UNIT-III.

PRIMARY TREATMENT OF SEWAGE

Important Question:

prbm & comp:

01. Design of septic tank with dispersion
02. Design of screen chamber.
03. Design of grit chamber.
04. Design of sedimentation tank.

Theory

05. Grey water harvesting.
06. construction, operation & maintainance aspect of treatment unit.

2m

01. objectives of primary treatments.
02. unit operation & unit process.
03. onsite sanitation.
04. Advantages of septic tank.
05. Assumption.

Primary treatment of Sewage:

The treatment of sewage is carried out in different stages;

(i) preliminary treatment

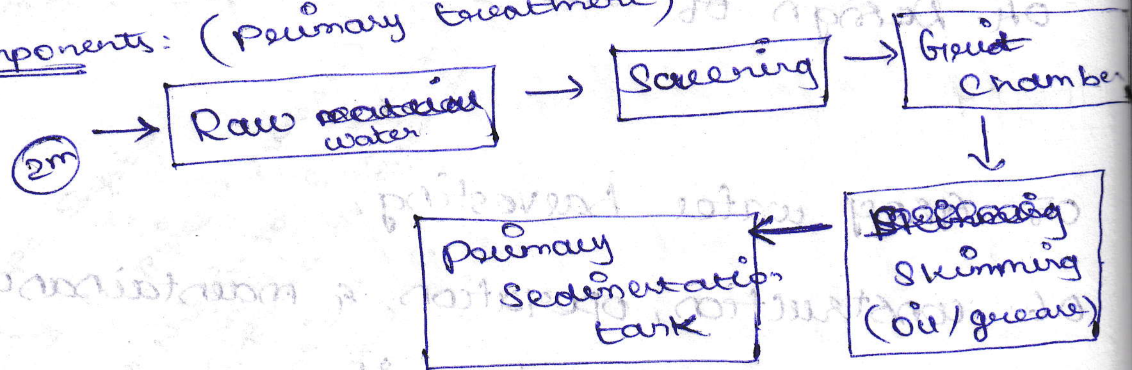
(ii) Primary treatment (physical & chemical)

(iii) Secondary treatment (Biological)

(iv) Advanced treatment (Disposal of sludge)

Components: (Primary treatment)

(2m)



Selection of treatment process:-

(2m)

Treatment process.

01. Unit Operation

Treatment in which the application of physical forces, predominates is known as unit operation.

(Eg: Screening, Sedimentation, Flowatation, filteration, heat transfer & drying)

02. Unit process

The type of treatment in which the removal of contaminents brought by addition of chemical (or) microbial activities is known as unit process.

(eg: Neutralisation, coagulation, disinfec

Biological unit process → Attached growth process.
→ Suspended growth process.

Suspended growth (Example)

Oxydisation pond, Aerated Lagoon's

Attached growth (Example)

trickling filter, Bio-tower, upflow filters.

Factors for Selection of treatment process:

*x*x*
(5m)

Selection of particular treatment plant depends on following factors.

→ Degree of treatment.
→ Availability of land at treatment site.
→ Topography of Land.
→ Availability of Suitable mechanical equipment.
→ Skilled person's availability.
→ Potential use of treated water.
→ Local Service & Support.

On-site Sanitation:-

(2m) The facilities, which are self contained within the site in contrast to sewerage system where, sewage is removes from site.

Onsite Sanitation technologies:-

- ✓ pit-Laterines.
- ✓ Composting toilet.
- ✓ Ecological Sanitation.
- ✓ Septic tank with disposal. } **
- ✓ Grey water harvesting

(13m) **Design of Septic tank.** **

~~It is the horizontal tank where the detention time of storage water is high,~~

Septic tanks are gerdeally provided area where sewer is not been layed & for the sanitary disposal of sewage from isolated communities. Schools, hospitals & other public institutions.

(2m) It may be defined as the Primary Sedimentation tank with horizontal continuous flow with longer deduction period of 12-36 hours, the digestion take place by anaerobic decomposition.

Due to this decommosition foul gases will be evolved in the tank. So tank is covered with high vent pipes for escape of gases.

This type of tanks directly at which raw sewage & removes 60 to 70% of dissolved matter from it.

