Treatement of Sewage

Sewage can be treated in different ways. Treatement processes are often classified as:

1) Preliminary treatement -
2) Primary Treatement -
3) Secondary (Biological) Treatement.
4) Complete final treatement -

1) Preliminary Treatement :- Removal of large suspended organic Matter. (like dead Animals, tree branches, paper, piece of rags)

Screening	Grit Chamber
(Removing organic matter)	(Removing inorganic matter eg. oil, grease, grit & Sand)

Detritus Tank : for removing grit & sand
Skimming Tank : for removing oil & grease.

Comminutor :- It is device to break large sewage solid to small particles. about 6mm.

2) Primary Treatement : Primary Treatement consist in removing large suspended organic solid. This is usually accomplished by sedimentation in settling basin.

Date / /

iii) Secondary Treatement!

This is generally accomplished through biological decomposition of organic matter. which can be carried out either under aerobic or anaerobic conditions.

in which organic matter decomposed by aerobic bacteria are known as aerobic biological unit. it consist of !

(i) filters
(ii) Aeration tank
(iii) Oxidation ponds and aerated lagoons.

in which organic matter is destroyed and stablished by anaerobic bacteria known as anaerobic biological unit and it consist of

(i) Septic tank
(ii) Anaerobic lagoons
(iii) Imhoff tanks (part of septic tank)

(IV) Complete final Treatement!

This treatement consisting in removing of organic load left after secondry treatement. & kill pathogenic bacteria carried out chlorination.

To make safe for drinking.

Screening

Screening is the very first operation carried out at a sewage treatment plant and passing of the sewage through different types of screens.

Types of Screen:

(i) Coarse Screen: also known as Racks and the spacing b/w the bars is about 50mm or more. These screen help in removing large floating object from sewage. They will collect about 6 Litre of solid per million litre of sewage.

(ii) Medium ~~Coarse~~: The spacing b/w the bars is about 6 to 40mm. These screens collect 30 to 90 litres of material per million litre of sewage.
Shape: Rectangular

(iii) Fine Screen: The spacing b/w the bars 1.5mm to 3mm. Screen collect at a angle of 30° to 60° and velocity should be not greater than 0.8 - 1.0 m/s.

Q:9.1 Calculate the screen requirement for a plant treating a peak flow of 60 million litres per day of sewage.

peak flow, Q = 60 ML/Day = 0.694 m^3/sec
velocity, v = 0.8 m/s

Net Area = $\frac{0.694}{0.8} = 0.87\ m^2$

Using rectangular steel bars in the screen, having 1cm width, and placed at 5cm clear spacing.

$$\text{Cross Area of screen} = \frac{0.87 \times 6}{5} = 1.04\ m^2$$

Assuming that screen bars placed at 60° to the horizontal

$$\text{Cross Area Screen need} = \frac{1.04}{\sqrt{3}/2}$$

$$= 1.20\ m^2$$

Disposal of Screening (Solid waste after Screening)

(i) Burning :
(ii) Dumping : dispose of solid received through screening
(iii) Composting :

Grit chamber / Grid basin :

These are used to remove inorganic / organic whose specific gravity is about 2.65.

The horizontal velocity in a grid chamber about

$$U_H = 3 \text{ to } 4.5 \sqrt{gd(G-1)}$$

for grit particle size of 0.2mm this also known as critical scour velocity. The value of this velocity is generally 0.11 to 0.25 m/s

if $d = 0.2mm$

$V_H = 0.11$ to 0.25 m/s

$V_H = 0.25 - 0.3$ m/s for a grid chamber.

Detention time for a grid chamber is 40-60 ~~mins~~ sec.

The depth of a grit chamber is 1 to 1.8 m.

9.2

Q: A grit chamber is designed to remove particles with a diameter of 0.2 mm, specific gravity 2.65. Settling velocity of these particle has been found range b/w 0.016 to 0.022 m/s. ~~depending upon the~~ A flow velocity is 0.3 m/s will be maintained by proportioning weir. and max waste water flow of 10,000 m^3/day.

Determine the dimension of grit chamber.

