Settling velocity vertical velocity of particle
velocity of flow horizontal velocity (Length/Time)

Date: 17/08/23
Page No.

EN 301

Wastewater Engineering :: Design and application

5 NO attendance
5 NO assignment
5 NO Test

Physical chemical biological
1. Turbidity
2. Colour
3. Temp
4. Conductivity

→ COD is more
→ BOD is total oxygen demand for organisms (microbes) to decompose organic matter.
→ COD is the total chemical oxygen demand for microbes to decompose organic as well as inorganic.

- primary Secondary Tertiary
- Screening
- Coarse & fine screen

What is sewage
In India we have combined system.

Date 24/08/23
Page No.

Storm water is not so many polluted
Seperate sewage system / and combined sewage system

Storm water, properties or chraulerstics of waste water.
Sewage or waste water Treatment.

1) preliminary treatments → Initial
2) primary treatments
3) secondary treatments → also known as biological treatment like bacteria.
4) complete / final or tertiary treatment

① preliminary Treatment :- Large very big suspended particle is removed by screaning made up of iron rock either in the form of vertical or an inclined at 45° or 60°. Otherwise smashed.

Coarse screen at an angle of 45° to 60°

There are 3 Types of screen.
Coarse, medium and fine

① Coarse Screan :- The spacing b/w the bar is 50mm or more and coarse screen collects 6 L of solids per million of litre of sewage velocity of flow (horizontal) + length/time is Generally $\boxed{0.8 - 1.0 m/s}$ velocity

aste को
ring & dumping
करते हैं।

② Medium Screen :- The spacing b/w the bar is 6mm to 40mm. It collects 30 to 90 L of material per million of litre.
$\boxed{0.8 - 1.0 m/s}$

Shahadra & Najafgarh
→ fine screen smashed
Cross - Sectional area :: width
→ Gross area :: c x d

(3) fine Screen :: The spacing b/w clear space is 1.5mm to 3mm and fine Screen is removed about 20% of the total Suspended solids from the Sewage. It clogged & choked very frequently so we keep Backwashing.

Ques Calculate the Screen required for the treatment plant for treating a peak flow of 60 million l per day of Sewage?

$Q = 60\ ml/d$

$= 60 \times 10^6\ l/d \to 24hr$

$[1L = 10^{-3}\ m^3]$

$Q = 60 \times 10^6 L \times 24 \times 60 \times 60$

$Q = .694\ m^3/s$

Ques. Let us assume the velocity of flow through the Screen is 0.8.

$Q = VA$

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

$0.8675\ m^2$

Ques using rectangular Steel bar in a Screen having 1cm width and placed at 5cm spacing. So the Gross area of the Screen required is Equal to (Cross sectional area) * Spacing + 1cm width ÷ clear space

$$\frac{\text{Cross-Sectional}\ (m^2) \times (5+1)}{5} = m^2$$

clear space b/w the rod
width of the area
5 → Spacing

$1.041\ m^2$

commulators or stators to break the large suspended particle 6mm or less.

Date: 25 08 23
Page No.

→ Clarifflulator: wet and dry process
preliminary treatment.

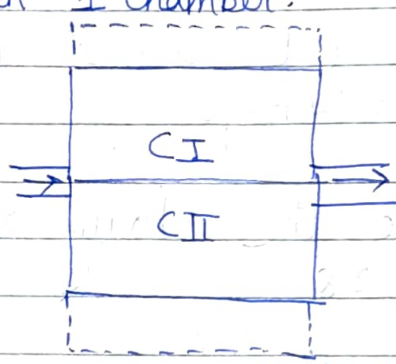
→ Assuming the screen bar at placed to are the are placed at 60° to the horizontal so that the gross area of the screen is required $\left[\dfrac{1.04 \times 2}{\sqrt{3}}\right]$ $1.2 m^2$

Greece and oil is further removed by Grit Channel.

floating materials (suspended particles)

→ Grit chamber: Like a sedimentation tank. Shape like a tank. It design more than 1 chamber.

Top View



Generally: 2
high speed & slow speed.

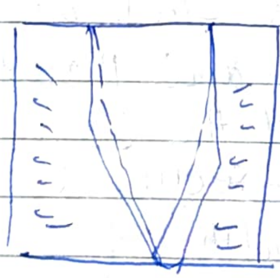
horizontal velocity = 3 to 4.5 $\sqrt{gd(G-1)}$

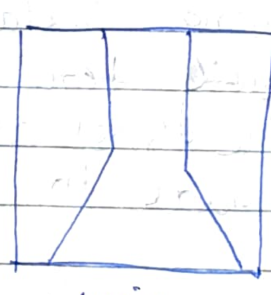
m^2/s^2

$\downarrow$ Ss
Specific Gravity

Stokes law more than 1mm

Cross-Sectional View
parabolic & weir





most commonly Parabolic weir

→ retention & detention time 40 to 60 seconds.
→ for the water depth of 1 to 8 m.

$hs = .25 - 0.3 m/s$ ① viscosity of water

what is sedimentation ② size & shape

① Sedimentation tank and principle → rate of flow of viscosity

② Types of sedimentation → intermediate & continuous [velocity is inversely proportional to temp.

③

Ques A Grit chamber is design to remove particle with the diameter of ·2mm specific Gravity is 2.65 the Settling velocity of the particle is Varies b/w 0.016– 0.022 m/s. Depending upon their shape. A flow through is 0.3m/s will be maintained by proportionaling weir. Determine the channel dimension for the maximum waste flow of 10,000 m^3 per day.

