Wastewater

treatment of sewage.

Sewage can be treated in different ways

1. Preliminary treatment
2. primary treatment
3. Secondary treatment
4. Biological treatment
5. complete final treatment

1) Prelim

→ consist solely in separating the floating material like dead animals, tree branches, wood pieces etc

→ removing the oils and greases.

→ BOD
 → ↑ → Ganda paani
 ↓ → clean

this treatment reduces the BOD of the wastewater by about 15-30%.

process

1. Screening: for removing floating papers
2. Grid chamber: detritus tank

for removing grit → dust particles

③ Skimming tank :
→ removing oil and grease

② Primary treatment

→ consist in removing large suspended organic solid
→ Its done through sedimentation.
→ 60% BOD removed
→ The effluent from primary treatment often contains a large amt of organic material and has a high BOD
→ prelim + prim (done tg. together)
→ digestion tank, incineration.

③ Secondary treatment
↓
Biological decomposition.
↓
aerobic / anaerobic
→ aeration tank
→ oxygen pond
→ Activated sludge
→ Septic tank

→ The effluent from the secondary biological treatment will usually contain a little BOD (5 - 10% of 0.4)
↓
to remove
use final treatment / tertiary treatment

④ final treatment
↓
Bacteria removal

→ To kill the Pathogenic bacteria
↳ coliform → can be measured
↳ pathogenic
↳ stable
cannot be measured

→ chorination

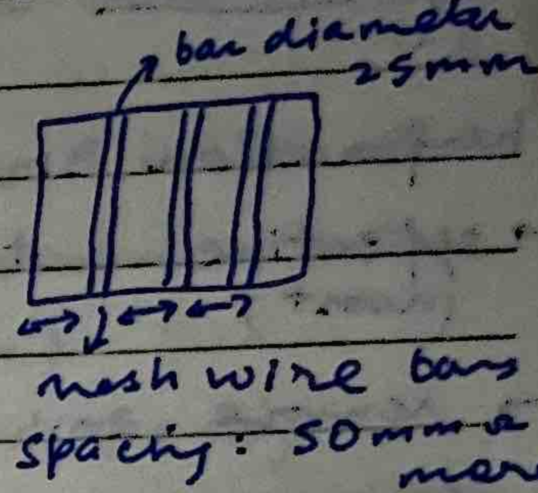
Screening
↓
to remove big particles.

Types of screen.
① coarse screen
② medium
③ fine

① Coarse screen

(Racks)

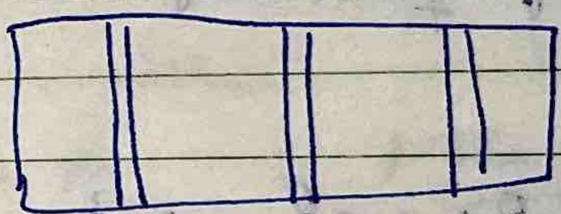
→ large floating material removal from sewage

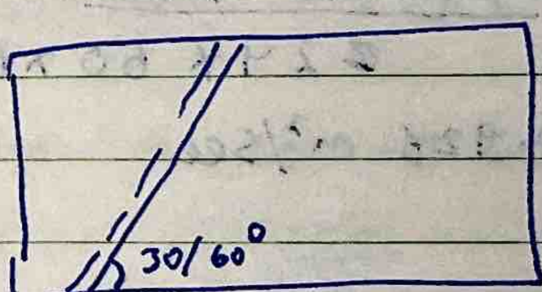


② Medium screen

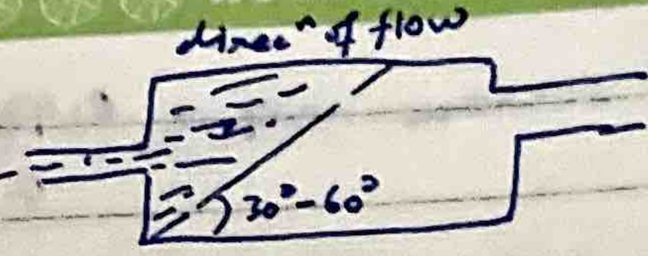
→ 30-90 L of material per million litre of sewage

→ spacing b/w bar : 6-40mm





3-6 :



water reduction after passing through screen is called head loss

$$\boxed{\text{Head loss} = 0.0729(v^2-u^2)}$$

velocity above the screen

velocity through the screen when opening get half clogged

Ques) peak flow of sewage = 60 mld

$$\frac{60\times10^3}{24\times60\times60}$$

$$= 0.694\ m^3/s$$

Assume 0.8 m/s
velocity through screen at peak flow is not allowed 0.8 m/s

Net area of screen openings req

$$= \frac{\text{peak flow}}{V \text{ thru screen}}$$

$\Rightarrow \dfrac{0.694}{0.8}$

$= 0.87\ m^2$

net area of screen opening

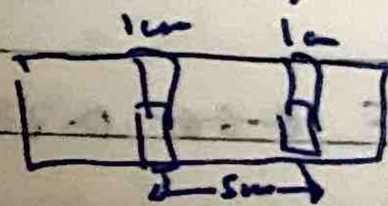
assuming that steel bars in screen having 1cm width and placed at 5cm clear spacing, we have