Velocity of flow $V_h = 0.3$ m/sec

settling velocity b/w 0.016 to 0.022 m/s we assume 0.020 m/s

$Q = V_h \times A$

$0.116 = 0.3 \times A$

$A = 0.385 \, m^2$

$Q = 10,000 \, m^3/day$

$= 0.116 \, m^3/s$

Assuming water depth 1m

$H \times B = 0.385 \, m^2$

$B = 0.385 \, m \approx 0.4 \, m$

overall depth (D) of grit chamber = water depth + 0.3m + free board of 0.45m

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$= 1 + 0.3 + 0.45$

$D = 1.75 m$

Now settling velocity $V_s = 0.02 m/sec$

$$\text{Detention time} = \frac{\text{water depth}}{\text{settling velocity}} = \frac{1}{0.02} = 50 \text{ sec}$$

Length of tank = $U_h \times$ Detention time = $0.3 \times 50 = 15m$

length will increase for non-idealities flow & settling of particle. about 30%

Length = 20m

Width = 0.4 m

Depth = 1.75m

Sedimentation Tank

It is component of waste water treatment system used to remove suspended solids from waste water by gravity. The primary principle behind sedimentation tank is to allow water to flow slowly so that suspended particle which are denser than water, settle at the bottom due to gravity.

Types:

i) Intermittent Settling tank are simple tank which store sewage for 24 hours during which suspended particle settle down and after it clean off.

(iii) Continous flow type in which flow velocity reduced only not the complete rest and settling of sewage cleaned.

Stokes law (mm/sec)

Settling velocity, $\boxed{V_s = 418(G-1)d^2\left(\frac{3T+70}{100}\right)}$ $\left\{\begin{matrix}\text{when} \\ d<0.1mm\end{matrix}\right\}$

Newtons law:

when $d > 0.1mm$ but $d < 1mm$

$$\boxed{V_s = 1.8\sqrt{gd(G-1)}}$$

if $d > 1mm$

$$\boxed{V_s = 418(G-1)d\left(\frac{3T+70}{100}\right)}$$

$d \rightarrow m$
$V_s = m/sec$

horizontal velocity, $V = \frac{Q}{BH}$

Settling velocity, $V_s = \frac{Q}{BL}$ (over flow rate).

* over flow rates range b/w 40,000 to 50,000 $L/m^2/day$
* with plain primary sedimentation.

* And b/w 50,000 to 60000 $L/m^2/Day$ with sedimentation with coagulation.

* Over-flow rate for secondary Sedimentation tank about 25,000 to 35000 $L/m^2/Day$.

* The effective depth of sedimentation tank ranges b/w 2.4 to 3.6m.
* In general not exceeded by 8m.
* The detentation time for sewage sedimention tank usually range b/w 1 to 2 hours. (generally 1hr) for extreme case 2.5 to 3 hr.

* Generally width of tank is about 6m and should not allowed by 7.5 m.
* The length of Sedimention tank should not greater than 4 or 5 times of its width.

* The ~~velocity of S.T~~ horizontal flow velocity is about 0.3 m/min.

Detention time for circular tank

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

Q. 9.6 Design a circular settling tank for primary treatement of sewage discharge 12 million per Day. Assume suitable detentation period & surface loading.

Assuming detention time 2hr

surface loading = 40,000 L/m²/Day.

Quantity of sewage = $12 \times 1000 \times \frac{2}{24} \Rightarrow 1000\,m^3$.

Capacity of tank = $1000\,m^3$.

$$\text{Surface loading} = \frac{Q}{\frac{\pi}{4} \cdot d^2}$$

$$40{,}000 = \frac{12 \times 10^6}{\frac{\pi}{4} \cdot d^2}$$

$$d = \sqrt{\frac{300 \times 4}{\pi}} = 19.55$$

$$\text{Effective depth of tank} = \frac{\text{Capacity}}{\text{Area of X-Section}} = \frac{1000}{\frac{\pi}{4} \times (19.6)^2}$$

$$\boxed{\text{Effective depth} = 3.2}$$

Sedimentation with coagulation

Disadvantages

We avoid this because it have more disadvantages than advantages and 1) it kill useful bacteria also 2) cost of chemical more than secondary treatment & 3) it required skill supervision & handly of chemical.

Advantages

(i) coagulated settling tank require less space.
Produces better effluent with lesser BOD.