Before disposing the effluent from tank secondary treatment is needed. The digested sludge from the tank is removed for the removal of 6-12 ~~years~~ months not exceeds 3 years.

Construction:

→ The tank is designed to prevent direct currents b/w tank inlet & outlet

→ The baffle walls are used to retain the ~~a~~ scum in the tank.

→ The holding of scum ~~free~~ freeze the effluent ~~of~~ to hold back odour. & create insulation ~~for~~ of heat for bacterial growth.

→ The tank is covered with RCC slab, man holes are provided for inspection & maintanance

Design consideration:

01. Capacity of the tank.

02. Free board.

03. Inlet & outlet baffle wall.

04. Deduction period.

05. Length to breadth ratio.

→ Min capacity of tank should be 2250 lit (for 8 - 10 persons)

→ 0.3 to 0.5 m, D = 1.3 to 1.8 m

→ 12 to 36 hours (24 hours)

→ L = 2 to 3 times width.

B (width) should not less than 90 cm

01. Design the dimensions of the ~~Spectic~~ Septic tank with small colony of 150 persons. With water supply at rate of 120 litres.

S.T = sludge + water
(30 lit)

Design process:

Quantity of water (Avg. water supply) = 120 × 150

= 18 000 lit/day.

Assume, 80% of flow as sewage

Avg. Sewage = 14,400 lit/day

Deduction flow is 24 hours.

$= 14,400 \times \frac{24}{24}$

Quantity of sewage water = 14,400 litres

Now, assume deposited sludge as 30 litres per capita per year. and assume period of cleaning as 1 year.

Volume of sludge = 150 × 30 × 1

= 4,500 litres

Total discharge (required capacity) = 14,400 + 4,500

= 18,900 litres

Capacity of tank = 18.9 m^3

Spectic tank for 19 m^3

Assume, depth of 1.2 m for Spectic tank.

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

$$= \frac{19}{1.2}$$

$$= 15.83 \ m^2$$

Assume $L:B = 3:1$ $(L = 3B \times B)$

$3 \times B^2 = 15.83$

$A = L \times B$
$A = 3B \times B$
$15.83 = 3B^2$
$15.83 = B^2$

B = 2.3 m

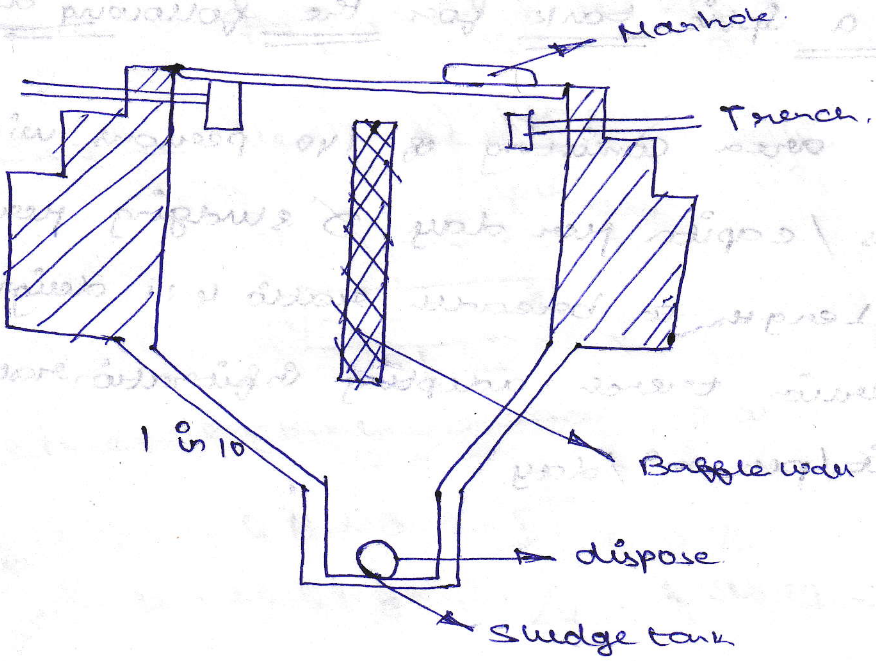
$L = 3B$

$\Rightarrow L = 6.9 \simeq 7$ m.