Given: Diameter = ·2mm

Discharge = ·1157 m^3/s

Q = velocity x cross sectional area

Q = VA

↓

0.115 m^3/s horizontal velocity

A = 0.385 m^2

assuming water depth of a channel is 1m.

width = 0.4m = 0.385

assume the settling velocity = 0.02 m/s

$$\text{Detention time} = \frac{\text{Depth of the basin}}{\text{Setting velocity}}$$

- Commutators and shreedars floating material less than or equal to 6mm. It cannot pass the material.

$$\text{Detention time} = \frac{1}{0.02} = 50s.$$

$$\text{horizontal velocity} = \frac{L}{T}$$

Vh x t

1 x ·385 x 15 = 5.775

$\boxed{b \times d \times L}$

Date : / /
Page No.

⇒ ~~Sceaming~~ Skimming tank :- for remove the large suspended particle. Coarse & fine screen. Oil & grease is removed by skimming tank. A surface area

$$A = .00622 \frac{q}{V_r} \; m^2$$

$A \rightarrow m^2$

$q \rightarrow$ rate of flow in sewage $\rightarrow m^3/d$

$V_r \rightarrow$ velocity minimum rising velocity of grey material to be removed (m/min)

$\therefore V_r = .25 \; m/min$

Imp.

$$V_s = \frac{g}{18} \frac{(G-1)}{\nu} d^2 \quad d \text{ where } < 0.1mm \quad \text{—— (i)}$$

Viscosity :-

Temp :- $V_s = 418 (G-1) d^2 \left(\frac{3T + 70}{100} \right)$ —— (ii)

$T \rightarrow$ Temp degree Celsius.

Newton's Law. Newtonian Eqn :- b/w .1mm to 1mm.

$V_s = 1.8 \sqrt{gd(G-1)}$ —— $d = 0.1mm - 1.0mm$

hyzine's Eqn :- particle size is more than mm.

Selling velocity → vertical velocity
Calculated Selling velocity particle is always greater actual Selling velocity in a tank.

Date 1/09/23
Page No.

Transition zone

9/2023

Hazen's Law: $V_s = 418\,(G-1)\,d\left(\frac{3T+70}{100}\right)$ — ③

Stoke's Law का derivation आना चाहिए।

⇒ primary Sedimentation Tank

Hazen's Improved Eqn:
Settling velocity is $60.6\,(G-1)\,d\left(\frac{3T+70}{100}\right)$
↓ Ss

greater than less than 1

for Inorganic Solid is Specific Gravity: 2.65
$V_s = 60.6\,(2.65-1)\,d\left(\frac{3T+70}{100}\right)$ — ④

⇒ for Inorganic Solids Setting velocity is primary Sedimentation tank where size is Greater than ·1 and less than 1.

$$\boxed{V_s = d\,(3T+70)}$$ — ⑤

⇒ for organic $G_s = 1.2$ solids
$$\boxed{V_s = 0.12\,d\,(3T+70)}$$

Types of Sedimentation tank

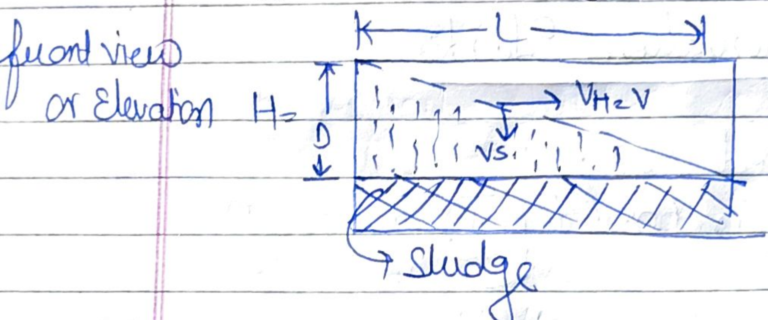
- Intermediate
Store for a particular time (that storing point is called retention/detention period that which hold for particular time).

- Continuous
flow is continuous.

Date : / /
Page No.

Intermediate tank is also known as quiescent Tank.

Design of primary sedimentation tank:-



$$\frac{V}{V_S} = \frac{L}{H}$$ — (i)

L → length of the tank
H → depth of the tank

flow velocity = $\frac{\text{length}}{\text{Time}}$ or $\frac{\text{discharge}}{V_H}$

$$V = V_S \frac{L}{H}$$

$$V_S = \frac{V \times H}{L} \quad \text{— (ii)}$$

$$V = \frac{L}{t}$$

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

$$\boxed{V = \frac{Q}{BH}} \quad \text{— (iii)}$$

Settling velocity $\boxed{V_S = \frac{Q}{BL}}$ — (IV)
than it is known as overflow rate. Or Surface Loading or overflow velocity

→ for plain primary sedimentation tank:-
The value of overflow rate = 40,000 to 50,000 l/m²/d

Date: / /
Page No.

⇒ for ~~sedimentary~~ Secondary Sedimentation tank or if the sedimentation with coagulation the value of overflow rate is $\boxed{50{,}000 \text{ to } 60{,}000}$ l/m²/d

- The depth of the sedimentation tank is varies b/w 2.4 to 3.6m (Excluding the sludge zone.)
always advisable not to took depth of more than 3m.

- Detention period:- If a shape of sedimentation is rectangular.

$$\text{Detention} = \frac{\text{Volume}}{\text{discharge}}$$

for a rectangular shape:- $\frac{L \times b \times H}{Q}$

$$t = \frac{BHL}{Q}$$

If the shape of the tank is circular

$$t = \frac{d^2(0.011d + 0.7854)}{Q}$$

- So range for the detension period is for the plain sedimentation tank (1 to 2 hours)

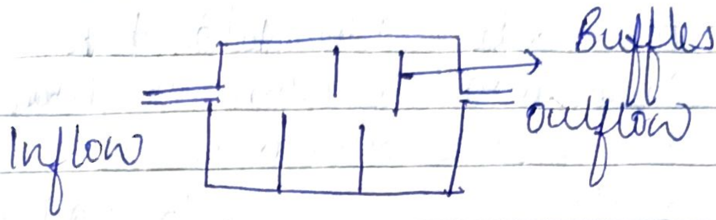
- The width of the sedimentation tank should be 6m and it should not be greater than 7.5m.