The gross area of the screen required

$5cm \rightarrow 0.87$

$6cm \rightarrow \dfrac{0.87 \times 6}{5}$

$= 1.04\ m^2$



$5 + 1/2 + 1/2 = 6$

Assuming that the screen bags are placed at 60° to the horizontal

$A' = \dfrac{A}{\sin\theta}$

The gross area of screen req

$= \dfrac{1.04 \times 2}{\sqrt{3}}$

$= 1.2$

hence, a coarse screen of $1.2\ m^2$ area is required

The head loss through the cleaned screen and half cleaned screen

velocity through screen = 0.8 m/s

$6 \rightarrow 0.8\ m/s \rightarrow 6$

$5 \rightarrow \frac{0.8}{6}\ m/s \times 5$

$\longrightarrow$ velocity above the screen

$= ~~0.66~~\ 0.67\ m/s$

~~Velo~~ when the screen opening get half clogged then the velocity through the screen $= 0.8 \times 2 = 1.6\ m/s$

$$\text{head loss} = 0.0729\left((1.6)^2 - (0.67)^2\right)$$

$$= 0.153\ m$$

method 2

peak flow = 60 mld

$= 0.694 \ m^3/s$

velocity assumed = 0.8 m/s

Net area = $\cancel{0.69}$ $\frac{0.694}{0.8} = 0.87 \ m^2$

assume clear spacing = 5 cm

diameter of bar = 1 cm

net width = $\frac{0.87}{1} = 0.87$ m

no of opening = $\frac{0.87}{0.05} = \cancel{15}\ 17.4 \simeq 18$

$\left(\frac{\text{net width}}{\text{clear spacing}}\right)$

no of bars = 18 − 1 = 17 bars.

Internal

end bars = 2

total = 19

gross width of screen = (no of opening × clearspacing) + (no of bar × dia of bar)

$$= (18 \times 0.05) + (19 \times 0.01)$$

$$= \cancel{2.28}\ 1.09$$

Screen is inclined 60° with the horizontal

now length $= \frac{1}{\sin 60^\circ} = 1.15m$

Now Total gross area of a screen

$$= 1.09 \times 1.15$$

$$= 1.2 m^2$$

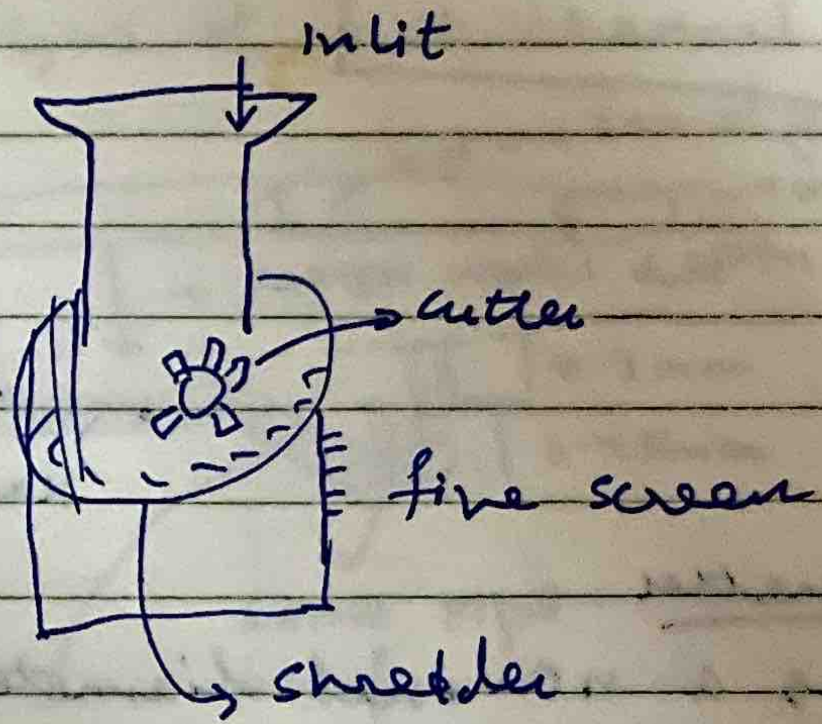
~~communication~~

comminutors / shredders

↓

Sort of like paper shredder

→ to break the largest sewage solid to about 6 ml in size when the sewage is screened through them



= outlet

The cutters mounted on ~~drum~~ drum, collect screening against a comb, until they are small enough through 5mm to 3 mm slot of the drum gross width of screen = (no of opening × clearspacing) + (no of bar × dia of bar)

$= (18 \times 0.05) + (19 \times 0.01)$

$= \cancel{2.28}\ 1.09$

Screen is inclined 60° with the horizon.

now length $= \dfrac{1}{\sin 60^\circ} = 1.15\,m$

Now Total gross area of a screen

$= 1.09 \times 1.15$

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communications

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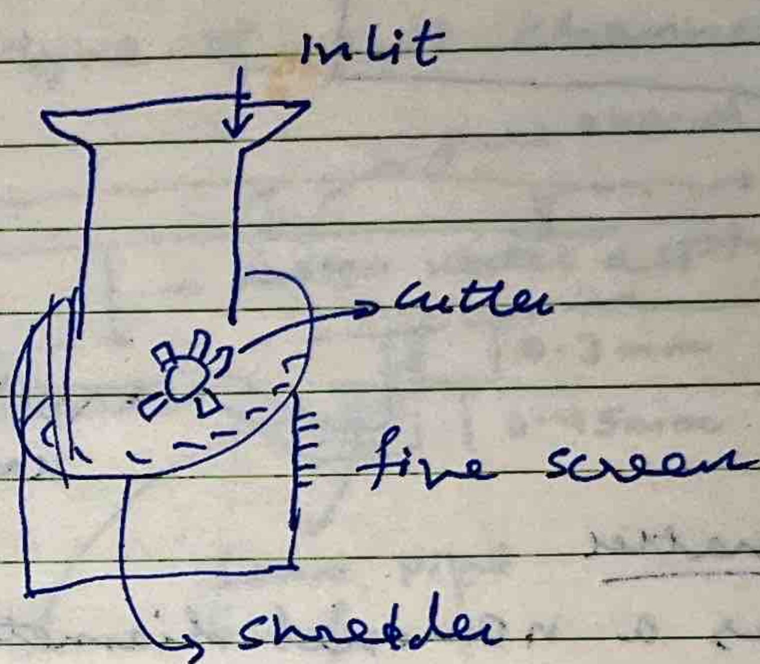
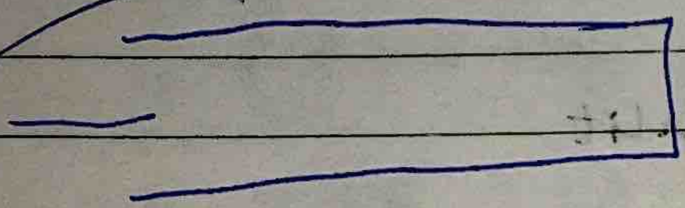