L = 7 m.

Provide ~~(...)~~ m^2 ~~dimension~~ $(7 \times 2.5 \times (1.5 + 0.5))$ m^3 freeboard for dimension of given popuation of 150 person's, ~~Spectic~~ Septic tank.

$(7m \times 2.5m \times (1.5+0.5)m)$



Disposal of Effluent from Septic tank.

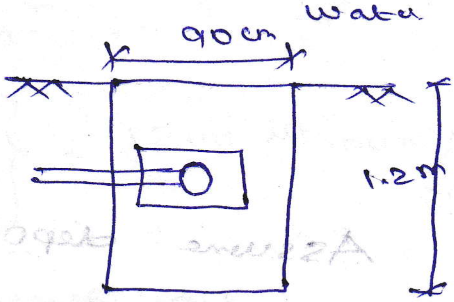
3 Methods :

- ✓ Soil absorption System.
- ✓ Biological filters.
- ✓ Up flow Anaerobic filter.

} Advanced method for treating Sewage water

→ Soil absorption System

- ✓ Soak pit
- ✓ Absorption trench.



Design a Septic tank for the following data.

01. An area consisting of 140 persons with 120 litres / capita per day. D sludging period = 1 year. Length to breadth ratio 4 : 1 design a dispersion trench adopting infiltration rate 1200 lit/per m^2/day.

Solution:-

Quantity of sewage water = 140 × 120

= 16,800 lit/day

Assume 80% of Sewage = 0.8 × 16,800

= 13,440 lit/day.

Assume 24 hours detention time of the tank.

$= \frac{13440}{24} \times 24$

= 13,440 litres.

Assume deposit sludge as 30 litres/capita per year.

Vol. of sludge = 30 × 140 × 1 = 4,200 litres.

Total required Capacity = 13,440 + 4200

= 17,640 litres

= 17,640/1000

= 17.64 m^3

≃ 18 m^3

Assume depth of 0.3 free board = 1.2 m.

$$\text{Surface area} = \frac{\text{Volume}}{\text{depth}} = \frac{18}{1.2}$$

$\therefore$ $\boxed{A = 15\ m^2}$

Assume, length to breadth ratio 4:1

$4B \times B = 15$

$B^2 = 15/4 = 3.75$

$A = L \times B$

$L = A \div B$

$\therefore B = 1.93\ m$ $\quad B = 1.93\ m$

$L = 4 \times B$

$\therefore$ $\boxed{L = 7.7\ m}$

Provide dimension of septic tank is

8 × 2 × 1.5 m

Design of soak pit,

Infiltration capacity of filter media } = 1200 lit/per m²/day

$$\text{Volume required} = \frac{\text{Vol. of tank}}{\text{Infiltration Capacity}}$$

$$= \frac{18}{1.2}\ m^3/day$$

$$= 15\ m^3$$

Assume, the depth of soak pit = 3 m

Surface area = Volume / depth

$= 15/3$

$\therefore$ $A = 5\ m^2$

$A = \frac{\pi}{4} (d)^2$

$d = 2.5\ m$

Design of dispersion trench:

$Q = 204/\sqrt{t}$

Design the absorption trench for 100 percent in 135 lit /per capita / day.

Time taken (t) = 3 min.

Total sewage water = 100 × 135

= 13,500

Max. Effluent discharge,

$Q = 204/\sqrt{t}$

$\therefore$ Q = 117.78 lit/perday/m²

Area of trench = $\frac{\text{Total Sewage water}}{Q}$

= 13,500 / 117.78

= 114.62 lit /perday

Using 0.7 m as bottom width.

Length of trench = 115 / 0.75

∴ L = 153 m

Provide 3 numbers of trench.

L = 153/3

∴ L = 51 m [for one trench]

Grey water harvesting :-

The waste water generated from wash basin, showers & bath are known as grey water.

Grey water can be recycled for gardening, irrigation, flushing, etc.,

Any water containing human waste is called as black water.

Elimination :-

The seperate sewer system that removes grey water & black water.

Purification System :-

Water recycling without purification

Water recycling with purification.

- ✓ Mechanical.
- ✓ Biological.

Applications of grey water :-

- ✓ Irrigation.
- ✓ Indoor reuse.

