Unit - IV Important Questions.

01. Design of trickling filter. (+ theory)

02. Design of Oxidisation ditches (+ theory)

03. Theory : UASB (Upflow Anerobic Sludge Blanket)

04. Waste stabilisation ponds. (Theory) + (Design)

05. Recent advancement in sewage treatment

06. Reclamation & reuse of sewage (6m)

07. Construction & Operational maintanance

Unit - IV Secondary treatment of sewage

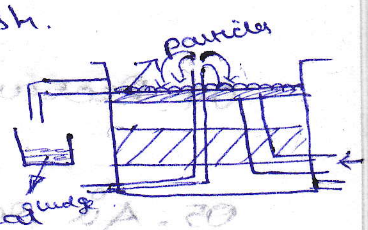
(Biological treatment)

Methods :

01. Filtration method.

02. Activated Sludge process

Sloughing : Clearing of particle (sludge) which was removed by using back wash.



Activated Sludge process :-

It is a Suspended biological type process in which aerobic decomposition takes place

Aeration tank → (sludge) Clarifier → sludge

In this process the micro organism in suspension is used to decompose the organic matter.

→ Suspended biomass is known as activated sludge

→ It is measured in mixed Liquor Suspended solids (MLSS) or it is also measured in MLVSS (mixed Liquor Volatile suspended solids).

→ It has two main functions

(i) Synthesis of new cells/new microorganism

(ii) Stabilization of organic matter

Design criteria for Activated sludge process

01. No. of aeration tanks is min 2, usually

02. Depth of waste water in tank is 4.5 to 7.5 m for defined aerator. usually 3 to 4.5 m

03. Free board = 0.5 m

04. Rectangular aeration tank : L : B = 5 : 1

05. Air required = 20 to 55 m^3 of air / kg of BOD.

06. Power required = 10 to 14 KW / 1000 m^3

Most frequently used design criteria (assumptions)

- Detention period =
- Flow through Velocity.
- Settling Velocity (V_s)
- Surface loading rate
- Organic loading (BOD)
- F/m (Food to mass ratio)

Biological treatment of waste water:

- ✓ Attach growth process. → Trickling
- ✓ Suspended growth process. (Activated sludge process) ↓ Oxidation ditch

Trickling filter:- (Attached growth process)

. (3m) Design of trickling filter:

rotary dist & suspended sludge

Two types:

→ Conventional filter

Treatment Eff. < 85%.

→ High rate filter.

Treatment eff > 85%

✓ The design involves the designing of circular filter tank & its depth.

✓ The design of rotary distributors & under drainage system is also involves in filter design.

✓ The design of filter size is based upon filter loading, adopted for design.

Filter loading
- → Hydraulic loading rate
- → Organic loading rate.

Hydraulic loading rate:

→ By the quantity of sewage applied per unit surface area of filter per day.

→ It is expressed in million lit/hectare/day

→ The values for conventional filter is 22 - 44 million litre/hectre/day.

→ For high rate filter -
220 million lit/hectre/day.

Organic loading rate:

→ It is the BOD per unit volume of filter media per day.

→ It is expressed in kg/hectre-m.

→ For conventional filter -
900 - 2200 BOD of kg/Ha-m.

→ For high rate filter -
upto 18000 BOD of kg/Ha-m

Design criteria :-

✓ Organic loading decides the volume of filter.

$$\text{Vol. of filter} = \frac{\text{Total BOD of sewage entering the filter per day}}{\text{Assumed value of organic loading}}$$

✓ Hydraulic loading rate gives the area of the filter.

$$\text{Area of filter} = \frac{\text{Total sewage vol. entering the filter}}{\text{Hydraulic loading rate}}$$

	Conventional filter	High rate filter
Hydraulic loading rate	22-44 MLD	220 MLD.
Organic loading rate	900 - 2200 Kg/ha-m	upto 18000 Kg/ha-m

Important:

→ Filter dia & depth is designed for avg. Sewage flow, the rotary distributors & underdrainage System & other pipe lines are designed for peak flow.

→ Rotary distribution arm should not be greater than 60 m in length, diameter of filter should not be greater than 60 m if diameter exists use more units of filters.

Q1. Design the suitable dimensions of a circular trickling filter units for treating 5 MLD sewage. BOD of sewage is 150 mg/lit also design suitable dimension for Rotary distribution system as well as under-drainage system.

Solution:- Design of circular tank:

Total BOD in sewage = 5 MLD × 150 mg/lit

$= (5 \times 10^6) \times 150 \times 10^{-3}$ (lit/day, kg)

$= 5 \times 10^3 \times 150 \times 10^{-3} \times$ (m³/day)

$= 750$ kg/day.

