Waste water Engineering (Sewage)

→ Study physical, chemical & Biological properties of waste water (sewage)

BOD < 3mg/L
DO > 4mg/L

Drinking water, BOD = NIL

Waste water ~~or~~ sewage treatment

① Preliminary Treatment

② Primary "

③ Secondary " / Biological treatment

④ Tertiary or complete final Treatment

PRELIMINARY

→ Large suspended organic matter are removed

Screening (organic) & Grid chamber (inorganic) & Detritus tank (Skimming) to remove oil

2.5/2

→ comminutors is used to break large particles into smaller.

PRIMARY TREATMENT

→ sedimention tank

SECONDARY TREATMENT
(aerobic) → doesnt smell foul

→ Filteration
→ Aeration tank
→ ~~oxygen~~ ~~oxid~~ oxidation tank & lagoons

aerobic

anaerobic

→ Septic tank $\xrightarrow{\text{improved}}$ imhoff tank
→ anaerobic lagoons

Complete final TREATMENT

→ Chlorination

SCREENING

Coarse | Medium | Fine

Coarse Screen

→ Racks, also known as.
→ Spacing → 50mm or more & this screen collects about 6L of solids | million litres of sewage.
→ Angle → 30–60°

Medium screen

→ The spacing → 6mm – 40mm
→ Collect 30L – 90L of materials | million litre of sewage

→ Rectangular shape usually.

→ Bars are made of steel or concrete
→ Angle 30–60°

Fine Screen

→ Spacing → 1.5mm – 3mm

Speed of waste water not > 0.8–1 m/s

Q Calculate the screen requirement for a sewage treatment plant having a peak flow of 60 million / litres per day of sewage

Discharge, $Q = 60$ million / L

$= 60 \times 10^6 \times \frac{1}{10^3}$

$= 60 \times 10^3$

$= 6 \times 10^4 \ m^3 / day$

$\frac{6 \times 10^4}{24 \times 60 \times 60}$

$= 0.694 \ m^3/s$

Assume velocity of flow $= 0.8 \ m/s$

$Q = AV$

(net area)

$A = \frac{Q}{V} = 0.867 \ m^2$

Assume,

Using rectangular steel bars in screen having 1cm width & place at 5 cm clear spacing

The gross area of screen = $\frac{\text{net area} \times 6}{5}$ (5+1)

$1.04 m^2$

Now Assuming the bars are placed 60° to the horizontal,
~~so~~ the gross area,

$$\frac{1.04}{\sin 60} = \frac{1.04}{\sqrt{3}} \times 2$$

$$= 1.2 m^2$$

Skimming Tank
> Removes oil & grease
> No need to do design, read theory

Sedimentation Tank

> Studied before (water)

what is, principle, types (continous, intermittent

Stokes Law

$$v_H = 418(S_s - 1)d^2\left(\frac{3T + 70}{100}\right)$$

(settling velocity) mm

when $d < 0.1mm$

Newtons Law
(mm/s)

$d > 0.1mm$ & $< 1mm$

$$v_H = 1.8gd(S_s - 1)$$

Hazen equation
$d > 1mm$
where

$$v_H = 418(S_s - 1)d\left(\frac{3T + 70}{100}\right)$$

m

horizontal velocity = $\frac{l}{t}$

$$\boxed{l = v_H \times t}$$

Q A grid chamber is designed to remove particles of 0.2mm, $S_s = 2.65$, settling velocity is ranged b/w 0.016 – 0.022 m/s. A flow velocity is 0.3 m/s & Max waste water flow is 10K m^3/day. Det. dimensions of the grid chamber (l, w, d)

O T

Q =

2918

~~Comminut~~
Comminutor is a mechanical device is used to break large solids to size of about 6mm

We ~~incinerate~~ incinerate the waste collected on the screen.

Dumping is the process of solid waste from screen to sea

Grid chamber / Grid channel / Grid basin:
used to remove inorganic particles who's SG is 2.65

The horizontal velocity in a grid chamber

$$= v_H = v_h = 3 \text{ to } 4.5\sqrt{g\,d\,(S_s - 1)}$$

size of particle in mm

specific gravity

> For particle size 0.2mm, this horizontal velocity is also known as critical scour velocity & is equal to 0.11 to 0.25 m/s

> General velocity of flow is taken as 0.25 - 0.3 m/s for a grid chamber

Detention time → 40-60s for grid chamber
Depth → 1 - 1.8 m

Q Resign a circular settling tank for a primary treatment of sewage of 12 ML/day. Assume t and surface loading

$Q = 12 \times 10^6$ L/day , $t = 2$ hr

$$\text{volume} = Q \times t$$

$$12 \times 10^6 \times \frac{2}{24}$$

$$= 1000 \, m^3$$

$$\text{Surface loading} = \frac{Q}{\text{Area}} = \frac{Q}{\frac{\pi}{4} d^4}$$

Assume = 40K litres/m^2/day

$$40000 = \frac{12 \times 10^6}{\frac{\pi}{4} d^2}$$

$$d^2 = \frac{12 \times 10^5 \times 4}{4000 \, \pi}$$

$$d = 19.54 m$$

Detention Tank

Retention

> Time is usually 1-2 hrs. (essence cos sewage sat gaggs)
usually 1 hr ideally
& max to max 2.5-3 hr.

width → generally taken as 6m
& not greater than 7.5m

Assume length of the sedimentation ~~than~~ tank should not be more than 4-5 times of its width

Value of horizontal flow is taken as 0.3 m/min

$$\text{detention time} = \frac{\text{Volume}}{\text{discharge}} = \frac{LBH}{Q}$$

for circular,

$$t = \frac{d^2(0.011d + 0.785h)}{Q}$$

* Learn these values for assignment

Horizontal flow velocity = $\frac{Q}{BH} = \frac{l}{T}$

Settling velocity, $v_s = \frac{Q}{BL}$
Overflow rate,
surface loading

For Sedimentation tank
Value of settling velocity → 40,000 - 50,000 L/m²/day
w/o coagulant

with coagulant → value ↑ → 50K - 60K L/m²/d

For Second Sedimentation tank
Overflow rate is 25K - 35K L/m²/d

The depth of the sedimentation ~~tract~~ tank varies from 2.4 - 3.6m
Gen, the depth shouldn't be > 3m

Trickling Filter

> A secondary treatment unit, used for wastewater treatment plant to remove OM & other pollutants from waste water

> Generally 2 types of TF

- Ordinary / conventional
- high rate TF / high rate filter

Working

1) Wastewater flows through a DS onto a bed of media, such as rock, ceramic, etc.