Primary treatment :

✓ Screening :-

The device with opening of uniform size & the screening unit may consists of parallel bars, rods, grating (or) wire meshes. Screens may be rectangular or circular.

→ To remove the floating matters of large size if not removed they will clog (or) damage the pumps, motors.

→ It is placed before the grid chamber.

Size of opening type :-

- ✓ Core Screen (spacing b/w screens are 40 mm greater)
- ✓ fine Screen (less than 6 mm)
- ✓ Medium Screen (6 - 40 mm)

According to movement:-

- ✓ Fixed Screen (Doesn't remove, permanently fixed)
- ✓ Moveable Screen (fixed, otherwise it may be open)
- ✓ Moving Screen (during operation it can be moving)

Design Consideration:-

Velocity of flow = 0.8 to 1m/sec

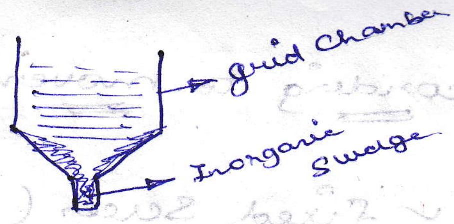
Slope is b/w is 30° to 60° (usually 45°)

Max depth = 1 m.

Deduction time = 0 mins.

Disposal of Screening:-

- ✓ Incineration (burn at high temp)
- ✓ Composting.
- ✓ Dumping.



Grit chamber:-

Grit chamber's are placed after the Screening chamber to remove inorganic particles such as sand, gravels, grit, egg shells, bones & other non-putresible (decay not done) materials that clog or damage pumps due to abrasion & prevent pumps & occumu in sludge digestors.

Types of grit chamber:-

Design.

01. Rectangular horizontal flow type
02. Detritus tanks.
03. Aerated grit chamber.
04. Square horizontal flow type
05. Vortex flow type.

Detritus tank.

It is a rectangular grit chamber designed to flow with smaller velocity 0.09 m/s & longer deduction period (3 - 4 mins) So has to seperate large amount of grit bus also some amount of organic matter that settles along with inorganic grit. This organic material

Seperated from grid by Control of currents in the tank, through baffle (partition wall) or by Control aeration of the flow through the tank.

The grit is removed by Scrapper mechanism

Q1. Design a suitable grit chamber cum for a sewage treatment plant getting a dry weather flow from Sewerage System of 400 lit/sec assume flow velocity through the tank as 0.2 m/sec & deduction period of 2 mins Max flow may be assume to be 3 times dry weather flow.

Given:

Discharge = 400 lit/sec

$= \frac{400}{1000} = 0.4$ m³/sec

Flow velocity = 0.2 m/sec

t = 2 min = 120 sec

(i) Length of the tank

$V = \frac{\text{Length}}{\text{time}}$ m/s

L = velocity × time

= 0.2 × 120

L = 24 m.

$Q = AV$

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

Max discharge = 3 x dry weather flow

= 3 x 0.4

$Q = 1.2\ m^3/s$

Since, ~~deep~~ peak flow is 3 times the dry weather flow provide 3 detritus tank.

$Q = Av$

$$C/s\ Area = \frac{Discharge}{Velocity} = \frac{Q}{v} = \frac{0.4}{0.2} = 2\ m^2$$