(ii)

(iii) It remove the phosphate which controlling eutrophication

Aerobic

- Secondary treatement also known as biological treatement.

- Decomposition of oxygen in presence of oxygen.

The character of the organic matter in sewage may be ~~classified~~ changed by different
(i) Filtration (trickling filter)
(ii) Activated sludge process

These process help in changing the unstable organic matter into stable forms, microorganism break the organic matter.

1) **Trickling filter**
In trickling filter microorganism attach to the media to break down the organic matter.

2) Rotatory Biological contractor (RBC)
It uses microorganism attatch to rotatory disc to breakdown organic matter.

3) Moving Bed biofilm reactors (MBBR)
uses micro-organism attached to moving media to breakdown organic matter.

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Date / /

TRICKLING FILTER

It is secondary treatement unit used ~~to~~ in waste waster treatement plant to remove organic matter & other pollutant from waste waster It broadly 2 types.

(i) Ordinary Trickling filter (conventional)
(ii) High rate Trickling filter

Working of filter

(1) Waste water flow through the distinguish system onto a bed of media such as rock, seramic etc.
2) Microorganism attach to the media & form a biofilter.
3) As waste water tricks through the media, microorganism break down organic matters.
4) Treated waste-water collect at the bottom of the filter.

Advantages

(i) Rate of trickling filter is high so required lesser area.
(ii) They can remove 75% BOD & 80% suspended solid.
(iii) Simple working not required skill supervision.
(iv) They are self cleaning.
(v) Mechanical wear & tear.

Disadvantages

(i) Cost of construction is high
(ii) Can't treat raw sewage
(iii) Head loss high

Design of trickling filter

It involves the design of the dia of the circular filter tank, and its depth. The design of rotatory distributors and under-drainge. system

i) Hydraulic loading Rate : The quantity of sewage applied per unit of surface area of the filter per day This is called hydraulic-loading rate and expressed in million litres per hectre per day.

- Vary b/w 22-44 ML/hec/Day } conventional TF
- Normally 28 ML/hec/Day.

- Vary b/w 110-330 ML/hec/Day } High Rate TF
- generally 220 ML/hec/Day

(ii) Organic loading Rate : mass of BOD per unit volume of the filtering media per day. This is called organic loading rate.

Expressed in kg of BOD_5 per hectare metre of the filter media per day

- 900-2200 kg of BOD_5/hec-m/Day (conventional)
- 6000-18000 kg of BOD_5/hec-m/Day (High Rate)

{ The filter dia & depth is designed for avg value of sewage flow. The rotary distributors under drainage system & other connected pipeline are designed for peak flow.

CLASSTIME Pg. No.
Date / /

Efficiency of filter (η)

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

u: Organic loading kg/hec-m/Day

* 80% suspended particle & 75% BOD removed by trickling filter.

Q 9.8 The sewage flowing @ 4.5 Million Litre / day from a primary Clarifier to a standard rate trickling filter. The 5-Day BOD of the influent is 160 mg/L. The value of adopted organic loading is 160 gm/m³/Day and surface loading 2000 l/m²/day. Determine the volume of the filter & its depth & efficiency.

5-Day BOD

$$\frac{160 \times 4.5 \times 10^6}{10^3} gm/Day = 7,20,000 \; gm/Day$$

Volume of filter media reqd

$$= \frac{\text{Total BOD}}{\text{Organic loading}}$$

$$\frac{7,20,000}{1600} = 4,500 \; m^3$$

Surface area reqd for filter

$$= \frac{\text{Total flow}}{\text{Hydraulic loading}} = \frac{4.5 \times 10^6}{2000} = 2250 \; m^2$$

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Depth of bed required

$$\frac{45000}{2250} = 2m$$

Efficiency

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

$U \rightarrow kg/ha\text{-}m/day$

$160\ gm/m^3/day$

$\frac{160 \times 10^4}{1000} \Rightarrow 1600$

$$\eta = \frac{100}{1+0.044\sqrt{1600}}$$

$$\boxed{\eta = 85.03\%}$$

Q: Differenite b/w conventional Vs High Rate

Conventional (Standard)	High Rate Filter
1) Depth of filter media varies b/w 1.6 to 2.4m.	1.) Varies b/w 1.2 to 1.8m
2) Size of filter media 25 to 75mm.	2) Size of filter media 25 to 60mm
3) More area is required	3) Less area is required.
4) Cost of operation is more	4) Cost of operation is less.
5) BOD ≤ 20ppm	5) BOD ≥ 30 ppm.
6) Dosing interval varies b/w 3 to 10 min.	6) It is not more than 15 seconds.
7) Recirculation not provided.	7) Recuirculation provided.