$= \frac{5 \times 10^6}{10^3 \times 10^3} \times 150$

$= 750$ kg/lit.

Assume,

Organic loading rate, 1500 kg / hectare / day.

$$\text{Vol. of filter media} = \frac{750}{1500} = 0.5 \text{ hectre-m.}$$

$\rightarrow m^2 (10^4)$

$\therefore V = 0.5$ hectre-m.

$= 0.5 \times 10^4 \; m^3$

$\boxed{V = 5{,}000 \; m^3}$

Assume,

depth of filter media = 2 m.

Volume = Area × Depth.

$$\text{Area} = \frac{\text{Vol}}{\text{Depth}} = \frac{5000}{2}$$

$\boxed{A = 2500 \; m^2}$.

$$\frac{\pi}{4} d^2 = 2500$$

$$d^2 = \frac{2500 \times 4}{3.14} = 56.43$$

$\therefore \boxed{d = 58 \; m}$.

Since,

(Do not design 60 m nearer) $\boxed{d = 40 m}$

Assume, 40 m dia circular tank,

$$\text{No. of units} = \frac{2500}{\frac{\pi}{4} \times 40^2} = 1.9 \simeq 2$$

Provide,

40 m ϕ circular filtre tank of

2 no. of filter media.

Rotary distribution:

Peak flow = Avg. flow × 3

$$= 3 \times \frac{(5 \times 10^6)}{10^3} \times \frac{1}{24 \times 60 \times 60}$$

$$= 0.17 \ m^3/sec$$

Discharge.

Flow is divided into 2 filters,

∴ flow through each unit = 0.085 m^3/sec

Assume,

($\nless$ 1 m/sec)

Velocity at peak flow is 2 metre/sec

through central column of distributor.

Dia of central column,

$$A = \frac{Q}{V}$$

$$\frac{\pi}{4} \times d^2 = \frac{Q}{V} \times \frac{4}{\pi}$$

$$d = \sqrt{\frac{Q4}{V\pi}}$$

$$= \sqrt{\frac{0.085 \times 4}{2 \times 3.14}}$$

∴ $\boxed{d = 0.23 \ m}$

Design of arms,

Let us use Spray type distribution of rotary arms, (with 4 arms)

Discharge / arm $= 0.085/4 = 0.021 \ m^3/sec$

Dia of filter $= 40$ m

Length of arm $= \dfrac{Dia - 2}{2}$

$= \dfrac{40 - 2}{2}$

$\boxed{L = 19 \ m}$

Design of underdrainage System,

Assume,

Slope = 1 in 40 for the underdrain laid from main effluent channel, are 10 cm dia semi-circular underdrain pipes running half full

$$Q = AV.$$

$$Q = A\left[\frac{1}{n} r^{2/3} S^{1/2}\right]$$

$$A = \frac{\pi}{4} \times 10^2 = 78.5 \ cm^2 = 78.5 \ (10^{-2})^2 \ m^2$$

~~A = 0.785 m²~~

$\boxed{A = 0.00785 \ m^2}$

$\therefore (P = \pi \times D)$

$$r = \frac{A}{P}$$

$$= \frac{0.00785}{3.14 \times 10 \times 10^{-2}}$$

$$r = 0.025$$

$$Q = 0.00785 \times \frac{1}{0.013} \times (0.025)^{2/3} (1/40)^{1/2}$$

$$= 0.00816$$

$$Q = 0.008 \ m^3/sec$$

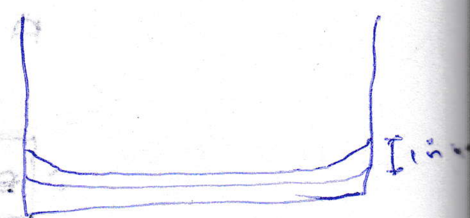
No. of laterals $= \frac{0.085}{0.0015} = 56$

Semicircle $\Rightarrow q = 0.196 \times Q$

$$q = 0.0015 \ m^3/sec$$

$\therefore$ No. of laterals $= 56$

Hence, 60 Semi circular laterals of 10 cm dia, discharging into effluent channel laid at slope 1 in 40



For Conventional filter, efficiency

(2m)

$$\eta = \frac{100}{1 + 0.044\sqrt{u}}$$

u → Organic loading rate ...

Q2. The sewage is flowing at 4.5 MLPD, 5 day BOD 160 mg/lit, the value of adopted organic loading 160 gram/m³/day. Surface loading 2000 lit/m²/day. Determine Vol. & depth of filter & its Efficiency?