$\therefore A = 2\ m^2$

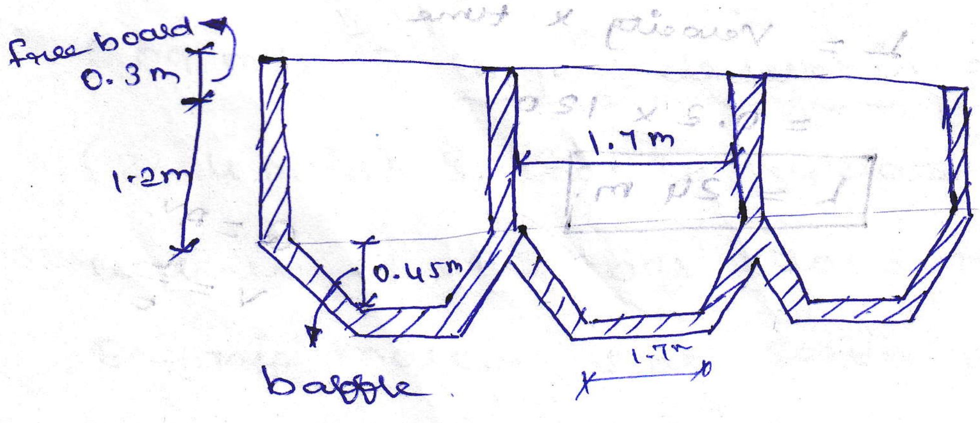
Assume, $d = 1.2\ m$

$$Width, = \frac{Area\ of\ C/s}{depth} = \frac{2}{1.2} = 1.66$$

$\therefore b = 1.7\ m$

Hence,

use detritus tank with dimension as $(24 \times 1.7 \times 1.2)\ m^3$.



Aerated grit chamber:-

They are Spiral flow aeration tanks that provide detention period of about (3 min) at max rate of flow the grit hopper. (sludge collector) is provided at above 0.9 m depth with steep slope located under air defuser. The spiral/helical flow in the waste water drives the grit into the hopper, the performance of aerated grit chamber is the function of roll velocity & detention time.

→ The velocity of air should be in the range of 0.15 to 0.45 $m^3/min/m$

→ Detention time is 3 m.

→ L : B = 2.5 to 7

→ Depth = 2 to 5 m

Q2. Design aerated grit chamber for treating waste water with average flow of 0.5 m^3/s. peak flow is 3 times the avg flow

Solution:

Max. rate of flow = 3 x 0.5

$Q = 1.5\ m^3/s$

Deduction time = 3 min = 3 x 60

$t = 180$ sec.

Vol. of the aerator = Q x t

Discharge x time

= 1.5 x 180

$\therefore V = 270\ m^3$

Vol for two chamber is 270 m^3.

Vol. of one chamber = $\frac{270}{2}$ = 135 m^3

Assume,

depth = 3 m

D : B = 2 : 1

B = 2 x depth = 2 x 3 m

B = 6 m

$$\text{Length of Channel} = \frac{\text{Vol of Chamber}}{\text{Area of Chamber}}$$

$$= \frac{135}{3 \times 6} = 7.5 \text{ m}$$

$$\therefore L = 7.5 \text{ m.}$$

Increase the length of channel by about 20% (7.5×0.2)

Length of Channel $= 7.5 \times 1.20$

$$\therefore \boxed{L = 9 \text{ m}}$$

Size of camber is $9 \times 6 \times 3$

No. of chamber units $= 2$.

______ × ______ × ______ × ______

$Q = A \times V$

Vel = Length/time

Vol = $Q \times t$

Rectangular Horizontal flow type :- (V = Constant)

The flow passes through the channel in horizontal direction, the chamber is designed to give horizontal velocity which is kept constant, over varying discharge. The constant velocity is obtained by providing velocity control section such as proportional ~~weir~~ weir at effluent end of rectangular channel having varying depth.

Constant velocity :-

The important point is that the design of grid chamber should have the flow velocity that is neither too low so as to cause the settling of lighter organic matter, nor it should be too high not to cause ~~settlement~~ settlement.

The flow velocity should be enough to scoreout the settle organic matter.

Critical Scouring Velocity $(V_H) = 3 \text{ to } 4.5 \sqrt{gd(G-1)}$

Definition: (wash off organic matter to next treatment unit)