2) Microorganisms attach to the media & form a biofilm.

3) As waste water trickles through media, microbes break down organic matters.

4) Treated wastewater collect at the bottom of the filter & then discharged.

☆ What, types, Working, Adv, Disad. Study this about TF

* STP in delhi → 38

Wednesday unit 1 test → numn & theory

Unit - 2

Secondary treatment → Biological Treatment.

Aerobic

Activated sludge process (ASP) & Trickling (TF) filter

→ uses microbes to break down organic treatment

→ TF uses microbes, attached to media to breakdown the organic matter.

Rotating Biological Contractors (RBC)

→ uses microbes attached to rotating disc to breakdown organic matter

* Moving bed biofilm reactor (MBBR)

→ uses microbes attached to the moving media to breakdown OM

Sedimentation with coagulation.

> We avoid coagulations, as disadvantages outweigh the advantages.

Disadvantages

> Biological / Secondary are widely available and are better with less difficult

> Kills, useful bacteria for settling / decomp. of sludge.

> cost is higher.

> needs skill supervision & handling of chemicals. → labour cost

Advantages

> Settles faster

> Sewage BOD is ↑ & chemicals reduces it quickly.

> Area requirement for sedimentation tank with coagulation is lesser

> Controls Eutrophication by killing phosphorous & Nitrogen.

Efficiency

$$\boxed{\eta = \frac{100}{1+0.0044\sqrt{\mu}}}\ \%$$

organic loading

Efficiency of trickling filter 75%
& about 80% of suspended solid (SS)

Q The sewage is flowing @4.5 ML/day from a primary clarifier to a trickling filter, the $BOD_5 = 160 mg/L$ value of organic loading is 160 g/m³/day & the surface loading 2000 litres/m²/day. Det. the volume of the filter & its depth. Also calculate the efficiency.

$$1 m^2 = 1 \times 10^{-4} \text{ hec.}$$

$$\text{hydraulic loading} = \frac{Q}{\text{Area}}$$

$$\text{Area} = \frac{4.5 \text{ ML}}{2000 \times 10}$$

$$\text{Area} = 225 m^2$$

Step 2

Organic Loading Rate

Mass of BOD(5) per unit volume of the filter media per day.

→ we take 5 day BOD @ 20°C

Unit → kg(BOD5) / ha-m / day

Range : 900 - 2000 kg/ha-m/d
~ ordinary

Range : 6000 - 8000 kg of BOD5/ham/d
~ high rate

☆ IMPORTANT NOTE
The filter ~~design~~ dia & depth is designed for average rate of discharge

Design of TF

> involves diameter of the circular filter tank & its depth

> Detailed design involve, design of rotatory distributers & under-drainage ~~filters~~ systems

Step 1

* Hydraulic Loading Rate

It is the quantity of sewage applied to surface area of the filter

$$\text{Discharge / surface area} = \frac{Q}{\text{Area (hectare)}}$$

* Unit → million litres per hectares per day.

Range = 22 - 44 Ml / hec / d [For ordinary]

usually 28 Ml / ha / d

Range = 110 - 330 Ml / ha / d [for high-rate]

usually 220 Ml / ha / d

F → recirculation factor (ratio, numbers)

R → volume of sewage recirculated

I → volume of Raw sewage

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

Efficiency of a single stage High rate TF

$$\boxed{\eta = \frac{100}{1 + 0.0044\sqrt{\frac{Y}{VF}}}}\ \%$$

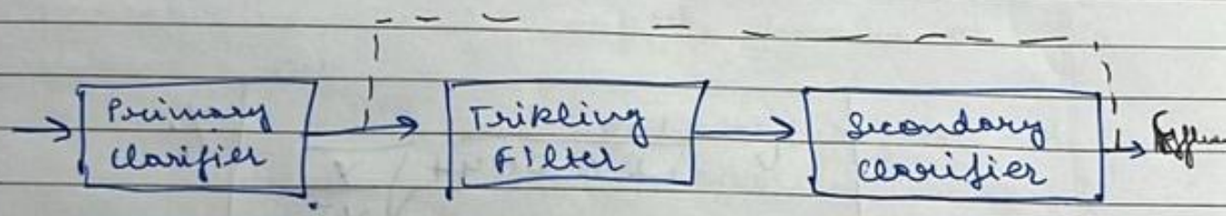
Y = total organic loading in kg/day applied to filter
or total BOD in kg