Oxidisation pond: (Trapezoidal tank)

→ Earthen dam. (stones, bricks, cement)

→ 7 to 14 days.

→ BOD gets consumed by micro-organisms.

→ Depth - < 1m - Aerobic pond.

> 1.5m → top layer → Aerobic decomposition.

→ Bottom layer - Anaerobic decomposition.

(facultative decomposition ponds)

> 2-4m. → Anaerobic ponds.

(liberates methane (CH_3) No O_2 is used)

rarely used

Design criteria: (Assumtion)

Organic loading = 150 - 300 kg/ha/day.
(hot region)

Length = 2 x width.

Depth = 1 to 1.5 m.

Free board = 0.5 to 1m

Detention period = 20-30 days.

03. Design an oxidisation pond for treating sewage from 5000 persons contributing sewage at 120 lit/capita/day. The five day BOD of sewage 300 mg/lit.

Sol:-

Quantity of sewage $= 5000 \times \frac{120}{~~[illegible]~~ \times 1000}$ $24 \times 60 \times 60$

$= ~~[illegible]~~$

$= 600 \ m^3/day$

$= 0.0069 \ m^3/sec$

BOD content per day $= 5000 \times 120 \times 300$

$= \frac{180 \times 10^6}{10^3 \times 10^3} \ mg/lit$
(kg) (m³)

$= 180 \ kg/day$.

Assume, Organic loading as 300 kg/Hec/day

Surface area $= \frac{\text{Total BOD/day}}{\text{Organic loading}}$

$= \frac{180}{300} = 0.6$ factor.
$(10^4) m^2$

$A = 6{,}000 \ m^2$

Length = 2 x width.

$L = 2B$

$2B \times B = 6000$

$B^2 = 3000$

$\therefore \boxed{B = 55\,m}$

$L = 110\,m$

Use, Eff. depth = 1.2 m.

Capacity $= L \times B \times D$

$= 110 \times 55 \times 1.2$

$\boxed{Q = 7260\,m^3}$

Detention time = Vol / Quantity of sewage

$= 7260/600$

$=$ 12.1 days.

02.

Solution :-

Total 5 - day BOD present in Sewage

$$= \frac{160 \times 4.5 \times 10^6}{10^3} \text{ gm/day}$$

$= 7,20,000$ gm/day.

Vol. of filter media required.

$$= \frac{\text{Total BOD}}{\text{Organic loading}} = \frac{720000 \text{ gm/day}}{160 \text{ gm/m}^3\text{.day}}$$

$$= \frac{720000}{160} \text{ m}^3 = 4500 \text{ m}^3$$

Surface area required for filter,

$$= \frac{\text{Total flow}}{\text{Hydraulic loading}} = \frac{4.5 \times 10^6 \text{ l/d}}{2000 \text{ l/m}^2\text{.d}}$$

$= 2.25 \times 10^3$ m²

$= 2250$ m².

Depth of bed required,

$$= \frac{4500}{2250} \text{ m} = 2\text{m}$$

Efficiency of filter,

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

$u = 160$ gm/m³/day

$u = 160/1000 \times 10^4$ kg/Ha.m/day

$= 1600$ kg/Ham/day

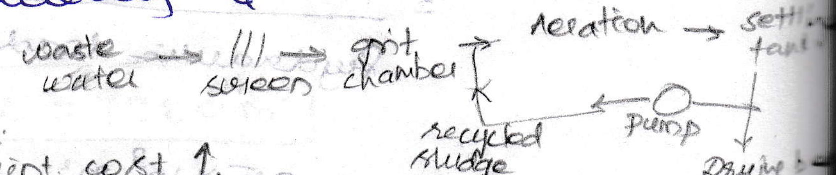
$\therefore$ $\eta = 85.03\%$

It is an endless ditches for an extended aeration activated sludge process, with a detention period of about 12 to 15 hours with out 1° sedim process

** Oxidisation ditches :-

(rectangular tank) It is Constructed by earthwork (or) Stone masonry with vertical walls. In this process there is special type of horizontal axis rotor for oxygenation & agitating mixing sewage

The velocity is maintained at 0.3 m/s stoping the rotor for 2 hours. The vol. of aeration channel require should be such as to give a detention period of 12 - 15 hrs 95% of suspended solids are removed efficiently & it has high removal of BOD 98%.