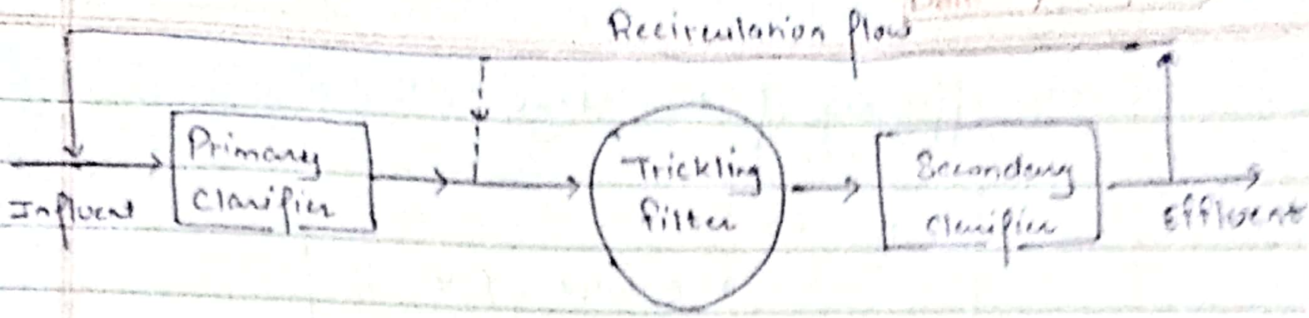

Fig. Single stage commonly adopted Recirculation Process.

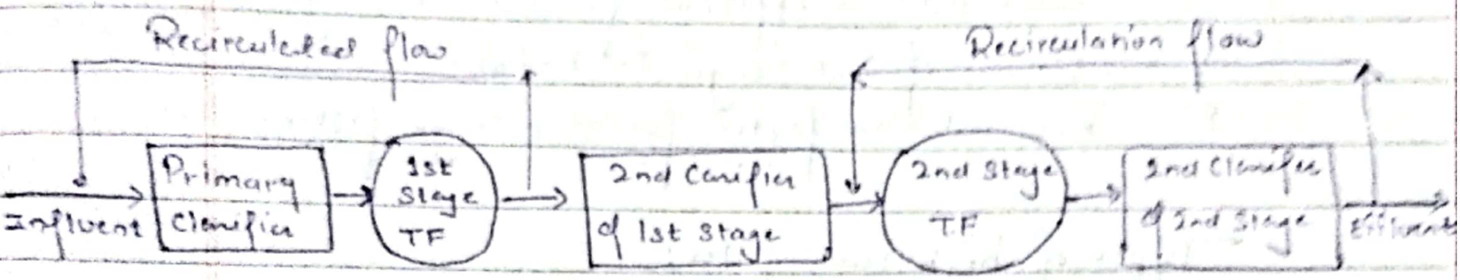

Fig. Two stage commonly adopted Recirculation Process.

F : Recirculation factor
R : Volume of sewage circulated
I : Volume of raw sewage

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

The efficiency of single stage high Rate Trickling filter

$$\boxed{\eta(\%) = \frac{100}{1 + 0.0044\sqrt{\frac{Y}{V.F}}}}$$

Y : The total organic load in kg/day applied to filter i.e the total BOD in kg.
V : Filter volume (hec-m)
F : Recirculation filter

CLASSTIME Pg. No.
Date / /

The efficiency of two stage.

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

Y' = Total BOD in effluent from first stage (kg/day)
V' = Volume of 2nd stage in ha-m
F' = Recirculation factor for 2nd stage filter.

Types of high rate filter:

1) Bio-filters:
- The depth varies 1.2 to 1.5
- Organic loading adopted, normally b/w 9000 to 11,000 kg BOD_5
- Total hydraulic loading b/w 110-330 ML/Day/hec

2) Accelo-filters
- The depth varies 1.8m to 2.4m
- Organic loading varies b/w 9000-11000 kg of BOD_5
- Total hydraulic loading b/w 110-330 ML/Day/hec.