$\frac{Y}{VF}$ = unit organic loading on filter

V = filter volume in ha-m

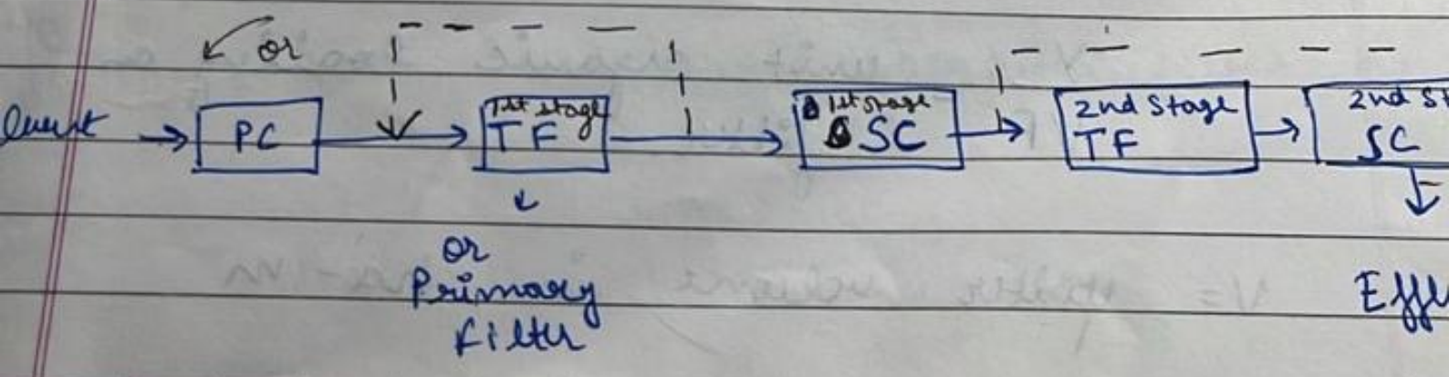
Recirculation	NO	Yes usually

→ Single stage Recirculation process



Commonly adopted single stage recirculation process

→ 2 Stage commonly adopted recirculation pr



Sewage = 80% = 14,400 l/d

Difference between

	Conventional TF/ ordinary	High rate filter/ Std
Depth	1.6 - 2.4m	1.2 - 1.8
Size of filter media	25-75 mm	25-60 mm
Land requirement	More	less
cost	higher	less
...hod ...peration		
...s of ...ent ...ced		
	lesser, <20ppm	more, ≥30ppm

Activated sludge process.

Sludge moisture content → 90%.

The sludge is stabilized by decomposition of organic matter under the control anaerobic condition
& after this it is disposed off suitably, after drying on the drying bed.

The process of s

And the tank is called the sludge digestion tank

In a sludge digestion process, sludge gets broken into 3 forms

3 forms :
- digested sludge 65-75%
- supernatant liquor 30%
- Gaseous of decomposition (CH_4, CO_2)

Factor affecting sludge digestion and their control

1. Temp
2. pH
3. Seeding with digested sludge
4. Steeping of raw sludge with digested sludge

Sludge = 80% = 14,900 l/d

Accelio : 1.8 m - 2.4 m (depth)

HL = OL = Bio filter

Aero : More than 1.8 m

OL 11,000 - 12,000 kg of BOD_5/ha-m/day

HL should not be less than 150 ML/ha/day

Q Determine the size of high rate TF for the following data sewage flow : 4.5 ML/day, f = 1.5, BOD = 250 mg/L BOD removal = 30%. Final effluent BOD desired 30 mg/L (Circular to depth, dia)

Ans

Ponds & oxidation ditch (theory padhlena).

no numericals

Adv, disad.

Final Efficiency for a 2 stage High rate TF

(Final e) $\eta' = \dfrac{100}{1 + 0.0044 \sqrt{\dfrac{Y'}{V'F'}}}$

$1 - \eta$ → single stage

Y' = total BOD in the effluent from 1st stage in kg/day

V' = Volume of the second stage filter in ha-m

F' = Recirculation factor for 2nd factor

Padhlena theory

Q Types of high rate trickling filter.

	(D)	(organic L)	HL
① Bio - filter	1.2 - 1.5 m	9K - 11K kg	110 - 300 MG day/ha
② Ascelo - filter			
③ Aero - filter			

depth, size, BOD kitni filter, OL

Sewage = 80% = 14,400 l/d

(b) Methane : CH_4 & CO_2

Closed systems that generate foul odour.

(2) SEPTIC TANKS

DELTA
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$$HRT / t = \frac{Vol}{Q}$$

$$OLR / VL = \frac{QY_0}{V}$$

$$F/M = \frac{QY_0}{X_T \, Vol}$$

X_T → MLSS

$$\theta_c \text{ (sludge age)} = \frac{\text{Mass of SS in reactor}}{\text{Solids leaving}}$$

$$= \frac{V X_T}{Q_w X_R + (Q - Q_w) X_e}$$

↳ tends → 0

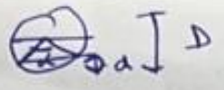
Mid sem

$$V_h = 3 \text{ to } 4.5 \sqrt{g d (s_s - 1)}$$

$$\boxed{l = v_H \times t}$$

$$v_h = \frac{Q}{BH}$$

$$v_s = \frac{Q}{BL}$$



Full flow	Partial
$A = \frac{\pi D^2}{4}$	$d = \frac{D}{2}\left(1 - \cos\frac{\alpha}{2}\right)$
$P = \pi d$	$a = \frac{\pi D^2}{4}\left[\frac{\alpha}{360^\circ} - \frac{\sin\alpha}{2\pi}\right]$
$R = \frac{A}{P}$	$p = \pi d\left(\frac{\alpha}{360^\circ}\right)$
$= \frac{d}{4}$	$r = \frac{D}{4}\left[1 - \frac{\sin\alpha\,(360)}{2\pi d}\right]$

$$\boxed{S = \frac{R}{r} \times S}$$

in %.