- The length of the tank should not be allowed to 4 or 5 times of the width of the tank.

- The horizontal velocity for the sedimentation tank is 0.3 m per min.

$$\boxed{V = 0.3 \text{ m/min}}$$

Imp



1) proper Inlet and outlet arrangement
2) Buffles wall
3) remove oil and greece → Screaming tank
4) Sludge removed.
5) cleaning the Sedimentation tank (Effciency)

Ques.) Design a suitable rectangular sedimentation tank for treating a sewage from the city provide with a public water supply system with a maximum daily demand of 12 million litre per day. Assume the suitable value for the detention period & velocity of $Q = 12 MLD = 12 \times 10^6$ l/day flow.
Assume a suitable data wherever it is missing.

→ 80% of waste water.
Assume the 80% of water supply converts into wastewater / sewage.

$Q_s = 0.8 \times 12 \times 10^6$ lpd

first Convert the discharge into m.

$0.8 \times 10^3 \times 12 \times 60 \times 60 \times 24 = 400\, m^3/hr$

Let assume detention / retention period for a city.

Volume of the sewage $= 400 \times 2 = 800 m^3$

av velocity $V = 0.3\, m/min$
= Length / time

$V = \frac{L}{t}$

(t) → detention time

$$0.3 = \frac{L}{2 \times 60}$$

$$0.3 \times 120 = L$$

$$36m = L$$

Volume $= L \times B \times H$.

cross-sectional area $\rightarrow H \times B = \frac{800}{36} = 22.2m^2$

- Let assume the depth of tank

$$\frac{22.2}{3} = B$$

$$= \boxed{7.4m}$$

- Let us assume free board $= 0.5m$.

free board $= 0.5m$.

H

Dimension of the tank $= 36 \times 7.4 \times 3.5m\,(3m + .5m)$ free body

OR

Let us assume over flow rate $= 40{,}000 L/m^2/d$

$$\frac{Q}{BL} \leq 40{,}000\ l/m^2/d$$

$$\frac{.8 \times 10^6 \times 12}{B \times 36}$$

$$\boxed{B = 6.66 \simeq 6.7m.}$$

$$H \times B = 22.2$$

$$H \times 6.7 = 22.2$$

$$H = \frac{22.2}{6.7} = \boxed{3.31m} \simeq 3.3m$$

$$\boxed{36m \times 6.7m \times 3.8\ m}$$

Date 12/09/23
Page No.

Primary characteristics of sewage + Numerical

Coagulant → Chemical

Grey → fresh wastewater
Black → older (bad smells)

for the decomposition of sludge. Instead we use coagulation in a waste-water treatment we use secondary treatment (aerobic)
filter & sludge design process (trickling filter).

Disadvantages

① Now a days more advance methods of sewage treatment based on biological action available & they are prefer to coagulation and the disadvantages of coagulations are as below:-

→ The chemical used in coagulation react with sewage & during their reaction. They destroy certain microorganisms which are helpful in the digestion of sludge, so they creating difficult in sludge digestion.

② The cost of chemical added to the cost of sedimentation which increases cost of treatment process.

③ The process of coagulation requires skill supervision & handling of chemicals.

→ During the coagulation process the sludge is produced is more in coagulation as compared to other.

④ Detention period of sewage is not more than 2 hours then it become septice. It produce

Combination of coagulation & flocculation is called calleflulocclator (adding mixing)

foul smell and gases. Sometimes we use In Industries field.

Secondary Treatment is called as Biological Treatment process.

The Effluent from the primary sedimentation tank contain about 60-80% of unstable organic matter. orginal present in the sewage. (CO_2, methane, carbon monoxide for bad gases)

Imp
Secondary treatment divided into 2 main grps

① filteration (Trickling filter) ② Activated Sludge process.

All the filteration & Activated Sludge process are design to work on aerobic bacterial decomposition (oxygen presence)

This is because of the fact that aerobic decomposition does not produce bad smell & gaseous as compared to anerobic condition.

→ Trickling filter :- is the secondary treatment process 2 types of trickling filter.

① Conventional trickling filter (called as low rate trickling filler or ordinary trickling filter, Standard trickling filter)

② high rate trickling filter

Advantages of Trickling filter :-

① The rate of filter loading is high as much requiring lesser land area & small

Date :
Page No.

quantities of filter media for their installation.

(2) Effluent coming out from the trickling filter is supersufficient, nitrates should be utilize & stabilize. They can remove about 75% of the BOD & 80% suspended solids and the effluent can be easily decompose in smaller quantities of dilution of water.

(3) Working of trickling filter is simple & not require any supervision.

(4) They are self cleaning.

(5) Mechanical wear & tear is small because they contain less mechanical equipment.

→ Effluent of trickling filter is warmer more than colder atmosphere surroundings.

Disadvantages:

(1) Cost of trickling filter is high.

(2) The head loss is also high in case of trickling filter.

Date: / /
Page No.

Trickling filter Design & Theory
Low rate & high rate Trickling filter.

Design the filters Surface Loading → hydraulic Loading

22-44 ML/hec/day design for organic loading
Low rate trickling filter
In general 28 ML/hec/day

Value of organic Loading Vol 110-330 ML/hec/day
Organic loading → Vol of the organic loading + discharge

Surface Loading we can f is use for area of the filter so we can find depth of the filter : $\left(\frac{\text{volume}}{\text{area}}\right)$

The organic Loading for low rate trickling filter is $\boxed{900-2200 \text{ kg/hec m/day}}$ of BOD at 5.

for high rate trickling filter $\boxed{6000-18000 \text{ kg/hec-m/day}}$

Efficiency is denoted by $\eta\,(\%) = \frac{100}{1+0.0044\sqrt{u}}$

Small u is the Organic Loading kg/hec m/day
or
kg/ha.m/day

$\boxed{\begin{array}{l} 1\text{kg} = 10^3 \text{gm} \\ 1\text{kg} = 10^6 \text{mg} \\ 1\text{m}^2 = 100 \text{ hectares} \end{array}}$

Date : / /
Page No.