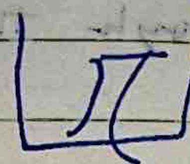
= outlet

The cutters mounted on drum, collected screening against a comb, until they are small enough through 5mm to 3m mm wide slap of the drum

Grit chamber

→ removes the inorganic grit such as sand, gravel





↓
opening

• vel → nam kanta hai

mineral matter that has a nominal diameter of 0.15 to 0.2 mm or more

generally grit chanels are designed to remove all particles of higher specific gravity of 2.65 or more.

$d = \cancel{2.76}\ 4.85 \times 1000$

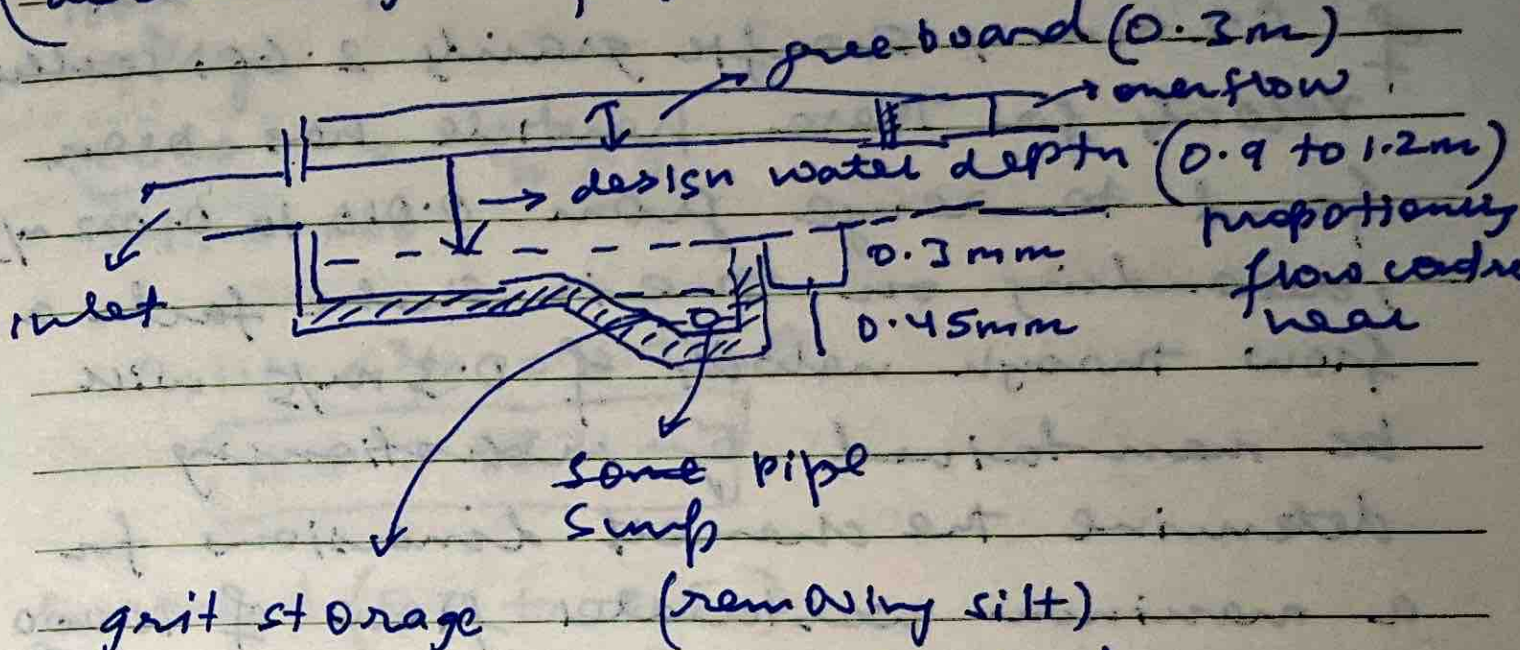
4850 → density
↓
kg/m^3

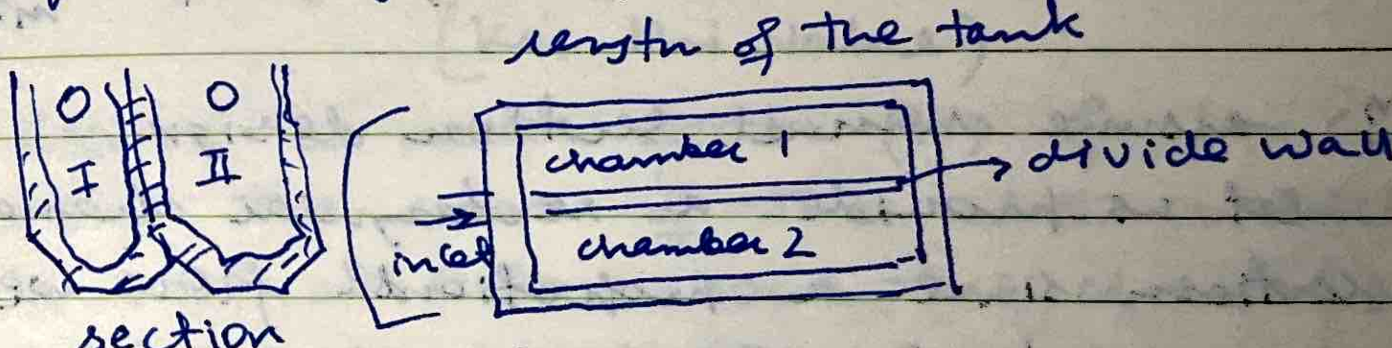
comminutor
↓
screen
↓
grit

having settling velocity of about 0.21 m/s at 10°C

(Rectangular and circular)