ASP

$$V = V_1\left[\frac{100 - P_1}{100 - P}\right]$$

capacity of digestion tank $= \cancel{V = \frac{V_1 + V_2}{2}}\,t$

$$V = \left[V_1 - \frac{2}{3}(V_1 - V_2)\right]t + V_2 T$$

(21) SEPTIC TANKS

DELTA
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Formulas

Sewage

Max D flow = $2 Q_{avg}$

Max Hourly " = $1.5 \times Q_{max}$
$= 3 \times Q_{avg}$

$$Q_{max} = \frac{18 + \sqrt{P}}{4 + \sqrt{P}} Q_{avg}.$$

$$Q_{min} = \frac{2}{3} Q_{avg}$$

Q_{min} hourly $= \frac{1}{2} \times Q_{min}$
$= \frac{1}{3} Q_{avg}$

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

Manning: $V = \frac{1}{n} r^{2/3} S^{1/2}$

$$\boxed{Q = AV}$$

Design guide

① Screens Assume speed = 0.8 m/s

	coarse	medium	fine
Spacing	>50mm	6 – 50mm	1.5 – 3
collects	6 L of solids per ML of sewage	30 – 90 L	

1 cm bars with 6cm spacing
Angle = 60°

② Grit chamber.

For 0.2mm partical size, v_H = 0.11 – 0.25 m/s

General, v = 0.25 – 0.3 m/s

Depth = 1 – 1.8 m/s

Detention time = 40 – 60 s

X section = D×B

③ Sedimentation tank

Depth = 2.4 – 3.6 m (usually 3)

Time = 1 – 2 hrs (1 ideally)

Length = 4 – 5 times (width)

OL = 40K – 50K L/m²/day

② methane " : conversion into CH_4 & CO_2

Closed systems that generate foul odour.

$$\eta' = \frac{100}{1 + \frac{0.0044}{\eta}\sqrt{\frac{\gamma'}{V'F}}}$$

Recirculation

$$F = \frac{1 + R/I}{1 + 0.1(R/I)}$$

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

γ → Total OL

V → filth volume in m^3

② Methane " : CH_4 & CO_2

Closed systems that generate foul odour.

(2) SEPTIC TANKS

$d < 0.1$

$$v_H = 418(S_s - 1)d^2\left(\frac{3T+70}{100}\right)$$

d b/w 0.1 & 1mm

$$v_H = 1.8\,gd\,(S_s - 1)$$

$d > 1mm$

$$v_H = 418(S_s - 1)d\left(\frac{3T+70}{100}\right)$$

$$\text{discharge} = \frac{\text{volume}}{\text{time}}$$

$$\boxed{t = V/Q}$$

$$t = \frac{d^2(0.011d + 0.785h)}{Q}$$

TF

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

$u \Rightarrow OL$

$$HL = \frac{Q}{Area}$$

$$OL = \frac{BOD_5}{Vol.}$$

(6) ASP

~~OL = 40,000 L/m²/day~~

~~depth = 2.5m~~

MLSS	1500 - 3000 mg/L
F/M	0.4 - 0.2
HRT	4-8 hrs
VL/OL	300 - 700
Sludge age	5-15 days
$\frac{Q_R \text{ (Return sludge)}}{Q \text{ (Influent ")}}$	0.25 - 0.5
Air reqd per kg of BOD5	40 - 100 m³
kg of O₂ required per kg of BOD removed	0.8 - 1.1

③ Acid fermentation: break down of complex OM into acids & alcohol.

④ Methane " : conversion into CH_4 & CO_2

Good systems that generate foul odour.

⑦ SEPTIC TANKS

⑤ Digestion tank

dia = 3-12 m

~~trapezoidal slope~~ = 1:1 | 1:3 (H : V)

depth = 6 m

capacity = 21 - 61 l/capita

Digestion period = 1 month (30 days)

Amount of sludge gas = 14-28 l/c/d (usually 17)

Circumference to find dia

Assume SG = 1.02
density = 1020 kg/m3

M.C = 95% can be assumed

T. Removed in Sedimentation 65%

★ can be circular or rectangular

width = 6 m (gen)

v_H = 0.3 m/min

Area of X section = B X Depth

④ Trickling filter.

	Conventional	high rate
HLR	22-44 Ml/ha/d	110-330
OLR	900-2000 kg/Ha-m/d	6K-8K
Depth	1.6-2.4	1.2-1.8
size of filter media	25-75 mm	25-60 mm

for general

Depth = 1.5 m

OLR = 1500 kg/ha-m/d

d = 40 m

★ circular

★ can be circular or rectangular

width = 6 m (gen)

v_H = 0.3 m/min

Area of X section = B X Depth

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into acids & alcohol.

③ Methane " : conversion into CH_4 & CO_2

Closed systems that generate foul odour.

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(1) Preliminary
(2) Primary
(3) Secondary
(4) Tertiary

① Preliminary: Large suspended OM is removed

Screening	Grid chamber	Detritus tank
↓	↓	↓
O	IO	Oil

Screening: Trap & remove floating matter
Speed of waste water not > 0.8 – 1m/s

(i) Coarse screen: Racks

Spacing → 50mm or more of sewage
collects about 6L of solids per ML ~~per do~~

(ii) Medium

Spacing → 6 – 50mm
collect 30 – 90L

→ 30 – 60°
→ Rectangular shape usually
→ Bars of steel

(iii) fine
→ 1.5 to 3mm
→ get clogged often
Brass or Bronze plate or wire net

Good Write

generate fecal

(21) SEPTIC TANKS

(7) Imhoff

Detention time 2-4hrs

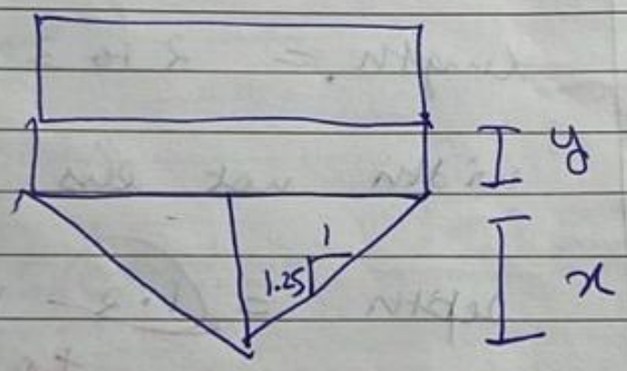
velocity not > 0.3 m/min

SL not > 30,000 l/m²/day

Length not > 30m

L : width = 3 to 5

Total depth = 9 to 11



off depth = $\frac{x}{2} + y = 2.2m$

(2) Methane : conversion into CH_4 & CO_2

closed systems that generate foul odour.