Ques.) The Sewage is flowing at the rate of 4.5 million l/day from a primary clarifier to a Standard rate trickling filter. The (low rate)
5 day BOD of the Effluent is 160 mg/l.
The value of organic loading is to be 160 gram per m^3 day and the surface loading 2000 litre per m^2 per day.
Determine the value of the filter of the Depth. Also calculate the Efficiency of the filter.

Given: $Q = 4.5$ million l/day
$BOD = 160$ mg/L

Vol of the filter media $= \frac{\text{Total BOD}}{\text{organic loading}}$

5 day BOD of Sewage $= 160/10^6 \times 4.5 \times 10^6 = 720$ kg/hec-m
= Effluent × discharge.

⇒ Volume $= \frac{720}{160} \times 10^3 = 4500\ m^3$

⇒ Surface area of the filter = discharge / Surface loading $= \boxed{\frac{\text{Total flow}}{\text{Surface Loading}}}$

$= \frac{4.5 \text{ million } L/d}{2000 l/m^2/d} = \frac{4.5 \times 10^6 l/d}{2000 l/m^2/d}$

$= \boxed{2250\ m^2}$

Depth $\frac{\text{Volume}}{\text{area}}$ $\frac{4500\ m^3}{2250\ m^2} = \boxed{2m}$

Date: / /
Page No.

Efficiency : $\frac{100}{1+0.0044\sqrt{u}}$

for high rate recirculation rate = $\frac{R}{I}$ R → Vol of recirculation sewage
Inflow I → Vol of raw sewage

F → recirculation factor

$$\boxed{F = \frac{1+\frac{R}{I}}{\left[1+0.1\frac{R}{I}\right]^2}}$$

There are 2 Types of filter
1 filter → 1st Stage
2 filter → 2nd Stage high rate trickling filter

Recirculation only will be done on high rate

Single Stage efficiency (η%) $= \frac{100}{1+0.0044\sqrt{\frac{Y}{VF}}}$
high rate trickling filter

Y = Total organic Loading in kg/day
V = volume in hectares m
F = recirculation factor

for two Stage Efficiency (η%)
high rate trickling filter

$$\boxed{= \frac{100}{1+\frac{0.0044}{1-\eta}\sqrt{\frac{Y'}{V'F'}}}}$$

Y' = Total Bod in the Effluent from 1st Stage in kg/day

60-70% numerical
30% Theory

Date :
Page No.

V' = Volume of two stage filter in hectares-m
f' = recirculation factor for 2nd stage filter

Types of high rate trickling filter

	① Bio filter	② Accelo filter	③ Aerow filter
Depth Thickness	1·2m to 1·5m	1·8 m to 2·4m	depth should not more than 1·8m & organic loading varies from 11000 - 12000 kg/hec-m/d
Varies from organic loading	9000-11000 kg/hec-m/d g BOD at 5		
Surface loading	110 - 330 mL/hec/d		Should not be less than 150mL/hec/day

Ques.) Determine the size of high rate trickling filter for the following data of sewage flow 4.5mL/day recirculation ratio (R/I) = 1.5
BOD of the raw sewage = 250mg/L BOD removal of primary tank = 30%.
(70% of 250) final Effluent desired
Desired BOD is 30 mg/L