(horizontal flow grit chanel
aerated type of grit channel)

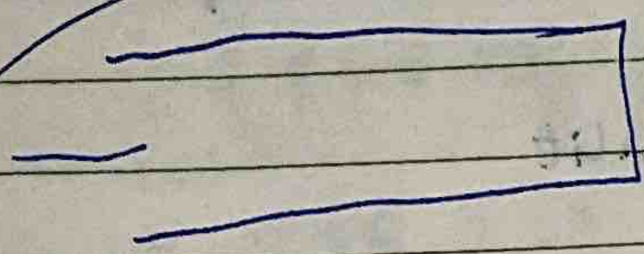


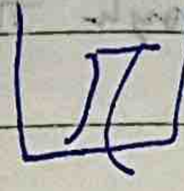


propotional flow wear

Grit chamber

→ removes the inorganic grit such as sand, gravel





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$\downarrow$

kg/m^3

commuitor

↓

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↓

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(Rectangular and circular)

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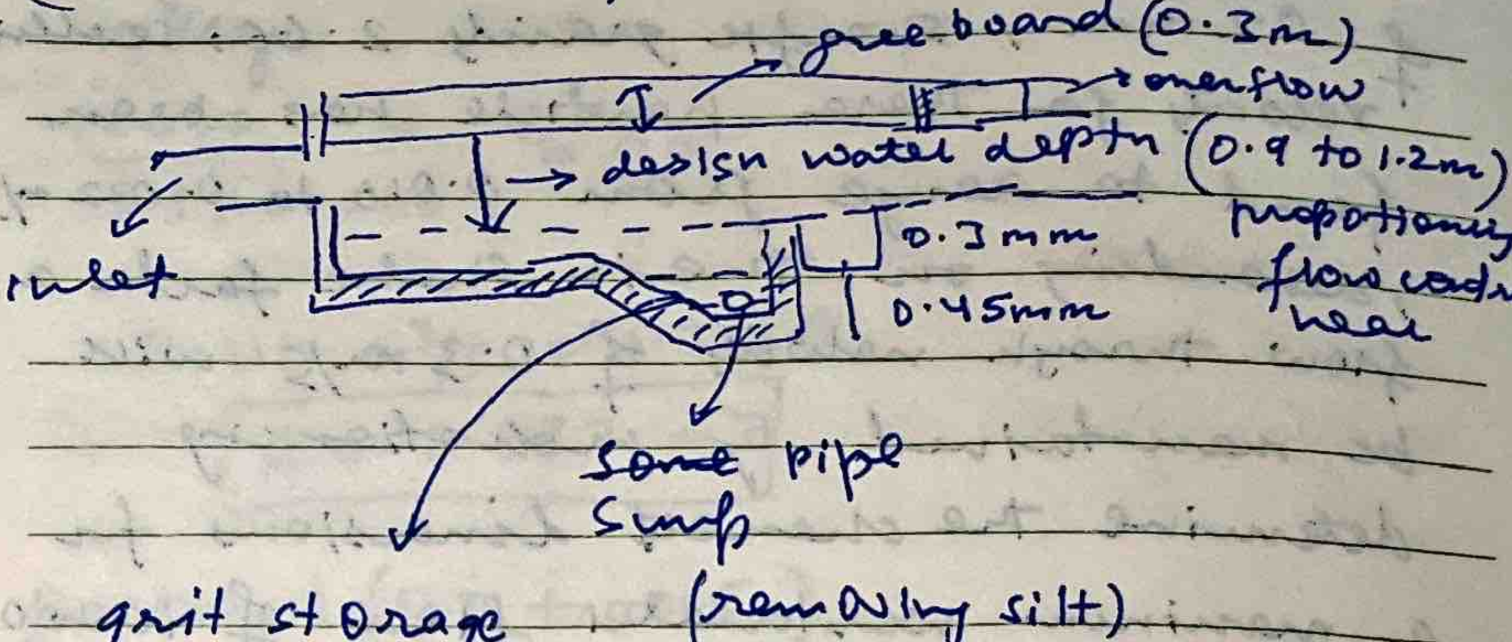
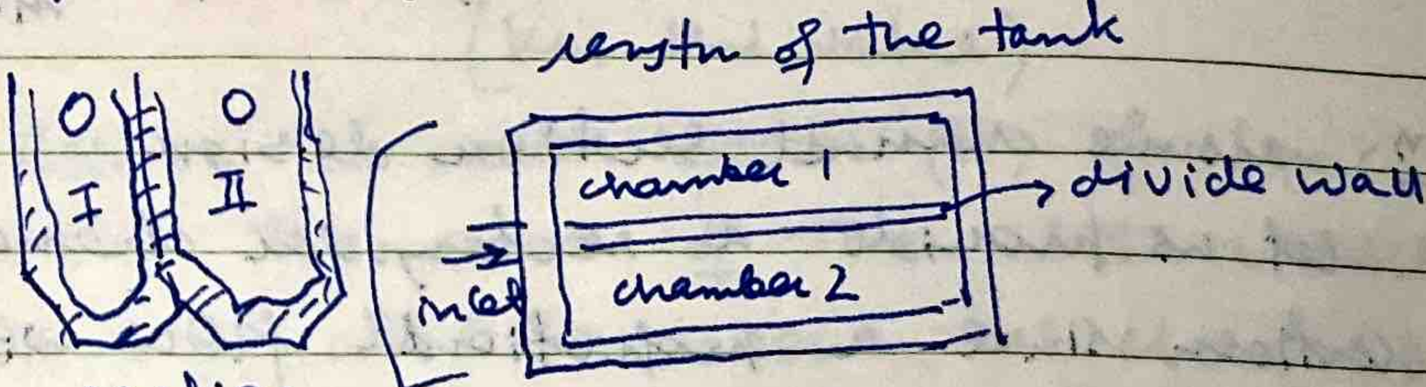
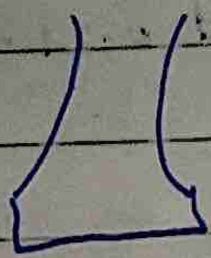
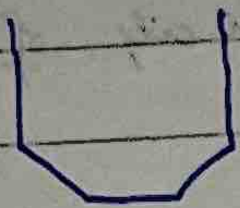