(2) SEPTIC TANKS

(6) Septic tank

Detention time = 12-36 hrs (12 usually)

Removal intervals = 6-12 months (not > 3 yr)

capacity: All : 90 - 150 l/c/d
only : 40-70 l/c/d

Rate of sludge accumulation = 30 l / person / year

Length = 2 to 3 width

width not less than 90 cm

Depth = 1.2 - 1.8 m
+0.3 m

Assume 80% supply is WW

into acids & alcohol.

(20) methane .. : conversion into CH_4 & CO_2

closed systems that generate foul odour.

(21) SEPTIC TANK

$\frac{Q}{BH} = \frac{Ql}{BHL} = \frac{Q}{A} = \frac{1}{t}$ $Qt = A$ $Q = A$

extended

Q 253

$d = 0.2\,mm$

$S_s = 2.65$

settling velocity (vertical) $= 0.016 - 0.022\,m/s$

Flow velocity (horizontal) $= 0.3\,m/s$

wastewater flow $10,000\,m^3/day$

$$Q = \frac{10,000}{24 \times 60 \times 60} = 0.115\,m^3/s$$

$Q = AV_h$

$A = 0.39$

Assume depth $= 1m$

Breadth $= 0.39m \approx 0.4$

Depth $= 1 + 0.3 + 0.5$ freeboard

0.3 depth above drained bottom

$$\boxed{V_s = \frac{d}{t}}$$

$$t = \frac{1}{0.02} = 50\,s$$

length $= V_h \times t = 0.3 \times 50\,m$

Good Write

anaerobic bacteria decompose OM

Involves

① Acid fermentation: break down of complex OM into acids & alcohol.

② Methane " : conversion into CH_4 & CO_2

Closed systems that generate foul odour.

(2) SEPTIC TANKS

> Primary ...

DATE: / /
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> Comminutors : mechanical device which breaks large solids to size of 6mm

> We incinerate the waste collected on screens.

> Dumping process of solid waste disposal on land/sea.

Grit chamber. 1 channel/basin used to remove inorganic particles with S_G about 2.65

for particle size 0.2 m, horizontal velocity is 0.11 to 0.25 m/s
⊙ critical scouring velocity.

General velocity = 0.25 - 0.3 m/s
Depth = 1 - 1.8 m
Detention time = 40 - 60 s

$$v_H = 3 \text{ to } 4.5\sqrt{g d_{mm} (S_s - 1)}$$

$$l = v_H \times t$$

Good Write

Q 9.1 (a+b)

60 ML / day

$= \frac{60 \times 10^6}{10^3} = 60 \times 10^3 \ m^3 / day$

$= \frac{60 \times 10^3}{24 \times 60 \times 60} = 0.694 \ m^3/s$

Assume, Speed = 0.8 m/s

$\boxed{Q = AV}$

Net area $= \frac{0.694}{0.8} = 0.87$

rectangular steel bars have width 1 cm placed at 5 cm dist

gross area $= 0.87 \times \frac{6}{5} = 1.04$

Assuming placed at 60°

$\frac{1.04}{\sin 60} = 1.24$

> Depth 2.5-4m
> Photosynthesis reduces organic matter & anaerobic bacteria decompose O.M.

Involves
① Acid fermentation: break down of complex OM into acids & alcohol.
② Methane " : conversion into CH_4 & CO_2

Closed systems that generate foul odour.

depth → 3.4 - 3.6 (not > 3m)

Time = 1-2 hrs (1 usually)

length = 4-5 times width

width → generally 6

Horizontal flow = 0.3 m/min

$$\boxed{\text{discharge} = \frac{\text{volume}}{t}}$$

$t = V/Q$

for circular

$$t = \frac{d^2 (0.011d + 0.785h)}{Q}$$

273

Q MDD = 12 ML/day

Sewage demand = 80% of MDD (Assume)
= ~~0.8 ML/L~~ 9.6 ML/day

Assume time = 2hrs

$Q = \frac{9.6}{24} \times 2 = 800 m^3/hr$

$V_h = 0.3 m/min$

length = 0.3 × (2 × 60) = 36 m

Pg 16

anaerobic bacteria decompose OM

Involves

① Acid fermentation: break down of complex OM into acids & alcohol.

② Methane " : conversion into CH_4 & CO_2

Closed systems to ... down.

DATE:
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Formulas.

$V_h = \frac{Q}{BH}$

$V_s = \frac{Q}{BL}$ overflow rate / surface loading.

$d < 0.1\,mm$

$v_H = 418(S_s - 1)\,d^2\left(\frac{3T + 70}{100}\right)$

d b/w 0.1 & 1mm

stokes $v_H = 1.8\,g\,d\,(S_s - 1)$ ~~Newton~~

~~b/w~~ $> 1mm$ (Hazen's

$v_H = 418(S_s - 1)\,d\left(\frac{3T + 70}{100}\right)$

$V_s \rightarrow 40K - 50K\ L/m^2/day$ (w/o coagul)

$V_s = 50 - 60K\ L/m^2/day$ (with)

$V_s \rightarrow 25K - 35K$ (for secondary sedi. tank)

Good Write

> Depth 2.5 - 4m
> Photosynthesis reduces organic matter & anaerobic bacteria decompose O.M.

Involves
① Acid fermentation: break down of complex O.M into acids & alcohol.
② Methane " : conversion into CH_4 & CO_2

Closed systems that generate foul odour.