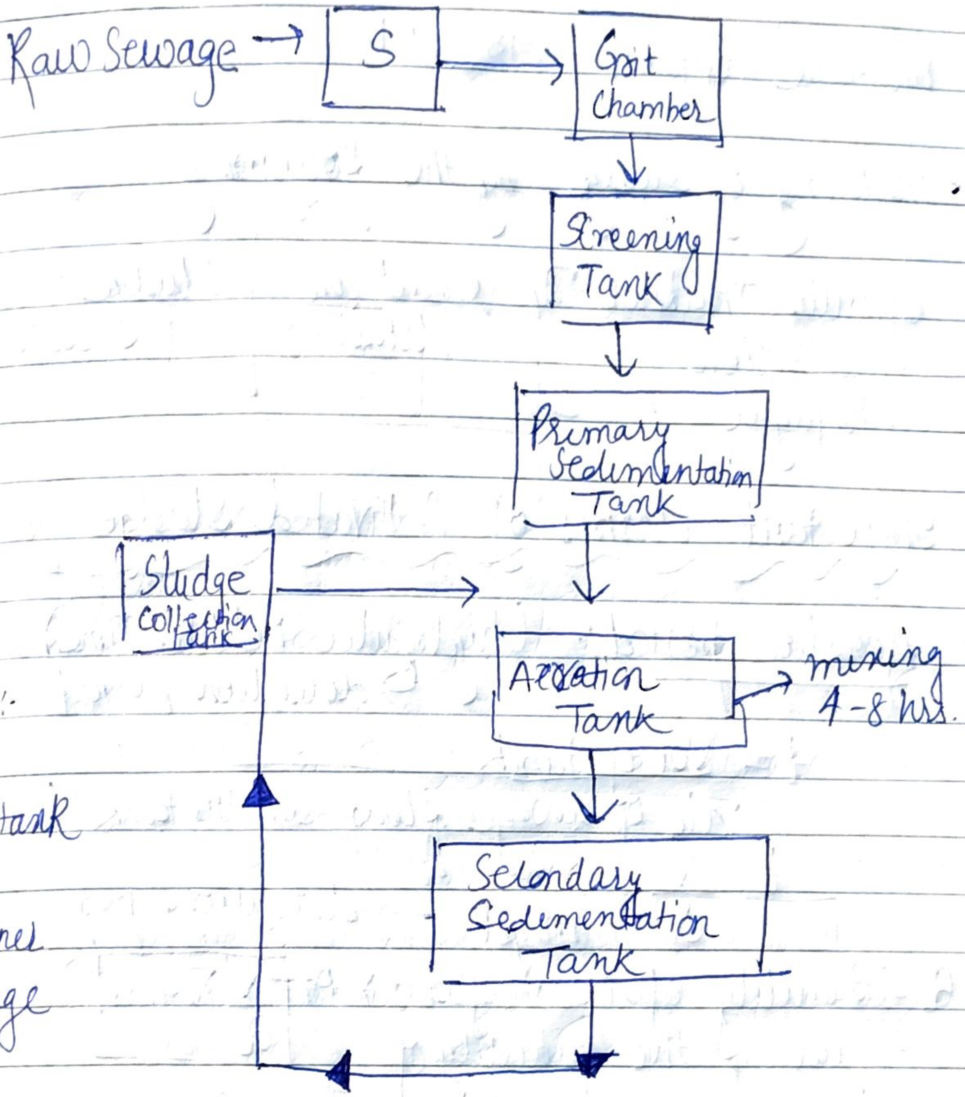
Date 21/09/23

Page No.

Activated sludge process

Secondary treatment
↳ Aerobic

Secondary treatment biological in the presence of oxygen.



To read:
What is aeration tank
2) Types
3) thickness of sludge

→ BOD removal through Activated Sludge process → 80-95%.

→ The bacteria also removes → 90-95%.
20-30% vol. of sludge coming from P.S.T

Date : /
Page No.

There are 3 types
1) Diffuse air } air diffusion
2) Mechanical }
3) Combination of both (D & M) rarely used

→ Moisture contain 98-99%

Thickening of Sludge by the following
① Gravity Thickner } read in detail | Sludge Thickner unit
② Floatation }
③ Centrifugal }

Important terms of Activated Sludge process

① Aeration period :- (hydraulic Retention Time) HRT ↳ detention period

$t = \frac{\text{Vol of tank}}{\text{rate of sewage flow in the tank (aeration tank)}}$

$t = \frac{V}{Q} \frac{\rightarrow m^3}{m^3/d}$ → detention period.

Q = Quantity of waste flow × Excluding the quantity of recycling sludge

AT $\boxed{\frac{V}{Q} \times 24 hrs}$ → hours में लेते हैं।

② Volumetric Loading (BOD Loading) (Organic Loading)
Mass of BOD applied per day to the aeration tank through influent sewage in gram.

⇒ $\frac{Q Y_0}{V}$ where Q is the sewage flow in the aeration tank

unit = m^3/d

| Q = l/d
| BOD_5 = mg/l
mg/d
= $\frac{gm}{m^3/d}$

Sludge digestion process - read urself (Imp)
3 forms.
→ Digested sludge ② Supernatant liquor ③ gaseous of decomposition.

Y_0 = BOD_5 in milligram / l or gram / m^3 of the effluent sewage.

V = Volume of the aeration tank in m^3.

Assignment - 01

→ What are the stages in the sludge digestion process
3 Stages : → acetic fermentation ② acid regression
③ alkaline fermentation.

→ Explain the factor affecting sludge digestion process and their control ?
① Temperature ② Ph value ③ seeding with digested sludge ④ mixing and sluring of the raw sludge with digested sludge.

Digestion Design Consideration for sludge digestion tank / Digestor.

Imp → The digestion tank is of cylindrical shape with diameter 3m to 12 m

→ Depth of the digestion tank is Generally 6m and so on. deeper. The deeper tank are costlier [sometime 2m for Larger area]

→ Sludge digestion we assume that the process of sludge digestion process is linear so the Volume / Capacity of digestion tank

$$V = \left(\frac{V_1 + V_2}{2} \right) \times t \quad \text{--- (1)}$$

V ↓ m^3; $V_1 + V_2$ in m^3/day

Capital V Volume
small V velocity

V = Volume of the digestor
V_1 = raw sludge added per day (m^3/day)
V_2 = Equivalent digested sludge produced per day on Completion of degestion (m^3/day)
t = digestion period (day)

Date
Page No.

Imp. When the daily digested sludge could not be removed due to factors:- ① Monsoonal Seasonal Sometimes winter seasons.
Then the seperate capacity should be provided in the tank for it's storage should be provided in the tank capacity is V_2 (The capacity is V_2).
The total digestor volume is Equal to $\boxed{\left(\frac{V_1+V_2}{2}\right)\times t + V_2 T}$ — (11)

T:- No. of days for which the digester sludge is stored.

The capacity provided per capita may range 21 to 61 litre per capita per day
In general 1 month for the range 21 to 61 l/day.

** The amount of sludge gas produced in the digestion tank range b/w 14 to 28 litres per capita per day.

Ques. Design a digestion tank for primary sludge with the help following data.
→ avg flow 20 million litre/day
→ total suspended solids in a raw sewage = 300 mg/l
→ The moisture content of digested sludge = 85%.
→ assume any other suitable data if you required.

Given:- 20 mL/day
20×10^6 /day

Total suspended solids = 300 mg/L
weight of suspended solids in 20 mL/day of sewage flowing in a day = 6000 kg/day.
assume 65% solids are removed in primary settling tank.
weight of solid removed in primary settling tank

Date / /
Page No.

3900 kg / day
assume the fresh sludge has a moisture content = 95%.
** 5 kg of dry solids is Equal to 100 kg of wet sludge.

So 3900 kg / day dry sludge = 78000 of wet sludge
assume the specific gravity of per day wet
(q) Sludge is = 1.02 so unit weight = 1020 kg/m3
The volume of raw sludge produced per day

$(V_1) = \frac{78000}{1020}$ m3/day

76.47 m3/day

The volume of digested sludge (V_2) at 85% moisture content is given by following formula.

$$V_2 = V_1 \left(\frac{100 - P_1}{100 - P_2} \right)$$

P_1 → fresh sludge moisture content
P_2 → digested sludge moisture

$$V_2 = V_1 \left[\frac{100 - 95}{100 - 85} \right]$$

V_2 = 25.5 m3/day
assume design period = 30 days.

