UNIT – IV

SECONDARY TREATMENT OF SEWAGE

1. *Give any four advantages of activated sludge process?*

- Lesser land area is required
- The head loss on the plant is quite low
- There is no fly ash or odour nuisance
- Capital cost is less

2. What are the disadvantages of the activated sludge process?

- High cost of operation, tooth greater power consumption
- A lot of machinery to be handled
- The sudden change in the quantity and character of sewage may produce adverse effects on the working of the process thus producing inferior efficient

3.What are the types of track long

- Conventional track long filter or ordinary or standard rate or low rate trick long filter

4.What are the disadvantages of trick long filters?

- The head loss through these filters is high, making automatic during of the filters necessary
- The cost of construction is high
- There filters cannot treat ratio sewage and primary sedimentation is a must

5.What are the special types of filters?

- Durban filter
- Magnetic filters
- Rapid sand filters

6.What do you mean by magnetic filters?

In this type of filter, a layer of crashed magnetic ore of
Iron is provided in about 80mm, thickness, and is supported on a non-magnetic metal wire screen sewage is filtered through the magnetic layer which removes the impurities purely by mechanical Starching action.

7.What are the types of high late

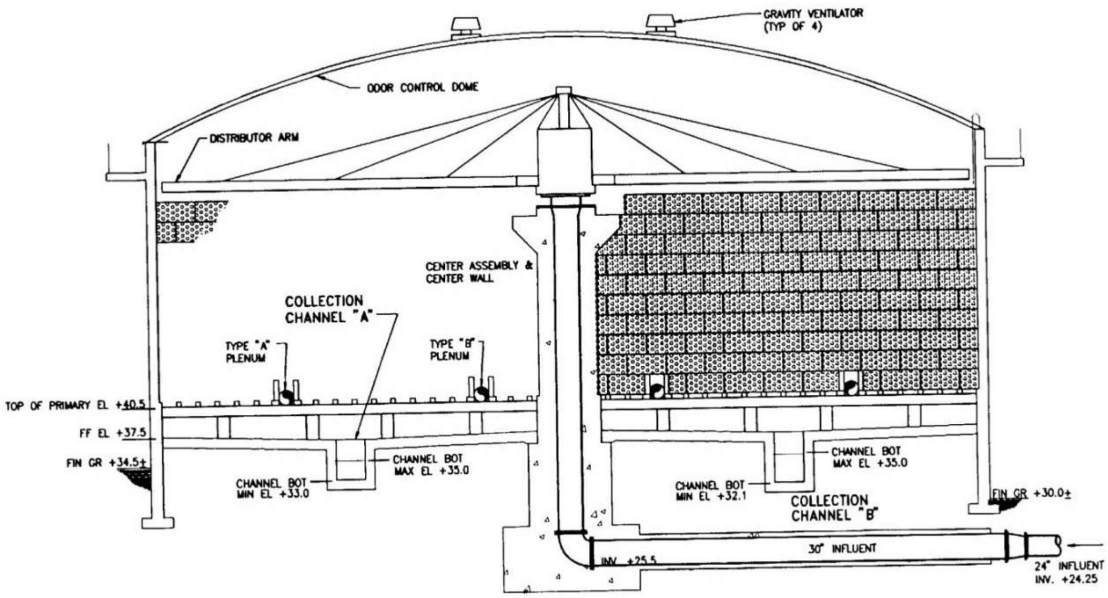
- Bio filters
- Accelo filters
- Aero filters

PART – B

1. Explain the construction and working of trickling filter

Trickling Filters

Trickling filter is an *attached growth process* i.e. process in which microorganisms responsible for treatment are attached to an inert packing material. Packing material used in attached growth processes include rock, gravel, slag, sand, redwood, and a wide range of plastic and other synthetic materials.