DATE:
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Skimming tank / Petties tank

> remove oil & grease
includes fats, waxes, soaps, fatty acid.

→ If they are not removed they form ~~orda~~ odorous scums on the surface of the settling tank or interfere with ASP & inhibit biological growth in trickling filter.

> In it air is blown through the bottom, which coagulates grease coming it to rise

Primary Treatment:

Sedimentation
→ can remove 30-35% of BOD from sewage

Intermittent St = stores sewage for certain period and help it in complete rest. (about 24 hrs)
→ Requires 30 - 36 hrs to be in working condition again

continuous flow type
→ flow velocity is reduced not at complete rest

Good Write

TF → uses microbes, to attached to a media to breakdown organic matter

① Wastewater flows through a DS onto a bed of media such as rock or ceramic

② The microbes attach to the the media form a biofilm.

③ As wastewater trickles through media microbes break down organic matter

④ Treated waste water collected at the bottom of filter & then discharged

Merits

> Require less land as rate of filter loading is high
> Remove 75% BOD & 80% SS
> simple, no skill supervision
> self cleaning
> Mechanical wear & tear is small
> flexible & withstand variety of loages.

Demerits

> head loss is high, making automatic dosing of filter necessary
> cost of construction ↑
> Primary treatment is must cant treat raw
> Poor no. of operational troubles: fly nuisance, odour, ponding trouble.

Good Write

Sedimentation with coagulation

Disadv

> Biological secondary treatment are complete, less difficult.

> kills useful bacteria, imp for digestion of sludge

> Cost of chemical

> Skill supervision & handling of chemicals.

> Adds to problem of sludge disposal

Adv

> lesser BOD

> less space

> faster

> controls eutrophication by killing P & K

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

$$= \underline{800}$$

Area of x section = B × D

Good Write

Circular

Final e in 2 stage.

$$n' = \frac{100}{1 + \frac{0.0044\sqrt{y'}}{n\sqrt{VF}}}$$

n → single stage.

Types of high rate TF

① Bio-filters

Depth : 1.2 - 1.5 m

OL : 9K - 11K of BOD

HL : 110 to 330 ML/day/ha

② Accelo

Depth : 1.8 - 2.4

Sand

③ Aero

More than 1.8

OL 11K - 12K kg/ha-m/day

HL not less than 150 ml/day

Good Write

(1) Anaerobic

> operates under anaerobic
> for extended range
> Depth 2.5-4m
> Photosynthesis reduces organic matter & anaerobic bacteria decompose OM

Involves
(1) Acid fermentation: break down of complex OM into acids & alcohol.

(2) Methane " : conversion into CH_4 & CO_2

... foul odour.

DATE:
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	Conventional TF / ordinary / Std or low rate TF	High rate TF
HLR	22 - 44 Ml/ha/d usually ~ 23	110 - 330 Ml/ha/d usually 220
OLR	900 - 2000 kg/ha-m/d	6000 - 8000 kg/ha-m/d
Depth	1.6 - 2.4 m	1.2 - 1.8
Size of filter media	25 - 75mm	25 - 60mm
cost	More	less, cost of operation
Method of operation	less flexible & less skilled supervision	more flexible & more ~~skilled~~ skilled operation is need
Quality of Sludge produced	Black, highly oxizied	Brown, not fully oxidized
Circulation	Not generally	Always.

Good Write

Design

Hydraulic loading rate
It is the quantity of sewage applied to the SA of the filter.

~~Discharge~~ hydraulic loading $= \frac{Q}{Area}$

Organic loading rate
→ Mass of BOD(s) per unit volume of the filter media per day. (M

$= \frac{BOD_5}{Area} = \frac{BOD_5}{Volume}$

efficiency

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

27 ppm
removes 50%
moisture content → 98%, find
sludge

$\frac{4.5 \times 275}{10^{-6} \times 10^{6}} = 1237.5$ kg/day

kg/day

ANAEROBIC STABILISATION UNITS

① Anaerobic stabilization Ponds :

> operates under anaerobic bacteria
> for untreated sewage
> Depth 2.5–4m
> Photosynthesis reduces organic matter & anaerobic bacteria decompose OM.

Involves
① Acid fermentation: Break down of complex OM into acids & alcohol.

② Methane " : conversion into CH_4 & CO_2

Closed systems that generate foul odour.

② SEPTIC TANKS

> Primary Sedimentation tank with extended detention time ;

12 – 36 hrs Commonly 12

> Produces gases like methane & RCC covers are used for odour & safety

① Find sewage

Sewage = 80% = 14,400 l/d

Involves
① Acid fermentation: break down of com into acids & alcohol
② Methane " : converted into CH_4 & CO_2
closed systems that generate foul odour

(2) SEPTIC TANKS

Oxidation Ponds:
→ Stabilization ponds are large, shallow basins uses to treat sewage
→ Natural processes allow bacteria & other microbes to break down waste

Adv
→ low cost
→ low maintenance
→ flexibility
→ suitability in hot, dry climate.