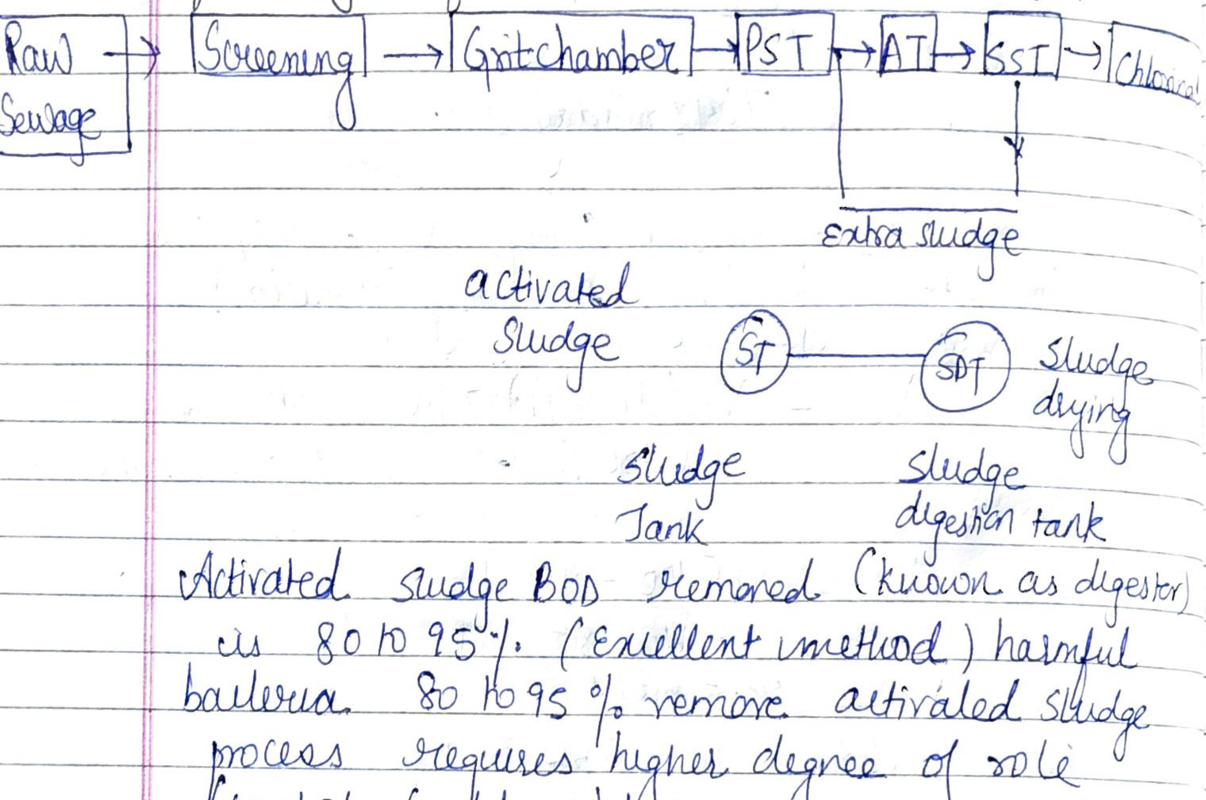
of biological
(presence oxygen) Activated sludge process for the treatment of Secondary
In activated sludge process is the Excellent method for treating the raw sewage. The sewage Effluent Coming from primary sedimentation tank is used in the process and we add 20 to 30% of on volume of activated sludge which Contain a large Concentration of highly active aerobic microorganisms. The mixture is Enter into the aeration tank or mixing in the presence of oxygen

detention time of aeration tank is almost 4 to 8 hrs.

almost 4 to 8 hours. Conventional flow diagram of

Aeration tank: Depth 3 to 4.5m
Detention period: 4 to 8 hrs
Width 4 to 6m
Length 20 to 200m.

Flow diagram for a conventional activated sludge plant



Activated sludge BOD removed (known as digester) is 80 to 95%. (Excellent method) harmful bacteria 80 to 95% remove. activated sludge process requires higher degree of role (control conditions) because

1. It required ample supply of oxygen
2. It is also required in intimate and continuous mixing of activated sludge.
3. The volume should be maintained by 20 to 30% (constant)

The rate of volume activated sludge added to the volume sewage is kept constant

→ primary tank fresh sludge should be more than 2 hrs generally 1.4 hrs

Date: / /
Page No.

Methods of aeration

→ Diffuse air aeration } also known as air diffusion
→ Mechanical aeration
→ Sometimes mixture of 1 and 2

Design of activated Sludge

1. Aeration period :- also called as hydraulic retention time. HRT

fluent → represented by Small t.

$$\boxed{t = \frac{\text{volume}}{\text{discharge}}} \begin{matrix} \rightarrow m^3 \\ \rightarrow m^3/\text{day} \end{matrix}$$

2. Volumetric Bod Loading :- also called as organic Loading. Mass of Bod applied per day to the aeration tank through effluent sewage in gm/volume of the aeration tank.

$\boxed{\text{In India } Bod_5 \text{ at } 20° \text{ Temp.}}$

$= \frac{QY_0}{V}$ where Q → sewage flow in the aeration tank

→ Y_0 Bod_5 in (mg/L) (g/m³)
→ V = Volume of aeration tank in m³.

3. F/M → microorganisms :- = daily Bod Load applied to the aeration system. / Total microbial mass in the system.
↳ food

unitless $\frac{F}{M} = \frac{QY_0}{V \times t}$

xt is mix liquor suspended solids (MLSS) (milligram/litre)

Date 13/10/23
Page No.

2m note

F/m ratio for an activated sludge plant, the main factor controling Bod removal. If low F/m (lower value) means higher the Bod removal and vice-versa.