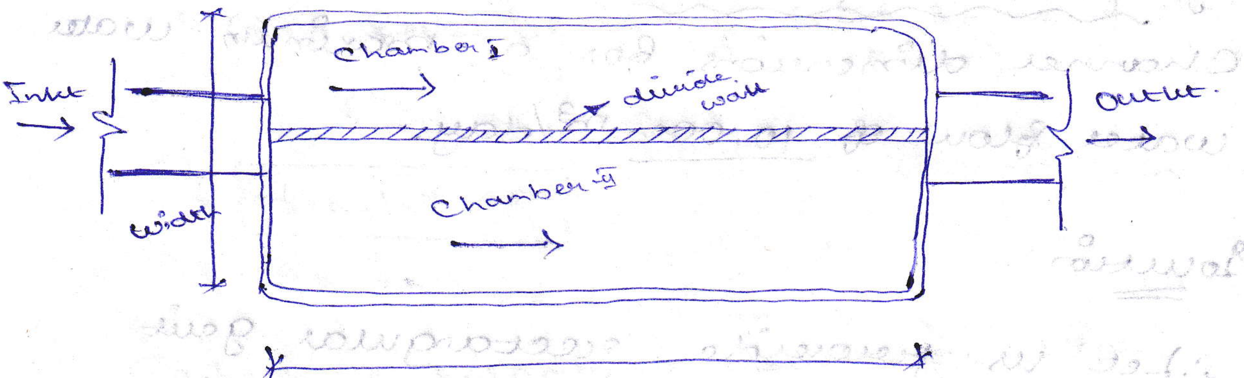
d = dia of particle (0.2 mm)

V = 0.25 to 0.3 m/sec

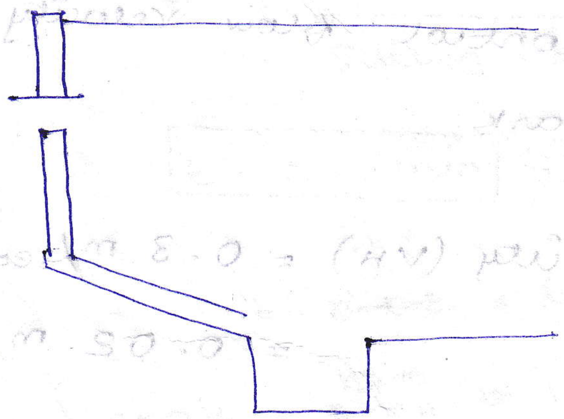
t = 1 min

depth, D = 1 to 1.8 m

L = Velocity × time of detention



Proportional weir :- (To Control Velocity)



(weir → design → rectangular grid chamber).

01. Design a rectangular grid chamber to remove the particles of diameter 0.2 mm. Specific gravity of particle is 2.65, Settling velocity of the particle is 0.016 to 0.022 m/s depending upon shape factor of flow through velocity 0.3 m/s will be maintained by proportional weir. Determine the channel dimensions for a maximum water water flow of 10,000 m^3/day.

Solution:

Let us provide rectangular grit chamber since proportional weir is provided for to control flow velocity of waste water in tank.

Horizontal flow velocity (V_H) = 0.3 m/sec

Settling velocity = 0.02 m/sec.

Discharge of waste water = 10,000 m^3/day

$Q = 0.115 \ m^3/sec$

$$\text{Area} = \frac{Q}{V} = \frac{0.115}{0.3} = 0.385 \ m^2$$

$A = 0.385 \ m^2$

Assume, depth of water is 1 m. above the weir

~~Length~~ = B × D. = 0.385 (Area)

= | B = 0.385 m |

∴ | B ≃ 0.5 m |

Over all depth,

D = free board (0.3) + dead space (0.45) + depth (1 m)

| D = 1.75 m |

Length = velocity × deduction time.

$$t = \frac{\text{water depth}}{\text{Settling velocity}} = \frac{1\,m}{0.02} = 50 \text{ sec}$$

| t ≃ 1 min | = 60 sec //

= $\frac{0.3}{\text{~~0.02~~}}$ × 60 (sec)

Length = ~~18~~ $\frac{}{\text{~~0.02~~}}$ = 18 m. ∴ | L = 18 m. |

Sedimentation tank:

✓ It is designed for settlement of particles by reducing the velocity by detain (store) the sewage.

✓ The tank is RC structure & may be rectangular / circular in shape.

✓ Long narrow rectangular tanks are preferred to circular tank.

✓ It removes high percentage of suspended organic matter (60-65%) & removes BOD (30-35%)

Types :-

✓ Continuous flow.

✓ Intermittent flow.

(2m) The sewage is stored in the tank for 24 hrs the top water is washed off & collected for next unit. (Intermittent flow)

The sludge & silt is clean again the water is filled.

It take nearly 30-36 hours to fill the tank.