3) Aero filter
- The depth is more than 1.8m
- Organic loading b/w 11000-12000 kg of BOD_5
- hydraulic loading not be less than 150 ML/hec/Day

Q:9.10 Determine the size of a high rate trickling filter for the following data.
(i) Sewage flow = 4.5 Mld
(ii) Recirculation ratio = 1.5
(iii) BOD of raw sewage = 250 mg/L

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Date / /

(iv) BOD removed in primary tank = 30%
(v) final effluent BOD desired = 30 mg/L

Total BOD present in raw sewage = 4.5 × 250
= 1125 kg

BOD removed from in primary tank = 30%
BOD left in sewage
= 1125 × 0.7 = 787.5 kg

BOD conc. desired in final effluent = 30 mg/L
Total BOD left in effluent per day = 30 × 4.5 = 135 kg
BOD removed by filter = 787.5 − 135 = 652.5 kg.

$$\text{Efficiency of filter} = \frac{652.5}{787.5} \times 100 = 82.85\%$$

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

$$F = \frac{1 + R/I}{(1 + 0.1R/I)^2} = \frac{1 + 1.5}{(1 + 0.1 \times 1.5)^2} = 1.89$$

$$82.85 = \frac{100}{1 + 0.0044\sqrt{\frac{Y}{VF}}} = \frac{100}{1 + 0.0044\sqrt{\frac{787.5}{V \times 1.89}}}$$

V = 0.188 hec-m = 1880 m^3

Assuming filter depth 1.5 m

$$\text{surface area} = \frac{1880}{1.5} = \boxed{1253 m^2}$$

$$\text{area} = 1253 = \frac{\pi}{4} d^2 \quad \boxed{d = 40 m}$$

CLASSTIME Pg No.
Date / /

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Sludge digestion Process

Imp

The sludge is stablized by decomposing the organic matter under controlled anaerobic condition and the disposed of suitably after drying on drying bed. The process of stabilization is called the sludge digestion.

The tank where the process is carried out is called the sludge digestion tank.

The sludge gets broken into the following three form
(i) Digested sludge
(ii) Supernatant liquor.
(iii) Gases of decomposition.

Imp

Factors affecting Sludge Digestion & their Control.

(i) Temperature: in which rate of digestion being more at higher temperature and vice-versa.

(ii) pH value: A lot of volatile organic acids are formed in breakdown of organic material. These volatile acids are converted into methane gas by a specialised group of strickly anaerobic and slow growing bacteria, called methane formers. If methane formers are not operating properly causing pH to drop to a value as low as 5.0 which will suppress further bacterial action.

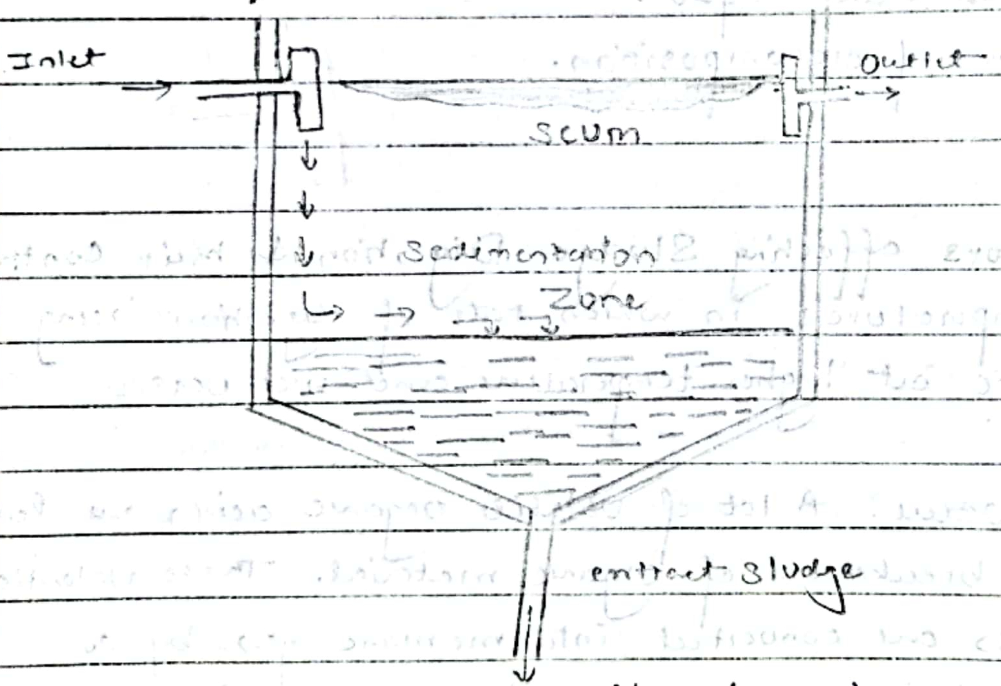
(iii) Seeding with digested sludge: It is highly beneficial to seed it with the digested sludge