→ The F/m ratio can be varied by varying the MLSS concentration in the aeration tank

Sludge age

$\theta c = \frac{\text{mass of suspended solids (MLSS) in the system}}{\text{mass of solids living the system per day}}$

Sludge age is also called as solid retention time (SRT) or it is also called mean cell residence time (MCRT)

(M) Mass of solid in a reactor (aeration tank) = V X (MLSS)
= $V \times xt$

Mass of solids removed with the wasted sludge per day = $Q_w X_R$ —— (i)

Mass of solid removed with the effluent per day
= $(Q - Q_w) X_E$ —— (ii)

Total solid removed from the system per day
(Eq i) + (Eq ii)

$$\theta c = \frac{Vxt}{Q_w X_R + (Q - Q_w) X_E}$$

xt is the concentration of solids in the reactor (aeration tank)
xt is MLSS unit in milligram / litre
V = Volume of the aerator.

Q_w = Vol of wastage sludge per day
X_R = concentration of solids in the return sludge or in the wastage sludge in milligram/litre

Q = sewage inflow per day.
X_E = concentration of the solid in the effluent milligram/litre

Design parameter for conventional activated sludge plant process.

Parameter	Design Value
MLSS	1500-3000 milligram/litre
FM	·4 to ·2
aeration period (HRT)	4 to 8 hours
Volumetric loading as gram of Bod applied per m^3 of that tank	300 to 700 g/m^3
Sludge age	5 to 15 days
Q_R/Q	·25 to ·5
Bod removal Efficiency	85 to 95%
kg of oxygen required per kg of Bod removed	·8 to 1·1
Air required per kg of Bod_5	40 - 100 m^3

The data for conventional activated sludge treatment plant is given below:
wastewater flow - 35000 m^3/day
Volume of the aeration tank - 10900 m^3.
Influent bod = 250 mg/L
Effluent bod = 20 mg/L
MLSS = 2500 mg/L

6. Effluent suspended solids = 30 mg/L
7. Waste sludge suspended solids = 9700 mg/L
8. Quality of waste sludge = 220 m^3/day
9. Calculate ① aeration period (HRT)
2. F/m ratio
3. % of η of the bod removed.
4. sludge age → always in days.

assume 80% of the water to the sewage
Avg 24 hrs if not given the detention time.

⇒ Septic Tank (Anerobic) process.
principle : Anerobic decomposition
The sludge settle at the bottom of the Septic and the oil and greese (scum) rising on the top of the surface are allowed to remain in tank for several months.

Design Consideration for Septic Tank :-
- ~~Capacity of septic Tank~~ / 40 to 70 L per capita per day (L/P/d)
- Detention period for septic Tank is vary b/w 12 to 36 hrs.

Imp. The septic tank should be capable for storing the sewage during the detention period & additional volume of the sludge for 6 months to 3 years depending upon the cleaning of the septic tank.

** The rate of accomendation of sludge has been recommended as 30 litres per person per year so the minimum capacity for the septic tank 8 to 10 persons.

~~In case~~ The minimum capacity of the tank may be kept 2250 litres.
(when all households discharge in septic Tank for washroom, Toilet & bathroom 1400 Litres) for 8 to 10 persons.

→ In case of septic tank free board 0.3 metres
The length of the rectangular tank should be 2 to 3 times of it's width.

→ Width should not less than 90 cm.

→ Depth of the septic tank range b/w 1.2 to 1.8m

Ques. Design the dimension of the Septic tank for a small colony of 150 persons provided with a assuare water supply from the municipality head at a rate of 120 litres per person per day. assume any data if you needed.

Date: 26/10/23
Page No.

Anaerobic digestion

Septic Tank → principle, what it is, design, numericals, advantages and disadvantages.

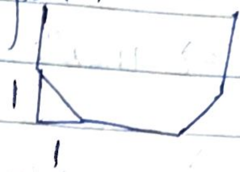
Double story tank, upper = Collecting fresh sewage
Bottom → Store sludge
freeboard 45cm or clear space → Neutral zone in Imhoff tank.
Imhoff tank shaped as hooper.
Mr. Kurl Imhoff

Construction of a Imhoff tank

Double storey or chamber rectangular tank.
Chamber 1 collecting fresh sewage called sedimentation of not given chamber or flowing through chamber. Detention period = 2 to 4 hrs. velocity of flow is very very low. velocity not more than 0.3 m/min. The lower chamber is called digestion chamber as sludge is digested due to anaerobic digestion.
Imhoff tank is called double storey digested tank. bottom chamber is further divided into 3 to 4 parts or component surface loading of sed^{m} the chamber should not.
Top Chamber → rectangular 30,000 L/m^2 of plans area/day.
Bottom of each digestion component is made up in the form of inverted cone or hopper with side slope 1:1.
Hooper is so that it concentrate the sludge at the bottom of hooper. Degested sludge

Date: / /
Page No.

from the bottom of hopper is removed either 1 or 1.5 months periodically depending upon 1:1 on the temp of the sludges.



But for activated sludge plant where recirculation is adopted, the surface loading may be increased upto 45,000 l/m²/day

Length < 30m & ~~15~~ Length : Breadth vary 3 to 5.

Depth (total) of Imhoff = 9 to 11m. & depth of Sedimentation ~~tank~~ chamber is 3 to 3.5m & 50 on free board = 45 cm.

Digestion chamber generally designed for minimum capacity of 57 l / capita (general)

Volume = 57 l × pop.

** In warmer climate, the capacity is reduced from (period of sludge withdrawal will be shorter 1 month or less) 35 to 40 L/capita.

Ques. Design an Imhoff tank to treat the sewage from a small town with 30,000 population the rate of ~~Imhoff~~ sewage assumed as 150 l / head/day (capita). Make assumptions if needed.

Sewar → Gravity flow & water supply → pressure flow

Date 2 / 11 / 13

Page No.

bed slope (sloping)

Sewar supply 2mp

Sewar can't be design for full
free board always required.