section

propotional flow wear





parabolic

paro

Q A Rectangular grit chamber is designed to remove particle with a diameter of 0.2 mm, specific gravity 2.66, settling velocity for these particle has been found to range from 0.016 to 0.022 m/s, depending on their shape factor a flow through velocity of 0.3 m/s will be maintained by proportioning determine the channel dimensions for a maximum wastewater flow of 10000 m³/day

soln) assume channel section design
let us provide a rectangular channel section since a proportional flow weir is provided for controlling velocity of flow

horizontal vel of flow = 0.3 m/s
(V_H)

settling = 0.016 m to 0.022 m/s
(V_s)

let V_s be 0.027 m/s

Area m^2

$$\underset{\substack{\downarrow \\ \text{discharge} \\ m^3/s}}{Q} = \overset{m/s}{Vel} \times Area$$

$$\underset{m^3/day}{10000} = V_H \times A$$

$$\frac{10000}{24 \times 60 \times 60} = V_H \times A$$

$$0.116 \ m^3/s = 0.3 \times A$$

$$\boxed{A = 0.387 \ m^2}$$

freeboard (0.3 to 0.5)

(Koi bhi value)

Assume a water depth (H) of 1m above the crest of the weir which is kept at 0.3m above the chanel bottom we have a width (B) of the basin

$$1 \times B = 0.387$$

↓

water depth

$$B = 0.387 m$$

↳ add crest and free board

overall depth (D) = water depth above the crest weir + 0.3 + 0.45.

$1 + 0.3 + 0.45$
$= \underline{\underline{1.75 m}}$

Now settling velocity = 0.02 m/s

$\underline{\underline{\downarrow V_S}}$ settling velocity = $\dfrac{\text{water depth in the basin}}{\text{detention time}}$

Detention time $= \dfrac{1}{0.02} = 50$ sec

length of the tank = $V_H \times$ det time

$= 0.3 \times 50$

$= 15 m$

$(L \times B \times D = 15 \times \underset{\downarrow \; 0.4}{0.387} \times 1.75 m)$

$\boxed{V = 10.5 m^3}$

(30% increase)

becoz of non idle flow

detritus tank

Q $\left\{ \begin{array}{l} Q = 20000\ m^3/day \\ V_H = 0.25\ m/s \\ V_S = 0.016 - 0.022 \end{array} \right.$

LBD
det time
midsem

Ex Detention period = 2 minute

length of tank = velocity × detention time

$= 0.2\ m/s \times 2 \times 60\ sec$

$= 24\ m$

since the peak flow is 3 times the dry weather flow provide 3 detrius tan each desig

The discharge passing through tank $= 400\ l/s$

$= \frac{400}{1000}\ m^3$

$= 0.4\ m^3/s$

cross sectional area required $= \frac{\text{discharge}}{\text{area velocity}}$

$\frac{0.4}{0.2} =$

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$1 + 0.3 + 0.45$
$= \underline{\underline{1.75\,m}}$

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Detention time $= \dfrac{1}{0.02} = 50$ sec

length of the tank $= V_H \times$ det time
$= 0.3 \times 50$
$= 15\,m$

$\left(L \times B \times D = 15 \times \underset{0.4}{0.387} \times 1.75\,m \right)$

$$\boxed{V = 10.5\,m^3}$$

(30% increase)

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$Q = 20000\ m^3/day$
$V_H = 0.25\ m/s$
$V_S = 0.016 - 0.022$

Q

CBD
det time
mdsem

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The discharge passing through tank = 400 l/s

$= \frac{400\ m^3/s}{1000}$

$= 0.4\ m^3/s$

Cross sectional area required = $\frac{\text{discharge}}{\text{area velocity}}$

$\frac{0.4}{0.2} =$

overall depth (D) = water depth above the crest weir + 0.3 + 0.45.

$1 + 0.3 + 0.45$

$= 1.75m$

Now settling velocity = 0.02 m/s

$\downarrow v_s$ settling velocity = $\frac{\text{water depth in the basin}}{\text{detention time}}$

Detention time $= \frac{1}{0.02} = 50$ sec

length of the tank $= V_H \times$ det time

$= 0.3 \times 50$

$= 15\ m$

$(L \times B \times D = 15 \times 0.387 \times 1.75m)$

$0.387 \rightarrow 0.4$

$\boxed{V = 10.5\ m^3}$

(30% increase)

becoz of non idle flow

detritus tank

$Q = 10000 m^3/d$

$V_H = 0.25$ m/s

$V_S = 0.016 - 0.022$

CBD

det time

midrem

Ex Detention period = 2 minute

length of tank = velocity × detention time

= 0.2 m/s × 2 × 60 sec

= 24 m

since the peak flow is 3 times the dry weather flow provide 3 detritus tank each desig

