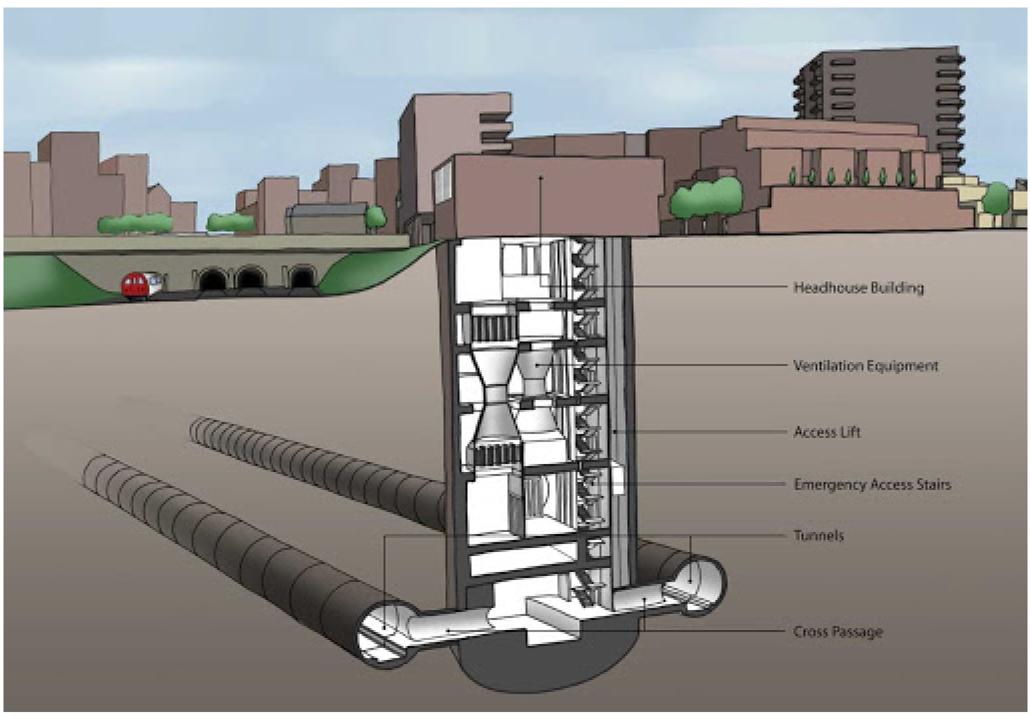



entering the sewer and causing explosion hazard. These traps should be regularly cleaned for their proper functioning.

( Prepared By: Ms Kajal, lecturer , CE)

## 7. Ventilating Shafts:

Various gases are produced in sewers due to decomposition of organic materials of sewage. These gases are very foul in nature, cause harm to human health and corrode the sewers reducing their life.




The gases so produced are highly explosive and in high concentration may cause fatal accidents to the maintenance people on duty due to their explosive and poisonous character. Due to the above difficulties, ventilation is provided to the sewer lines at every 80-100 meters which will provide fresh air to the workers working in the manholes.

Fig. shows a ventilating shaft commonly used in practice. It may be of R.C.C. or cast iron 15 to 23 cm in diameter with a cowl provided at the top. The height of the ventilating shaft should be more than the roof of the tallest building in its neighbourhood.

( Prepared By: Ms Kajal, lecturer , CE)

The ventilating shaft is generally connected to the manholes by a 15 cm diameter pipe as shown in the figure. In open areas, the manhole covers may be provided with vent pipes, but in crowded areas, they should be air-tight and connected with ventilating shafts.

### Procedure for maintenance of sewage system :

- Maintenance of sewage consists mainly of the removal or prevention of stoppages, cleaning of sewers and other sewer appurtenances and repair works.
- Maintenance of becomes she was costly when they are laid on flat gradients and tree roots find easy entrance in C sewers through defective joints.
- The maximum expenditure in maintenance comes on the cleaning of sewers.
- Which have been blocked due to the composition of silt, Grease and oily materials.
- **the following works are involved in the maintenance and repairs of sewage system :**
  - Repair of manholes
  - Repair of other sewer appurtenances
  - construction of new manholes
  - replacing stolon manholes
  - raising height of manholes with raising the road level
  - repair of broken sewer lines
  - cleaning of sewer
  - prevention of clogging
  - checking for leakage and repair.

### Duties of maintenance incharge :

- For proper functioning and maintenance of sewage system, the maintenance incharge has an problem the following duties:
- first periodically inspection of sewers .
- second measurement of flow rate.
- third cleaning of savers .
- fourth to carry out flushing of sewer to prevent clogging.
- Fifth repairing of pipelines and Sewer appurtenances .
- sixth to take suitable measures to prevent sewer explosion.

- seventh to prepare schedules for routine and periodical maintenance of sewer .
- eigthth to supervise the work of repair and maintenance .
- ninth to prepare estimates for maintenance and repair.
- tenth to prepare maintenance and repair proposals and take approval of higher authority.