Trickling Filter

<u>Process Description</u>

1. The wastewater in trickling filter is distributed over the top area of a vessel containing non-submerged packing material.
2. Air circulation in the void space, by either natural draft or blowers, provides oxygen for the microorganisms growing as an attached biofilm.
3. During operation, the organic material present in the wastewater is metabolised by the biomass attached to the medium. The biological slime grows in thickness as the organic matter abstracted from the flowing wastewater is synthesized into new cellular material.
4. The thickness of the aerobic layer is limited by the depth of penetration of oxygen into the microbial layer.
5. The micro-organisms near the medium face enter the endogenous phase as the substrate is metabolised before it can reach the micro-organisms near the medium face as a result of increased thickness of the slime layer and lose their ability to cling to the media surface. The liquid then washes the slime off the medium and a new slime layer starts to grow. This phenomenon of losing the slime layer is called ***sloughing***.
6. The sloughed off film and treated wastewater are collected by an under drainage

which also allows circulation of air through filter. The collected liquid is passed to a settling tank used for solid- liquid separation.

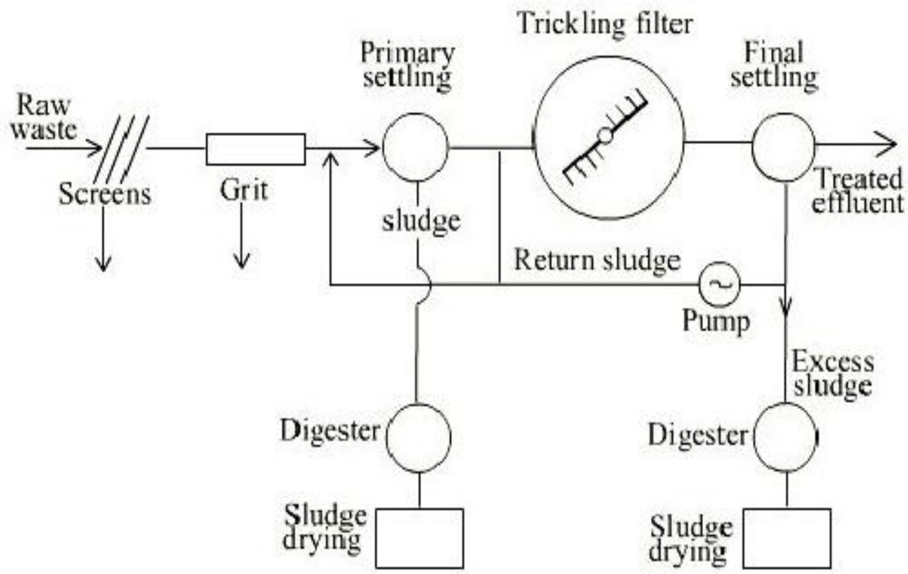
Types of Filters

Trickling filters are classified as high rate or low rate, based on the organic and hydraulic loading applied to the unit.

S.No.	***Design Feature***	***Low Rate Filter***	***High Rate Filter***
1.	Hydraulic loading, $m^3/m^2.d$	1 – 4	10 - 40
2.	Organic loading,kg BOD / m^3.d	0.08 - 0.32	0.32 - 1.0
3.	Depth, m.	1.8 - 3.0	0.9 - 2.5
4.	Recirculation ratio	0	0.5 - 3.0 (domestic wastewater) upto 8 for strong industrial wastewater.

1. The hydraulic loading rate is the total flow including recirculation applied on unit area of the filter in a day, while the organic loading rate is the 5 day 20°C BOD, excluding the BOD of the recircular, applied per unit volume in a day.
2. Recirculation is generally not adopted in low rate filters.
3. A well operated low rate trickling filter in combination with secondary settling tank may remove 75 to 90% BOD and produce highly nitrified effluent. It is suitable for treatment of low to medium strength domestic wastewaters.
4. The high rate trickling filter, single stage or two stage are recommended for medium to relatively high strength domestic and industrial wastewater. The BOD removal efficiency is around 75 to 90% but the effluent is only partially nitrified.
5. Single stage unit consists of a primary settling tank, filter, secondary settling tank and facilities for recirculation of the effluent. Two stage filters consist of two filters in series with a primary settling tank, an intermediate settling tank which may be omitted in certain cases and a final settling tank.