The discharge passing through tank = 400 l/s

$= \frac{400 \times m^3}{1000}$

$= 0.4 m^3$

Cross sectional area required = $\frac{\text{discharge}}{\text{area velocity}}$

$\frac{0.4}{0.2} =$

Ex) Design a suitable grit chamber cum detritus tank for a sewage treatment plant getting a dry weather flow from a separate sewerage system 400 l/s
Assume the flow velocity through tank 0.2 m/s and detention period of 2 min. Max flow may be assumed to be 3 times dry weather flow

(1-1.8) m
(water depth)
with a proportional flow

Assuming the water depth in the tank to be 1.2 m

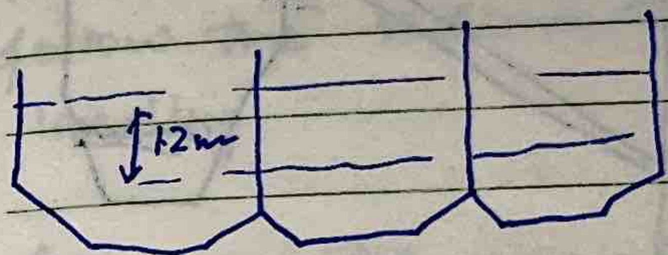
width $= \frac{\text{cross area}^{(2)}}{1.2} = 1.67\,m$

overall depth
free board + dead space
crest

$0.45 + 0.3 + 1.2 = \boxed{1.95\,m}$

At the top a freeboard of 0.3m provided and at the bottom dead space depth of 0.45m for collecting detritus tank may be provided

hence use a tank with 24m × 1.7 × 1.2m in size.



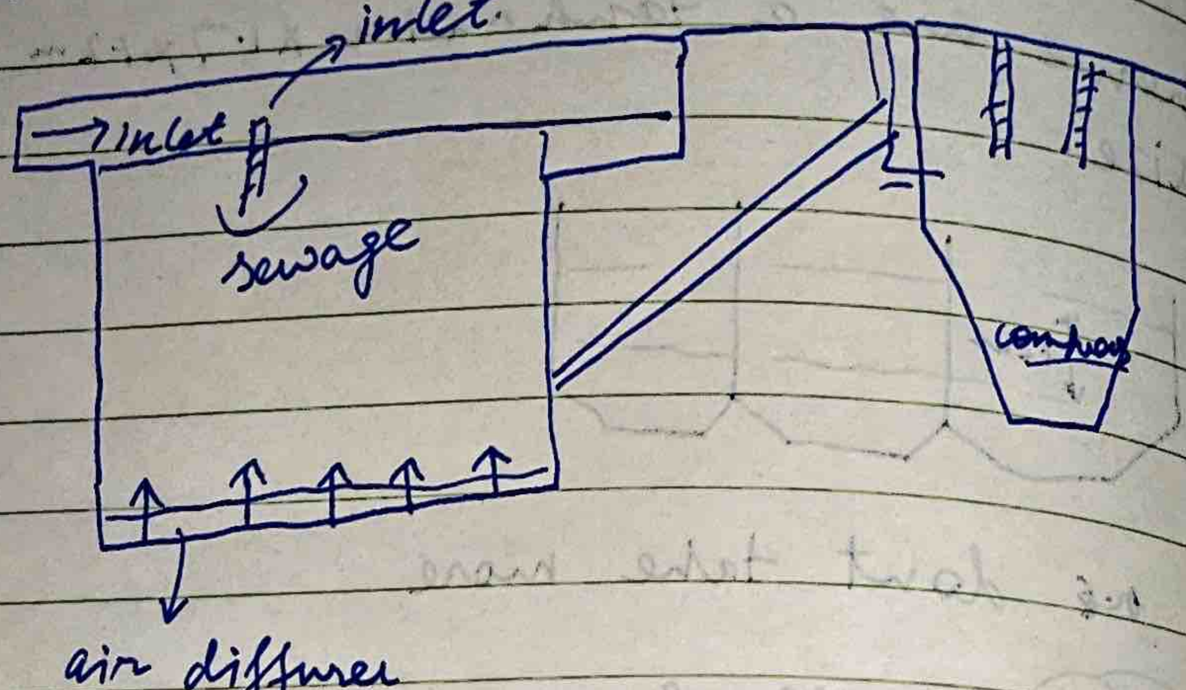
we dont take more

0.3
0.45 → assume

skimming tank

↓

for removing oil and grease from the sewage, done before the sedimentation tank.



Bubble form stiking component

oil and grease extract

We cheer for you in all th...

Sedimentation tank

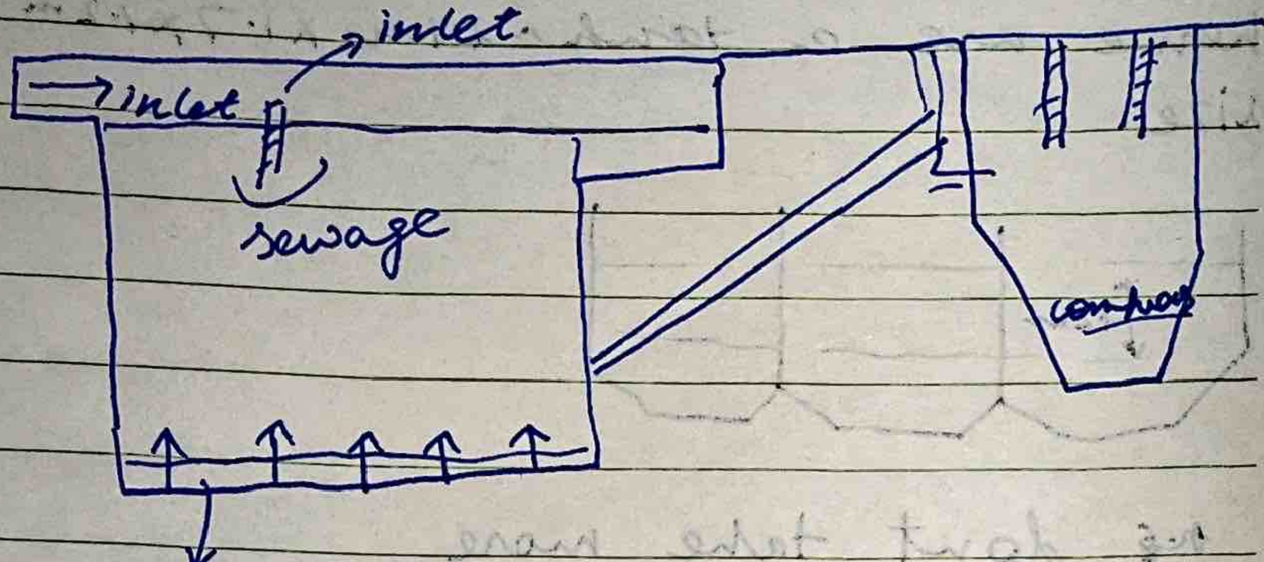
⇒
En. Design a circular settling tank unit for a primary treatment of sewage at 20 mil per day. Assume suitable value of detention period (~~hoohosting~~ assuming that trickling filter to follow the sedimentation tank) and surface loading