Dis
→ mosquito
→ Bad odour
→ Algal control

Oxidation Ditches
> Conventional activated sludge process, providing an aeration tank for longer retention time

Adv
→ cost effective
→ Reduced land use
→ Flexibility in construction

Dis
→ high operational complexity
→ limited depth

Anaerobic lagoons
> large shallow, ww treated anaerobically.
> OM broken down → CO_2 — CH_4
> used for high strength organic waste water

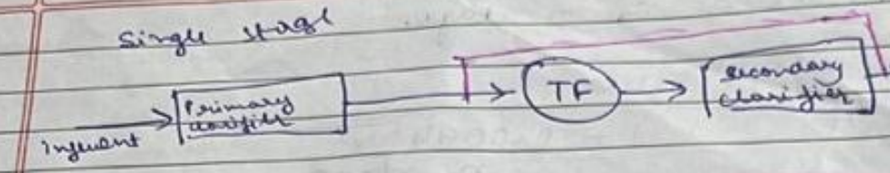
Good Write

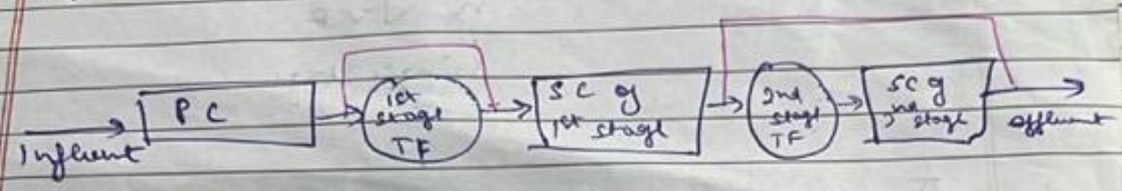
> Depth 2.5–4m
> Photosynthesis reduces organic matter & anaerobic bacteria decompose OM

Involves
① Acid fermentation: break down of complex OM into acids & alcohol.
② Methane " : conversion into CH_4 & CO_2

Closed systems that generate foul odour.

Single stage





Adv
> allows dosing of filter
> increases efficiency by equalizing
> & reducing load
> longer contact
> helps ↓ odor & fly nuisance by keeping influent fresh

F → recirculation factor
R → vol of sewage recirculated
I = vol of raw sewage

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

$$\eta\left(\text{single stage \& high rate TF}\right) = \frac{100}{1 + 0.0044\sqrt{\frac{Y}{VF}}}$$

Y = total organic loading in kg/day

$\frac{Y}{VF}$ = unit ", V = filter volume in ha-m

4.5 MLD
275 ppm SS
removal 50% SS

moisture content → 98%, find quantity of sludge

$$\frac{4.5 \times 275}{10^{-6} \times 10^{6}} = 1237.5 \text{ kg/day}$$

50% removed:

= 618.75 kg/day

→ make

Step 2: Detention time

Assume 24 hrs

Step 3: Capacity of sewage

$$14400 \times \frac{24}{24} = 14400 \text{ litres.}$$

Step 4: Capacity of sludge

Assume 30 l/head/year
Cleaning period = 1 year

$$= 30 \times 150 \times 1 = 4500 \text{ litres}$$

Step 5: Capacity tank = capacity of sewage + sludge

$$= 18900 \text{ litres}$$

$$1 \text{ litre} = \frac{1}{1000} m^3$$

$$= 18.9 m^3$$

Step 6: Assume depth find area of cross section

$$= \frac{18.9}{1.5} = 12.6 m^3$$

Step 7: Assume L : B ratio as 1 : 3 & find both.

$$L \times B \times (\text{Depth} + 0.3 \text{ m}) \text{ freeboard}$$

In case of secondary sludge
In case of " sludge

Pg 169 (author book) Q 3.16

4.5 MLD
27.5 ppm SS
removal 50% SS
moisture content → 98%, find quantity of

1237.5 kg/day

DELTA
Date / /
Pg No. 3

~~(ii) Inlet & outlet baffles.~~

Design help guide.

1) Detention period	12 - 36 hrs usually 24 hrs
2) length to width ratio	L = 2 to 3 (width)
3) width	not less than 90 cm
4) Depth	1.2 - 1.8 m add 0.3 m freeboard at last
5) Capacity (a) only water closets (b) All	 40 - 70 l/h/d 90 - 150 l/h/d
☆ Always Assume sewage / waste water as 80% of supply.	
6) Rate of sludge deposition	30 l/c/year

Q Pg 393 / 209
Design for 150 people with 120 l/hd

= 150 × 120 = 18,000 litres/d

help
(1)
d
ge

Sewage = 80% = 14,400 l/d

Raw sludge → collected in primary settling tank.

Raw sludge, water content = 95% → 5 litres of water in 100 l of sludge

In case of secondary sludge from TF = 96-98%
In case of " sludge from ASP = 98-99%

Pg 169 (online book) or 316

4.5 M2
27 Sppm SS
removes 50% SS

- Include inlet, outlet & scum retention systems

Maintenance:
> Sludge removed at intervals (6-12 months) → Never more than 3 yrs
> Disposal involves drying or subsurface irrigation.

Designed based on detention periods & Volume of sludge expected over the operational period.

(i) Capacity: Volume of liquid which can be accomodated

Only water closets : 40-70 l/c/d

Sullage (all) : 90-150 l/c/d

Rate accumulation of sludge recommended = 30 l/person/year

Min Capacity for 8-10 people

Only water closets : 1400 litres

All liquid : 2250 litres

A freeboard of 0.3 - 0.5 m

275ppm SS
remove 50% SS

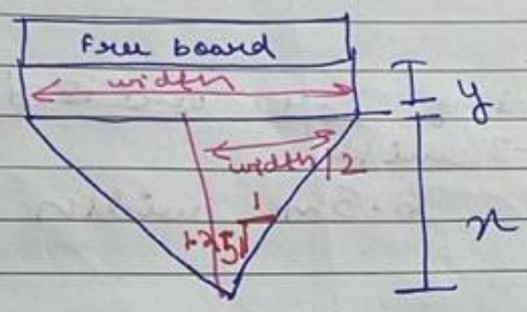
Moisture content → 98%, find quantity of sludge

$$\frac{4.5 \times 275}{10^{-6} \times 10^{6}} = 1237.5 \text{ kg/day}$$

Step 1 : Total sewage ~~per day~~
Step 2 : Detention time & find capacity.
Step 3 : Assume eff depth = 2.2 m

Area of cross section = $\frac{\text{capacity}}{\text{depth}}$

Step 4: Assume L-B ratio as 3 or 5 & find L & B.