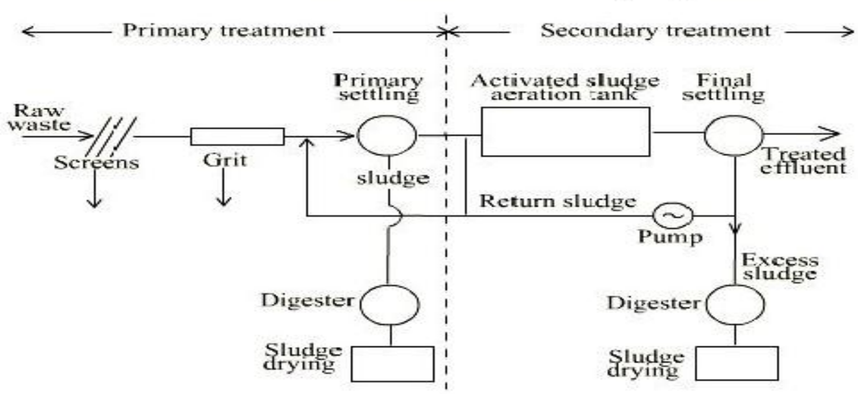
Flow sheet of a trickling filter system



2. Explain Activated Sludge Process

The most common suspended growth process used for municipal wastewater treatment is the activated sludge process as shown in figure:

Flow sheet of an activated sludge system



Activated sludge plant involves:

1. Wastewater aeration in the presence of a microbial suspension,

2. Solid-liquid separation following aeration,
3. Discharge of clarified effluent,
4. Wasting of excess biomass, and return of remaining biomass to the aeration tank.

In activated sludge process wastewater containing organic matter is aerated in an aeration basin in which micro-organisms metabolize the suspended and soluble organic matter. Part of organic matter is synthesized into new cells and part is oxidized to CO_2 and water to derive energy. In activated sludge systems the new cells formed in the reaction are removed from the liquid stream in the form of a flocculent sludge in settling tanks. A part of this settled biomass, described as activated sludge is returned to the aeration tank and the remaining forms waste or excess sludge.

Activated Sludge Process Variables

The main variables of activated sludge process are the mixing regime, loading rate, and the flow scheme.

Mixing Regime

Generally two types of mixing regimes are of major interest in activated sludge process: ***plug flow*** and ***complete mixing***. In the first one, the regime is characterized by orderly flow of mixed liquor through the aeration tank with no element of mixed liquor overtaking or mixing with any other element. There may be lateral mixing of mixed liquor but there must be no mixing along the path of flow.

In complete mixing, the contents of aeration tank are well stirred and uniform throughout. Thus, at steady state, the effluent from the aeration tank has the same composition as the aeration tank contents.

The type of mixing regime is very important as it affects

1. oxygen transfer requirements in the aeration tank,
2. susceptibility of biomass to shock loads,
3. local environmental conditions in the aeration tank, and
4. the kinetics governing the treatment process.

Flow Scheme

1. The flow scheme involves:
2. the pattern of sewage addition
3. the pattern of sludge return to the aeration tank and
4. the pattern of aeration.

Sewage addition may be at a single point at the inlet end or it may be at several points along the aeration tank. The sludge return may be directly from the settling tank to the aeration tank or through a sludge reaeration tank. Aeration may be at a uniform rate or it may be varied from the head of the aeration tank to its end.

3. Briefly discuss the functioning and advantage of an UASB (May/June 2013)

- UASB-The upflow Anaerobic sludge blanket. The UASB reactor maintains a high concentration of biomass through the formation of highly settle able microbial sludge aggregate . the waste water flows upwards through a layer of very active sludge to cause anaerobic digestion of organics of the waste water .At the top of the reactor ,these phase separation between gas-solid-liquid takes place any biomass leaving the reaction zone is directly recirculated from the settling g zone. The process is suitable for both soluble waste waters as well as waste water containing particulate matter.

- The methane or biogas is collected at the top of the tank in a gas collector ,from where it can be withdrawn for use as a by-product, while the water sludge mixture is made to enter a setting tank where the sludge mixture is made to enter a setting tank where the sludge settles down and flows back in to the bottom of the reactor. The sludge will show good settling properties after an initial start up period, followed by granulation, forming a sludge blanket or sludge bed in the lower past of the reactor.