Adv: Alu. removal ↑

Disad: maint. cost ↑ env. drawback ↑

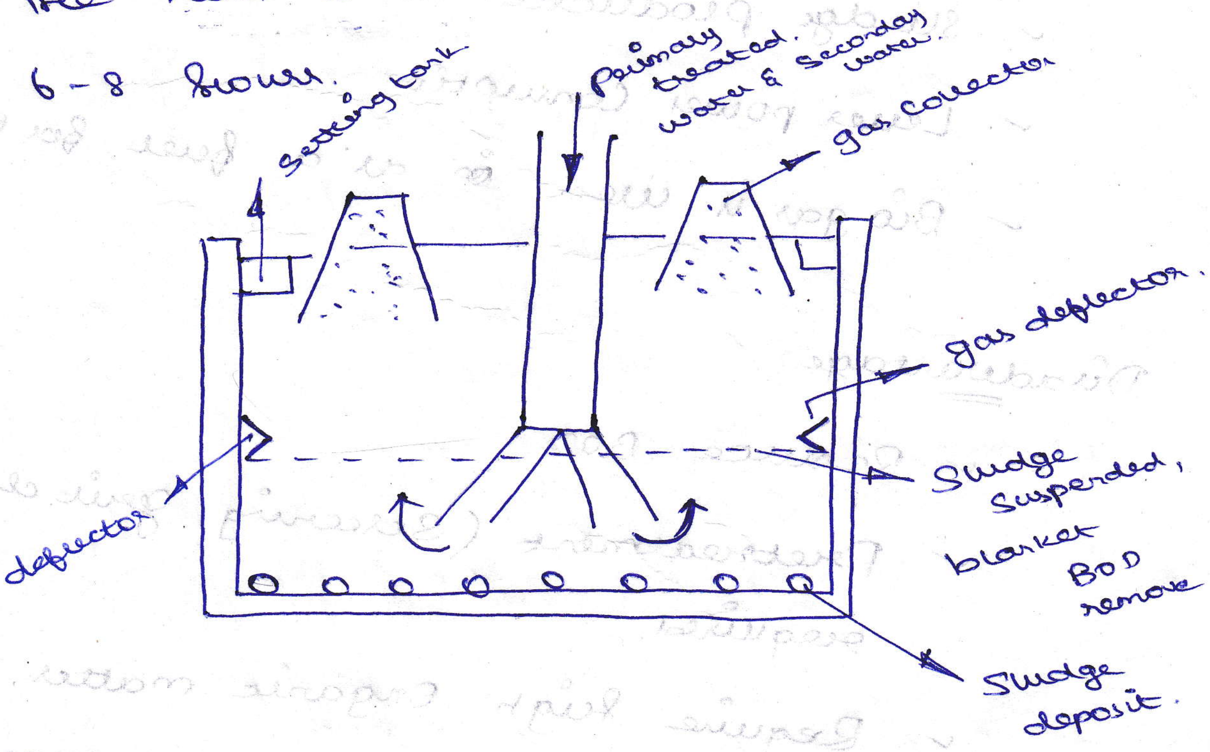
** Upflow anaerobic sludge blanket ** (UASB)

✓ Most advanced method in sewage treatment

→ UASB maintain a high concentration of biomass thro' the formation of highly settleable microbial sludge aggregate, the waste water flows upwards thro' a layer of very active sludge to cause anaerobic digestion of organisms in waste water.

→ At the top of reactor 3 phase seperation b/w gas - solid liquid takes place, any biomass leaving the reaction zone is directly requirelated from the settle zone. This process is suitable for treating waste water from industries & waste containing particular matter

→ Sludge bed develops micro-organisms that are capable of flowristing in anaerobic condition. The sludge bed traps suspended particles from the up moving waste water. The suspended solids traps / degraded by an anaerobic digestion producting 70% of methane & 30% of CO_2. This bio-gas is removed by gas collector. The retention time of water in UASB is 6-8 hours.



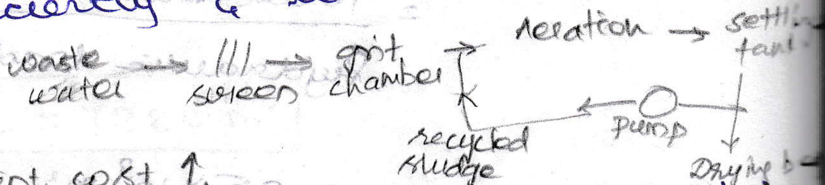
(continue)

**
Oxidisation ditches :-

It is an endless ditches for an extended aeration activated sludge process, with a dedention period of about 12 to 15 hours without 1° sedim. process

(rectangular tank) It is constructed by earthwork (or) stone masonry with vertical walls. In this process there is special type of horizontal axis rotar for oxygeration & agitating → mixing. Sewage

The velocity is maintained at 0.3 m/s stoping the rotar for 2 hours. The vol. of aeration channel require should be such as to give a detention period of 12-15 hrs 95% of suspended solids are removed efficiently & it has high removal of BOD 98%.