Design (max^m flow and min^m flow
It can be both for sewar and water.

⇒ max^m daily flow rate (water) = 1.8 times of avg daily flow

⇒ sewage max^m daily flow = 2 times the avg daily flow.

⇒ max^m hourly flow = 1.5 times of max^m daily flow
In other words max^m hourly flow = 3 times of avg daily flow.

⇒ minimum daily flow = 2/3 × avg daily flow

⇒ minimum hourly flow = $\frac{1}{2}$ × minimum daily flow

→ What is sewar
→ Basic difference in the design of water supply pipes and sewar pipes.
Sewar (provision of free board must)
↳ sloapy it can generate self cleaning velocity.

⇒ water line is always about the sewar line
$\frac{1}{2}$ Qmax

⇒ Generally sewar pipe whose diameter is less than 0.4 is running half full at maximum discharge. If the diameter is greater than 0.4 than it is running either $\frac{2}{3}$rd or 3/4th Qmax

⇒ freeboard Table learn
⇓
flow of discharge
of the peak discharge

maning formula.

pQ (m^2/sec)	freeboard m
< 0.3	·3
·3 - 1.0	·4
1 - 5	·5
5 - 10	·6
10 - 30	·75
30 - 150	·9
⋮	⋮
> 150	1

$Q = VA$

⇒ Chezy's formula According to chezy's

$V = C\sqrt{rS}$

for calculating the velocity

V = velocity of flow in channel (m/s)

r = hydraulic mean radius of channel / hydraulic mean depth.

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

- Wetted area or wetted perimeter whenever it is not running full.

- Dia $= \frac{\pi D^2}{4}$ $\qquad r = D/4$
- $P = \pi D$

⇒ S = hydraulic gradient

C = Chazy's Constant

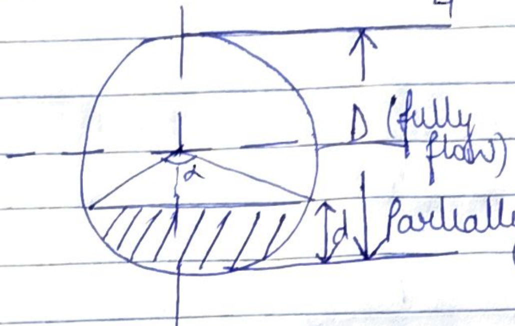
A = Area of cross-sectional.

⇒ Water is measure in depth of water.
Design depends upon :. $Q = AV$

Date 7/11/23
Page No.

Design of Sewars

It is the cross-section of circular sewar and the dia is D. When the circular sewar is run fully so then the area is $\frac{\pi}{4} D^2$.



$P = \pi D$

$R = \frac{A}{P} = \frac{D}{4}$

Water supply for full flow design & sewar is design for partial flow.

Now, consider sewar run at partially at a depth of d

(d) The depth at partial flow $\frac{d}{4} -$ $d = \frac{D}{2} - \frac{D}{2}\cos \alpha/2$

where α is central angle in degree.
Now area of cross-sectional when the sewar is running partial flow or full.
Partial Notation Small represent.

Imp.
$$a = \frac{\pi D^2}{4}\left[\frac{\alpha}{360^\circ} - \frac{\sin\alpha}{2\pi}\right]$$

Imp.:. ram
So the proportionate area $\boxed{\left(\frac{a}{A}\right) = \frac{\alpha}{360^\circ} - \frac{\sin\alpha}{2\pi}}$

Wetted perimeter when the sewar is partial flow

$$\boxed{P = \pi D \times \frac{\alpha}{360^\circ} \quad \text{or} \quad \frac{\pi D \alpha}{360^\circ}}$$

α is always in degree.

Proportionate perimeter $\boxed{\frac{p}{P} = \frac{\alpha}{360^\circ}}$

hydraulic men depth while Sewar is running its partial full OR written as HMD

$(r) = \frac{a}{p} \rightarrow$ (wetted)

$$\boxed{r = \frac{D}{4}\left[1 - \frac{360^\circ \sin\alpha}{2\pi\alpha}\right]}$$

Proportionate hydraulic mean depth :- $\left[\frac{r}{R}\right]$

$$\boxed{\frac{r}{R} = 1 - \frac{360^\circ \sin\alpha}{2\pi\alpha}}$$

Discharge :- velocity Equation

Maening formula:- To find out the velocity

Velocity at partial flow $v = \frac{1}{n} r^{2/3} s^{1/2}$

According to Meauning formula :- $\rightarrow$ Bed slope or gradient

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

n $\rightarrow$ maening's constant

r $\rightarrow$ hydraulic mean depth of sewar

Slope will not change.

proportionate velocity :- According to Maening's Eq:

$$\boxed{\frac{v}{V} = \frac{N}{n} \times \frac{r^{2/3}}{R^{2/3}}}$$

N is roughness coefficient for maening coeff

Circular and Egg (oval) shape sewers.

Date
Page No.

** $\boxed{\frac{v}{V} = \frac{r^{2/3}}{R^{2/3}}}$

Discharge:-

Proportionate discharge $\left(\frac{q}{Q}\right) = \left[\frac{\alpha}{360} - \frac{\sin\alpha}{2\pi}\right]\left[1 - \frac{360\sin\alpha}{2\pi\alpha}\right]^{2/3}$

Ques. A 300 mm diameter sewer is to flow at 0.3 depth on a ~~grid~~ grade ensuring a degree of self cleansing equivalent to that obtained at full depth at a velocity 0.8 per sec. Find a required grade (bed slope) and associate velocity. To find out rate of discharge at depth. If the following data is given meaning coefficient $(n) = .012$. proportionate area $= 0.317$, proportionate wetted perimeter is 0.472, proportionate hydraulic mean depth $= 0.7705$

$\frac{d}{D} = 0.3$