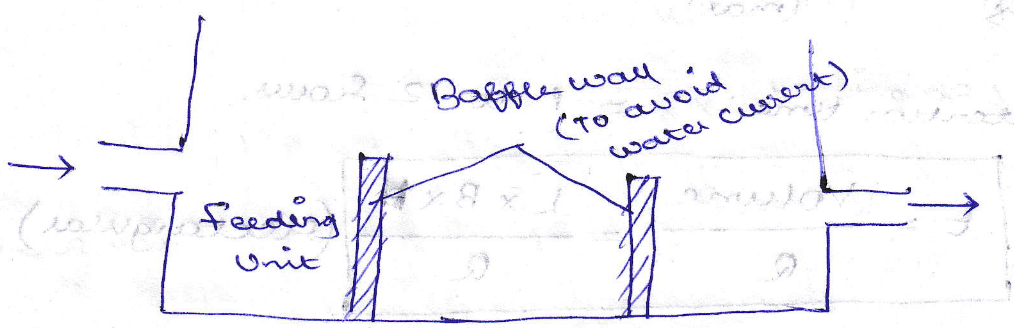
Remaining time it is at obslete. (rest

✓ It is gerdrally used. (Continuous flow)

(2m) ✓ The flow Velocity is ~~reduced~~ only reduced. & Sewage is at rest.

✓ The water ends from one end & comes out from other end

✓ The Velocity is so adjusted that the time taken by one particle to travel from one end to another is slightly more than time required for Sediment of the particle.



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

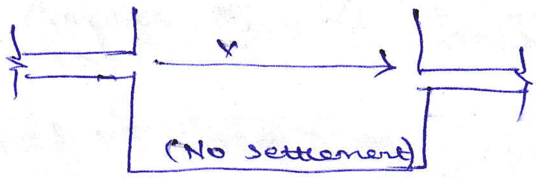
V = horizontal flow velocity

B = width of tank

H = Depth of water in tank

✱ Short circuit :-

(2m) The water moves from one end to another at certain velocity without setting of any particle in ~~seode~~ tank & reaches other treatment unit.



Settling velocity $(V_s) = \frac{Q}{V \times L}$

Design Consideration:

Normal Overflow rate (Discharge) [→ Surface loading] = 50,000 to 60,000 lit/m²/d

Depth of water (max) = 3 m

Detention time = 1 to 2 hours.

$$t = \frac{\text{Volume}}{Q} = \frac{L \times B \times H}{Q} \quad \text{(rectangular)}$$

$$t = d^2 (0.011 d + 0.785 H) / Q \quad \text{(circular)}$$

Width of tank ≯ 7.5 m.

Length of tank ≯ 4 - 5 times the width.

Horizontal flow velocity = 0.3 m/s

Max. dia of circular tank ≯ 60 m

02. Design
for tan
max. da
(assume

Solution :

Max. d

Assume

Deten

Len

→ Assume

Water depth = 3 m

$$\text{Width} = \frac{\text{Area}}{\text{Depth}} = \frac{22.2}{3}$$

$$\boxed{B = 7.4\ m}$$

→ Assume

Free board = 0.3 m.

Hence provide tank of $(36 \times 7.4 \times 3.3)\,m^3$

———— × ———— × ————

08. Design a circular settling tank (sedimentation) for a population of town having seewage ~~to~~ 12 million lit/day. assume suitable values of detention period & surface loading.

Given:

population = 12×10^6 lit/day

Solution:

Assume detention period of 2 hours.

Surface loading rate (Q) = 50,000 lit/m^2/day.

Quantity of Sewage = $12 \times 10^6 \times 2/24$

$= 1 \times 10^6$ lit ~~/day~~

$= 1000\ m^3$ ~~/day~~

Capacity of tank $= 1000\ m^3$

Now,

$$\text{Surface loading} = \frac{Q}{\text{Surface area of tank}}$$

$$\text{Area of tank} = \frac{12 \times 10^6}{60{,}000}$$

$$\frac{\pi}{4} \times d^2 = \frac{12 \times 10^6}{60{,}000}$$

$$d = 15.96$$

$$\therefore \boxed{d = 16\ m}$$

Assume, depth = 3 m & free board = 0.3 m

$$\therefore \boxed{D = 3.3\ m}$$

Hence we circular tank of $\phi = 20\,m$ & adopt depth of 3.3 m.

SPT