Assuming the normal detention period for such → $\boxed{\text{2 hour.}}$ → (only want 2 hour)

NOTE: The detention time for a sewage sedimentation tank usually ranges b/w 1-2 hours.)

The lower value of detention period (1 hr) in treatment is generally adopted when activated sludge process is used in se... treatment after the sedimentation skimming tank

for removing oil and grease from the sewage, done before the sedimentation tank.



Bubble form stilling component

oil and grease extract

Sedimentation tank

⇒

Qn. Design a circular settling tank unit for a primary treatment of sewage at 20 mil per day. Assume suitable value of detention period (~~[illegible]~~ assuming that trickling filter to follow the sedimentation tank) and surface loading

Assuming the normal detention period for such → $\boxed{\text{2 hours.}}$ → (only want 2 hours)

NOTE: The detention time for a sewage sedimentation tank usually ranges b/w 1-2 hours.

The lower value of detention period (1 hr) in treatment is generally adopted when the activated sludge process is used in secondary treatment after the sedimentation

→ when trickling filter are used as the secondary treatment → 2 hours.

→ detention time is greater ⇒ more efficiency

Surface flow:

trickling filter:

→ All activated sludge process not given take 2 hours.

overflow rate ranges b/w 40,000 to 50000 (normal values)
L/m²/day
↳ plain primary sedimentation tank

50,000 to 60,000
L/m²/day ↳ Sedimentation with coagulation.

25,000 to 35,000
L/m²/day ↳ Secondary sedimentation tank.

We cheer for you in all that you do!

$sol^n \rightarrow$

assuming detention period - 2 hours.
and surface loading = 40,000 L/m²/day.

Quantity of sewage for 2 hours

$20 mil \times 10^6 \longrightarrow 24$ hours
$? \longrightarrow 2$ hours

$20 \times 10^6 \times \frac{2}{24}$

$= 1.67$ million L

$1.67 \times 10^6 \times 10^{-3}$
$= \underline{\underline{1670\ m^3}}$
capacity of tank

surface loading $= \dfrac{Q}{\text{surface area of tank}}$

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

POCHACCO
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$$\underset{(L/m^2/day)}{40000} = \frac{20 \times 10^6 \text{ litre}}{\frac{\pi}{4} \times d^2}$$

$$4 \times 10^4 = \frac{\cancel{4 \times 10^4} \times d^2 \times \pi}{\cancel{20 \times 10^7} \times \cancel{4}}$$

$$d = \sqrt{\frac{20 \times 10^6 \times 4}{\pi \times}}$$

$$d = \sqrt{\frac{2000}{\pi}}$$

Now $d = 25.23$ m

effective depth = $\dfrac{\text{capacity}}{\text{area of cross section}}$

$$= \frac{1670}{\frac{\pi}{4}(25.23)^2}$$

$$= \frac{1670}{\pi \; 2000}$$

$= 3.34m$

hence use a settling tank with 25.23 m dia and 3.34 m water depth (with freeboard of 0.3m extra depth)

Ques) Design a suitable rectangular sedimentation tank provided with mechanical cleaning equipment for treating the sewage from a city provided with an assumed public water supply system, with a maximum daily demand of 20 million litre per day. Assume suitable value of detention p[eriod] and velocity of flow in the tank

Soln) Assuming that 80% of water supply to the city becomes sewage

Quantity of sewage required to be tre[ated] per day (MDD) = 80% of 20 000 000

$= \frac{80}{100} \times 20\ 000\ 000$

$$40000 = \frac{20 \times 10^6 \text{ litre}}{\frac{\pi}{4} \times d^2}$$
$(\ell/m^3/day)$

$$\cancel{4000} = \frac{4 \times 10^4}{20 \times 10^7} \times \frac{\cancel{d}}{4} \pi$$

$$d = \sqrt{\frac{20 \times 10^6 \times 4}{\pi \times}}$$

$$d = \sqrt{\frac{2000}{\pi}}$$

Now $d = 25.23\ m$

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

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$$= \frac{1670}{\pi \; \cancel{2000}\,500}$$

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Ques) Design a suitable rectangular sedimentation tank provided with mechanical cleaning equipment for treating the sewage from a city provided with an assured public water supply system, with a maximum daily demand of 20 million litre per day. Assume suitable value of detention period and velocity of flow in the tank

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Quantity of sewage required to be treated per day. (MDD) = 80% of 20 000 000

$= \frac{80}{100} \times 20\,000\,000$

$$40000 = \frac{20 \times 10^6 \text{ litre}}{\frac{\pi}{4} \times d^2}$$

$(L/m^3/day)$

$$4000 \cdot 4 \times 10^4 = \frac{\times \cancel{4}\ \pi}{20 \times 10^7 \times 4}$$

$$d = \sqrt{\frac{20 \times 10^6 \times 4}{\pi \times}}$$

$$d = \sqrt{\frac{2000}{\pi}}$$

Now $d = 25.23$ m

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

$$= \frac{1670}{\frac{\pi}{4}(25.23)^2}$$

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Soln) Assuming that 80% of water supplied to the city becomes sewage

Quantity of sewage required to be treated per day (MDD) = 80% of 20 000 000

$= \frac{80}{100} \times 20\,000\,000$

Now assuming detention period in the sewage sedimentation as 2 hours.