- The UASB, evidently operator as a suspended growth system, with no packing material in the reactor. In this system, the microbes attack themselves to each other, or to small particles of the suspended matter of sewage, to form granular or agglomerates and ultimately the sludge bed (blanket).The gas produced in the process causes sufficient agitation to keys the sludge fully mixed.

- Retention of the bacteria contacting sludge in the reactor is one of the most important features of the UASB process. The bacteria in the sludge continue to perform their function of treating the incoming effluent. The continuous bacterial presence and activity enables retention time in the reactor to be reduced to about 6- 8 hours ,as compared to at least 30 hrs, that is required in conventional sewage treatment systems.
- The treated effluent is collected in gukters, and discharged out of the reactor. The sludge is periodically shifted in to the drying beds, to be used as a soil enricher, The methane generated can be used as a gas for domestic or industrial use. It may also be used for generation of electricity for running the plant, after the approximate dehydration and cleaning.
- This process can be reactivated even after the plant remains shut down the for days or months, or after power breakdowns and interruptions in wastewater supply.
- Like other high rate anaerobic systems, The various advantages offered by UASB systems are

Advantages of UASB system:

- The space requirement of the system is quite comparable to that of an Activated sludge, ie, about 0.5 acres per MLD, as compared to 2.5 acres per MLD required for oxidation ponds, and 1.5 acres for Aerated lagoons.
- The capital cost investment of such a plant is about Rs.20 lakh/MLD as compared to about Rs.35lakh/MLD for an Activated sludge plant,Rs.75 lakh/MLD for oxidation ponds and Rs.15lakh/MLD for Aerated lagoons.
- The system requires lesser and simpler electromagnetic parts as compared to the ones required in an Activated sludge plant, leading to lower operation and Maintenance cost.
- Electricity consumption in this system ,like all anaerobic systems, is quite low, and the system is quite capable of withstanding long power failures.
- The sludge Production system is low, and the produced sludge is having quick dewatering characteristics.
- The system enables quicker sludge digestion, as compared to the conventional digestors.

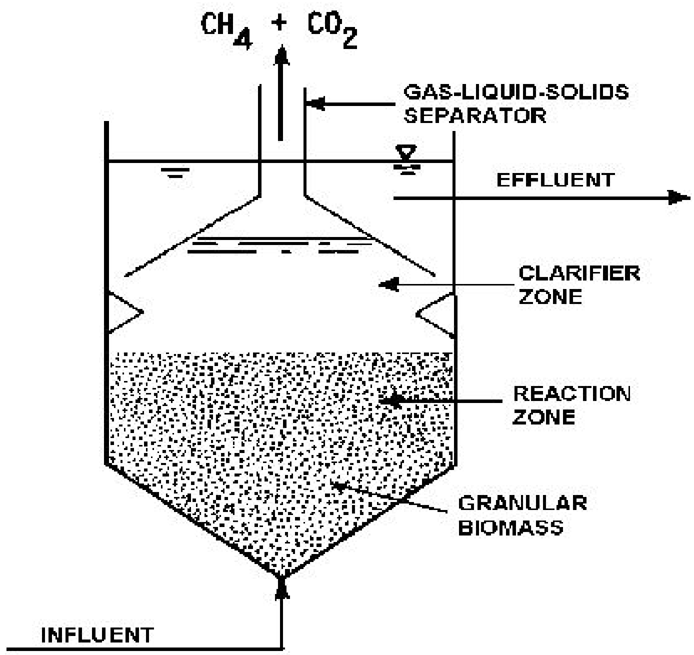
- Biogas is produced in the system as a by-product, which can be used to produce electricity to run the system.

Advantages:

(i) Rate of filter loading is high, as such requiring lesser land area and smaller quantities of filter media for their installations.

(ii) Effluent obtained from the trickling filters is sufficiently nitrified and stabilized. They can be removed about 75% of BOD and about 80% of suspended solids. The effluent can, therefore be easily disposed of in smaller quantity of dilution water.

(iii) Working of trickling filter is simple, and does not require any skilled supervision.