$$\text{eff depth} = y + \frac{x}{2}$$

Step 5: Check for length
Step 6: Check for velocity = L/detention period

Step 5: Surface loading = $\frac{Q^{\text{sink}}}{BL}$ (m)

Step 6: find x

$$x = \frac{\text{width}}{2} \times 1.25$$

Step 7: find y

$$y = \text{eff width} - \frac{x}{2}$$

Design consideration

(a) Sedimentation Chamber

Rectangular

(a) Retention time : 2-4 hrs
usually 2

(b) Check velocity not more than 0.3m/min

(c) " Surface loading not exceed 30,000 lpm²/day
max 45

(d) length not exceed 30 m

(e) L : width ratio 3 to 5

(f) Total depth = 9 to 11 m

Sedimentation chamber = 3 - 3.5 m
freeboard = ~~45 cm~~ 0.45m

Assume eff. depth as 2.2 m

(b) Digestion chamber

Designed for min capacity : 57 l / capita

(c) Gas vent / Scum chamber :
> 25 - 30% of area of the horizontal projection of digestion chamber
> Atleast 60 cm width

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$$\frac{4.5 \times 275}{10^{-6} \times 10^{6}} = 1237.5 \text{ kg/day}$$

50% removed:

$1237.5 \times 50\% = 618.75$ kg/day

The waste out of the septic tank is like effluent of a sedimentation tank with large amt of OM & high BOD
200-250 100-200

disposed using
1. Soil absorption system
2. Biological filters
3. upflow anerobic filters

IMHOFF TANK

> improved septic tank
> Separates sludge from sewage.
> Designed by Karl imhoff

1. Double chamber rectangular tank
   (a) sedimentation tank for sewage
   (b) lower: Digestion chamber for sludge digestion

2. Gas vent :
   - scum chamber
   - for CH_4

3. Neutral zone
   - 45 cm clear zone

sludge collected in a inverted cone hopper.

Imhoff tanks

Advantages	Disadvantages
Combines benefits of septic & sedimentation tank	Depth issues: high depth increases construction cost & uneconomical in rocks areas
Suitable for small treatment plants; economical	May emit offensive odors if not operated properly
Requires minimal attention for sludge removal	Scum foaming may allow solids to escape into effluent, degrading quality
Reduces solids by 60-65%, BOD by 30-40%.	Unsuitable for large plants; obsolete for areas

CSAT

DOSU

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and: 0.75 kg/day make

Septic tank.

Advantages	Disadvantages
① ease of construction: easy to built, minimal maintenance, no skill supervision	Risk of malfunction ~ leading to foul, dark & noxious effluent
② cost effective (for rural & semi)	large size required to serve larger population
③ Efficiency (in ↓ SS & BOD)	Gas leakage (eg CH_4) ~ odour & pollution
④ Reduces sludge vol (80% by, 30% by weight)	sludge maintenance → cleaning, removal & disposal
⑤ Best for isolated area.	unpredictable performance: operation may not always be uniform

CCERI

22 MU

~~Add free board to y~~

Depth = y + x + free board
= 0.45 m

Design of ~~Gas vent~~ ~~Design~~ Digestion chamber

Assume the capacity as : 40 L/capita

Capacity = Population × 40

Step 8 :

Considering 3-4 ~~units~~ compartments or 8-8 units with 6.5m width

Step 9 :

Capacity of each = $\frac{\text{Capacity of digestion}}{8}$

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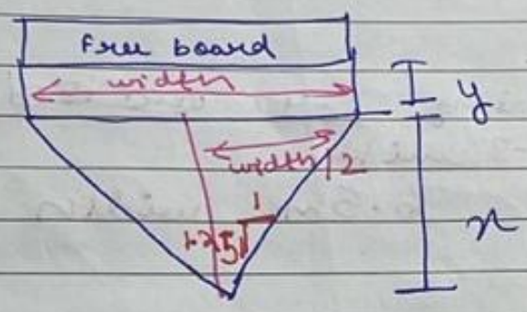

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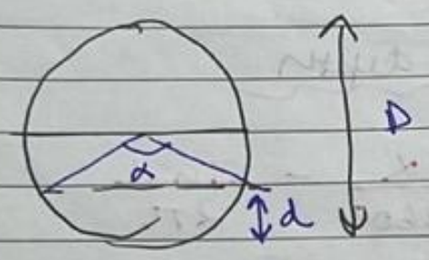
Manning's

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

n = manning coeff's.

Design of circular sewer



When sewer is running full

$$A = \frac{\pi D^2}{4} \qquad P = \pi D$$

depth at partial flow

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

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

Moisture content → 98%, find quantity of sludge

$$\frac{4.5 \times 275}{10^{-6} \times 10^{6}} = 1237.5 \text{ kg/day}$$

50% = 618.75 kg/

Chezy formula

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

C = chezy's constant
V = velocity in m/s

r = hydraulic mean radius (depth) of channel

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

where a is area
p is wetted perimeter.

For circular full running sewer

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

S = hydraulic gradient or slope

$$\boxed{Q = AV}$$

Moisture content → 98.

daily

$\frac{4.5 \times 275}{10^{-6} \times 10^{6}} = 1237.5$ kg/day

...used:

18.75 kg

Date / /
Pg No. 1

Sewage

Max daily flow = 2x Avg daily flow → not 1.8

Max. hourly flow = 1.5 x Max daily flow

= 3 x Avg daily flow

$$Q_{Max} = \frac{18 + \sqrt{P}}{4 + \sqrt{P}} Q_{avg}$$

Population in thousands

(Min daily flow)

$$Q_{min} = \frac{2}{3} \times Q_{avg}$$

Min hourly flow $= \frac{1}{2} \times Q_{min}$

$= \frac{1}{3} \times Q_{avg}$