Adv: sld. removal ↑

Disad: maint. cost ↑, env. drawback ↑

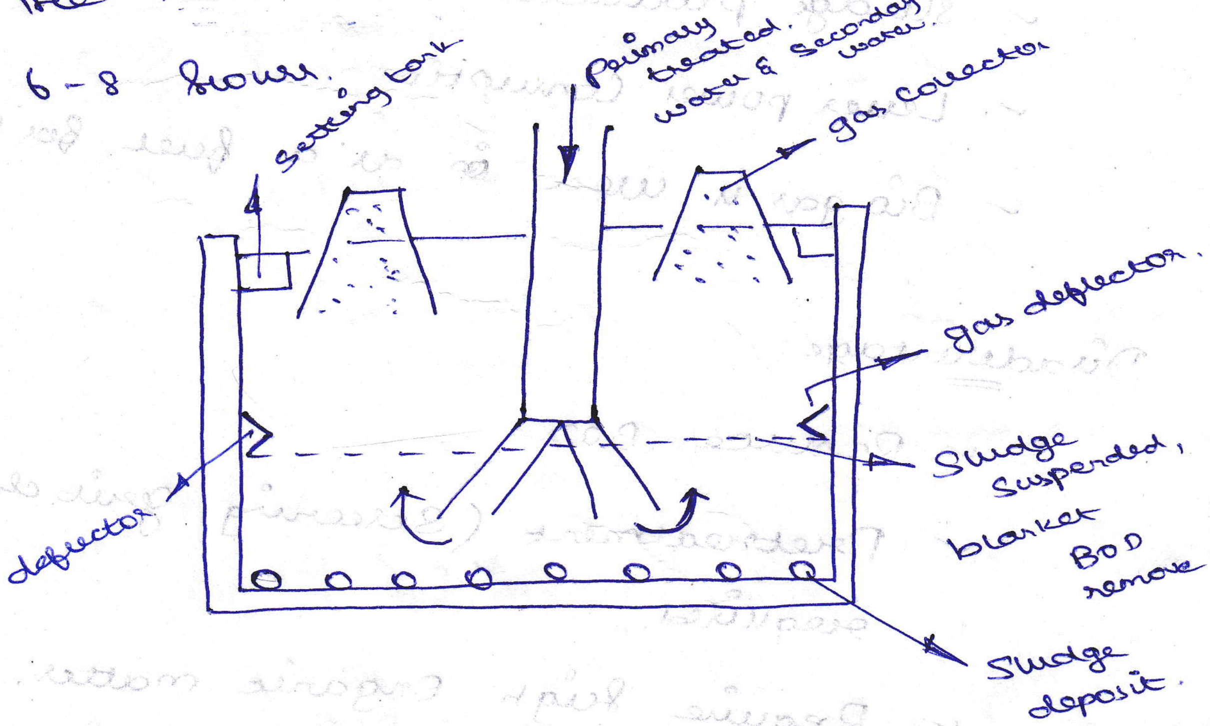
** Upflow anaerobic sludge blanket ** (UASB)

✓ Most advanced method in sewage treatment

→ UASB maintain a high concentration of biomass thro' the formation of highly settleable microbial sludge aggregate, the waste water flows upwards thro' a layer of very active sludge to cause anaerobic digestion of organisms in waste water.

→ At the top of reactor 3 phase seperation b/w gas - solid liquid takes place, any biomass leaving the reaction zone is directly requirelated from the settle zone. This process is suitable for treating waste water from industries & waste containing particular matter

→ Sludge bed develops micro-organisms that are capable of flourishing in anaerobic condition. The sludge bed traps suspended particles from the up moving waste water. The suspended solids traps / degraded by an anaerobic digestion producting 70% of methane & 30% of CO_2. This bio-gas is removed by gas collector. The retention time of water in UASB is 6 - 8 hours.



(continue)

Sewage recycle in residential Complex: **

(4 methods)

Sewage recycle consists of pre treatment (mechanically operated) (Screening), Primary (settling tank) treatment, Secondary (microorganism) & tertiary (disinfection) treatment.

✓ In residential complex, STP is operated only in sealed condition.

Design criteria:

Sludge detention time = 15 to 30 days.

Hydrolic detention time = 6 to 12 hours.

Removal eff = 90% to 95% of COD.

Advantage:

- ✓ Low cost.
- ✓ Sludge production less.
- ✓ Lesser power Consumption
- ✓ Bio gas is used as a fuel for other

... BOD.

... t (Screening, grit chamber

... high organic matter.

... high temp for carry process.