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UPFLOW ANAEROBIC SLUDGE BLANKET REACTOR

(iv) They are flexible in operation, and they can, therefore, withstand the application of variety of sewages having different concentration and composition. Even if they are over- loaded, they can recoup after test.

(v) They are self-cleaning.

(vi) Mechanical wear and tear is small, as they contain less mechanical equipment.

(vii) Moisture content of sludge, obtained from trickling filters, is as high as 99% or so.

(viii) Trickling filters have been found to be operated more efficiently in warm weather, and produce an effluent appreciably lower in BOD. Hence , they are of immense- use in hot countries like India.

Disadvantages of trickling filters:

1. The head loss through these filters is high, making automatic dosing of the filter necessary (through siphonic dosing tank)

2. Cost of construction of trickling filters is high.

3. These filters cannot treat raw sewage, and primary sedimentation is a must.

4. These filters pose a number of operational troubles such as

- Fly nuisance
- Odour nuisance

Ponding nuisance

4. A single stage filter is designed for an organic loading of 10000 kg of BOD in raw sewage per hectare meter per day with a recirculation ratio of 1.2. this filter treats a flow of 4 MLD of raw sewage with a BOD of 220 mg/L. using NRC formula, determine strength of effluent

[May / June - 2012]

Solution :

Flow = 4 MLD

BOD = 220 mg/l

Total BOD - raw sewage = Flow × BOD concentration

$= (4 \times 10^6)(220 \times 10^{-6})$

$= 880$ kg/d.

$$\text{Filter Volume} = \frac{\text{Total BOD - Raw sewage}}{\text{organic loading rate}}$$

$$= \frac{880 \text{ kg/d}}{1000 \text{ kg/ha-m/d}} = 880 \text{ m}^3$$

Assume 35% BOD removal in primary clarifier

BOD of influent applied to filter = 0.65 × 880 = 572 kg

$$\text{Efficiency of filter, } E = \frac{100}{1 + 0.44\sqrt{U}}$$

$$V = \frac{W}{V \cdot F}$$

$W = 572$ kg/d

$V = 880$ m³

U ⇒ kg/m³/d

W ⇒ BOD

V ⇒ Volume

F ⇒ Recirculation factor

$$F = \frac{1+R}{(1+0.1R)^2} = \frac{1+1.2}{(1+0.1\times1.2)^2} = 1.754$$

$$E = \frac{100}{1+0.44\sqrt{\frac{W}{VF}}} = \frac{100}{1+0.44\sqrt{\frac{572}{880 \times 1.754}}}$$

E = 0.789

Total BOD of effluent = (1 - 0.789) × 572 = 120.65 kg

$$\text{BOD conc of effluent} = \frac{120.65 \times 10^6}{4 \times 10^6} \text{ mg/l} = 30.21 \text{ mg/l.}$$

Note : In case the previous design was two stage trickling filter, then what would be the BOD of effluent.

Total Volume of filter remains the same

Filter Volume of single stage = Filter Volume of two stage (two filters)

Recirculation ratio of each filter = 1.2

R = 1.2 F = 1.754

First stage:

Efficiency

$$E = \frac{100}{1+0.44\sqrt{\frac{W}{VF}}}$$

$$= \frac{100}{1+0.44\sqrt{\frac{572}{440 \times 1.754}}}$$

$$= 72.53\ \%$$

Volume of first stage filter = $\frac{1}{2}$ of Single stage filter

$$= \frac{880}{2} = 440\ m^3$$

BOD of effluent from first stage = BOD of influent to second stage

$$= (1-0.7253) \times 572 = 157.15\ kg/d$$

Second stage:

$$E' = \frac{100}{1+\frac{0.44}{(1-e)}\sqrt{\frac{W'}{V'F'}}}$$

$W' = 157.15\ kg/d$

$e = 0.7253$

$V' = \frac{880}{2} = 440\ m^3$

$F' = 1.754$

$$= \frac{100}{1+\frac{0.44}{(1-0.7253)}\sqrt{\frac{157.15}{440 \times 1.754}}}$$

$$= 58.05\ \%$$

Total BOD of effluent from plant $= 157.15(1-0.5805)$

$= 65.95\ kg/d$

BOD conc. of effluent $= \frac{65.95 \times 10^6}{4 \times 10^6}$

$= 16.48\ mg/L$

6. (4) Design an oxidation pond for treating sewage from a hot climatic residential colony with 5000 persons contributing sewage @ 120 lpcd. The five day BOD of sewage is 300 mg/l.