Capacity

Q 16 mil → 24 hrs

(Q) ? → 2 hrs.

$Q = \frac{16 \times 2}{24}$ mil = 1.33 milion L

$1.33 \times 10^{6} \times 10^{-3}$

1.33×10^{3} } to convert to mil

1330 ~~mle~~ m^3

Now Assuming that the flow velocity through the tank is 0.3 m/min (V_H)

The length of the tank req = Vel of flow × detention period

$(0.3 \times 2) \times 60$ → min

= 36 m

cross-sectional area of the tank req

$= \frac{\text{capacity of the tank}}{\text{length}}$

$= \frac{1330}{36}$

$= \cancel{36.95}$

$= 36.94 \ m^2$

Assuming the water depth in the tank (i.e effective length) $2.4 \rightarrow 3.6$

$= 3$

width of tank $= \frac{36.94 m^2}{3 m}$

$= 12.5 m$

→ dead space not required (∵ tank is provided mechanical cleaning are ...)

→ freeboard required (0.3 – 0.5) Range

No extra space at bottom is required for sludge zone ~~0.3~~ (assuming 0.5 in this c...)

overall depth = ~~3.45m~~ 3.5 m

Now assuming detention period in the sewage sedimentation as 2 hours.

Capacity

Q 16 mil $\rightarrow$ 24 hrs

(Q) ? $\rightarrow$ 2 hrs.

$Q = \frac{16 \times 2}{24}$ mil $= 1.33$ milion L

$1.33 \times 10^{6} \times 10^{-3}$

1.33×10^{3}

1330 ~~mL~~ m^3

to convert to mL

→ Now Assuming that the flow velocity through the tank is 0.3 m/min (V_H)

The length of the tank req = Vel of flow × detention period

$(0.3 \times 2) \times 60 \rightarrow$ min

$= 36$ m

cross sectional area of the tank req

$$= \frac{\text{capacity of the tank}}{\text{length}}$$

$$= \frac{1330}{36}$$

$= \cancel{36.95}$

$= 36.94\ m^2$

Assuming the water depth in the tank (i.e effective length) $2.4 \rightarrow 3.6$

$= 3$

$$\text{width of tank} = \frac{36.94 m^2}{3 m}$$

$= \underline{\underline{12.5 m}}$

→ dead space not required (∵ tank is provided mechanical cleaning arrangement)

→ freeboard required (0.3 – 0.5) Range

No extra space at bottom is required for sludge zone ~~0.3~~ (assuming 0.5 in this case)

overall depth = ~~3.45m~~ 3.5 m

hence, a Rectangular sedimentation tank with an overall size of : 36m × 12.5m × 3.5m can be used.

NOTE: → length to 4-5 times of width cannot exceed

→ width cannot exceed 7.5 m

→ effective depth (2.4 – 3.6)

Overflow rate assume ∵ width ×

instead of assuming the depth we may assume an overflow rate = 40 000 L/m³/day

$$\frac{Q}{BL} = 40000 \, L/m^2/day$$

$$\frac{16 \times 10^6}{40{,}000 \, Lm} \Rightarrow \boxed{BL = 400 \, m^2}$$

×

take rate 50 000 L/m³/day.

Now take sedimentation with coagulation
∵ sewage quantity more.

$\boxed{B = 7.407\ m}$

depth required
$\boxed{4.987}$
$\rightarrow > 3.6$

assume = 3.6 m

Ques) Public water supply 12 mil L/day

soln) assume 80% of 12 mil

$$\frac{8\cancel{0}}{10\cancel{0}} \times 12 \times 10^6$$

9.6 mil /L/ day.

detention period = 2hrs

$$Q = \frac{9.6}{12} = 0.8$$
$$= 800 m^3$$

hence, a Rectangular sedimentation tank with an overall size of : 36m x 12.5m x 3.5m can be used.

NOTE: → length to 4-5 times of width
cannot exceed

→ width cannot exceed 7.5m

→ effective depth (2.4-3.6)

Overflow rate assume ∵ width ~~X~~

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∵ sewage quantity more.

$\boxed{B = 7.407\ m}$

depth required
$\boxed{4.987}$
$\to > 3.6$
assume = 3.6 m

Ques) Public water supply 12 mil L/day.

Soln) assume 80% of 12 mil

$$\frac{80}{100} \times 12 \times 10^6$$

9.6 mil / L / day.

detention period = 2hrs

$$Q = \frac{9.6}{12} = 0.8$$

$= 800 m^3$

We cheer f

v_H

$= 0.3\ m/min$

$\text{length} = 0.3 \times 2$

$\frac{800}{36} = 2$

$\text{width} = \frac{22.22}{3}$

$=$

or yo

+60 = 36m

2·22 m² Area

= 7·407

= 0.3 m/min

length = $0.3 \times 2 \times 60 = 36m$

$\frac{800}{36} = 22.22\ m^2$ Area

width = $\frac{22.22}{3} = 7.407$

=

$V_H = 0.3$ m/min

length $= 0.3 \times 2 \times 60 = 36$ m

$\frac{800}{36} = 22.22$ m^2 Area

width $= \frac{22.22}{3} = 7.407$

=

We cheer for you in all that you do!