Solution :

(i) Quantity of sewage treated per day = population × Sewage contribution

= 5000 × 120 lpcd

= 6,00,000 litres

= $600 \; m^3/d$ (or) 0.6 MLD

(ii) BOD content per day

Total BOD = Discharge × BOD concentration

= 0.6 MLD × 300 mg/l

= 180 kg/d

(iii) Assume organic loading in pond (Hot climate) = 300 kg/ha/day

$$\text{Surface area required} = \frac{\text{Total BOD of Sewage}}{\text{organic loading rate}} = \frac{180 \; kg/d}{300 \; kg/ha/day} = 6000 \; m^2$$

(iv) Assume L/B = 2

$L \times B = 6000 \; m^2$

$2B \times B = 6000$

$B = 55 \; m$

$L = 2 \times 55 = 110 \; m$

(v) Assume effective depth = 1.2 m

(vi) Volume capacity of pond = L × B × H

$= 110 \times 55 \times 1.2 = 7260 \; m^3$

(vii) Capacity = Sewage flow per day × Detention time (days)

$$D.T = \frac{\text{capacity}}{\text{flow}} = \frac{7260 \; m^3}{600 \; m^3/d} = 12.1 \text{ days} = 12 \text{ days}.$$

Result : Use oxidation pond with

Length = 110 m ; Width = 55 m

overall depth = (1.2 + 1) = 2.2 m

Detention period = 12 days.

7.

(4) Determine the size of a high rate trickling filter for the following data.

(i) Sewage flow = 4.5 MLD

(ii) Recirculation Ratio = 1.5

(iii) BOD of raw sewage = 250 mg/L

(iv) BOD removal in primary tank = 30 %

(v) Final effluent BOD desired = 30 mg/L

[May / June 2016]

Solution :

Quantity of sewage flowing into the filter per day = 4.5 MLD

BOD concentration in raw sewage = 250 mg/L

Total BOD present in raw sewage = 4.5 MLD × 250 mg/L = **1125 kg**

* BOD removed in primary tank = 30 % (Given)

BOD left in sewage entering per day in the filter unit = (1125) × 0.7 = **787.5 kg**

BOD concentration desired in final effluent = 30 mg/L

∴ Total BOD left in the effluent per day = 4.5 × 30 kg = **135 kg**

BOD removed by the filter = 787.5 − 135 = **652.5 kg**

$$\text{Efficiency of the filter} = \frac{\text{BOD removed}}{\text{Total BOD}} \times 100$$

$$= \frac{652.5}{787.5} \times 100 = 82.85\ \%$$

Using NRC equation :

$$\eta = \frac{100}{1 + 0.0044\sqrt{\frac{W}{VF}}}$$

W.k.T

$\eta = 82.85\ \%$

W = Total BOD in kg = 787.5 kg

$$F = \frac{1+R}{(1+0.1R)^2} = \frac{1+1.5}{(1+0.1 \times 1.5)^2} = 1.89$$

$$82.85 = \frac{100}{1 + 0.0044\sqrt{\frac{787.5}{V \times 1.89}}}$$

V = 0.2 hectare - m

$$V = 2000\ m^3$$

Assuming depth of filter as 1.5 m

$$\text{Surface Area} = \frac{\text{Volume}}{\text{Depth}}$$

$$= \frac{2000}{1.5}\ m^2$$

$$= \boxed{1333.3\ m^2}$$

Diameter of circular Trickling filter

$$\text{Surface Area} = \frac{\pi}{4} d^2 = 1333.3\ m^2$$

$$\boxed{d = 41.2\ m}$$

Hence, provide a high rate trickling filter of 41.2 m diameter and 1.5 m depth of filter media.