Date / /

from another tank. without seeding it may take a few months to get a tank operating properly.

(iv) Mixing and stirring of raw sludge with the digested sludge : In this way, the bacterial enzyme present in the digested sludge will get every opportunity to get mixed with raw sludge and ~~so~~ to attack it for subsequent decomposition.

Imp Design of Sludge digestion tank



The digestion tank are cylinderical shaped tank (circular from top) with dia ranging b/w 3 to 12m. The bottom hoppered floor of the tank is given a slope of about 1:1 to 1:3 (i.e 1H : 3V)

The depth of digestion tank is usually kept at about 6m or deeper. Deeper tank are coastlier.

The capacity of digestion tank (V) is

$$\boxed{V = \left(\frac{V_1+V_2}{2}\right) t} \quad \text{—— (i)}$$

V = Vol of digestor, m^3
V_1 = Raw sludge added per day (m^3/Day)
t = Digestion period, d
V_2 = Eq. digested sludge produced per day on completion of digestion m^3/day

A gas dome is made of suitable metal, and is cylindrical in shape. It is fixed on the ~~top~~ roof of the digestion tank, along with various accessories such as gas meter, pressure relief valve. Gas is taken off from gas dome and it is stored in gas holder.

The daily digested sludge could not be removed due to factors such as monsoon season, winter season etc, then separate capacity for its storage should be provided in the tank. This capacity eventually amount to $V_2 \cdot T$, where T is no. of days for which the digested sludge is stored is stored. and it is called the monsoon storage.

Total digestor volume will be

$$\boxed{V = \left(\frac{V_1+V_2}{2}\right) t + V_2 \cdot T} \quad \text{—— (2)}$$

NOTE! when the change during digestion is assumed to be parabolic rather than linear, the avg volume of digesting sludge will be

$$V = \left[V_1 - \frac{2}{3}(V_1 - V_2)\right] t \quad \text{—— (3)}$$

(without monsoon storage)

$$V = \left[V_1 - \frac{2}{3}(V_1 - V_2)\right] t + V_2 \cdot T \quad \text{—— (4)}$$

(with monsoon storage)

The capacity of sludge digestion tank calculated by eqn (3) & (4) may modified for the following factor.

~~The capacity of the sludge~~

(i) amount of sludge withdrawn and its interval.
(ii) provision of adequate free-board at top.
(iii) storage for winter.
(iv) type of pre-treatment given to fresh sludge
(v) collection of gas.

The capacity of digestion tank is vary b/w 21 to 61 litre per capita. usually one month.

The amount of the sludge ~~tank~~ gas produced in the digestion tank b/w 14 to 28 litre per capita. usually 17 litre per capita (or 900 litre per gm of volatile solid digested)

Q: 9.20 Design a degestion tank for primary sludge with the help of following data.

(i) Avg flow = 20 Ml/d.

(ii) Total suspended solid in raw sewage = 300 mg/l

(iii) Moisture content of digested sludge = 85%.

Assume any other suitable data you required.

Mass of suspended solid in 20 Ml of sewage following per day

$$= \frac{300 \times 20 \times 10^6}{10^6} \text{ Kg} = 6000 \text{ kg/Day}$$

Assuming 65% solid are removed in primary settling tanks,

$$= 65\% \times 6000 \text{ kg/Day} = 3900 \text{ kg/Day}$$

Assuming that the fresh sludge has moisture content 95%.

5 kg of dry solid = 100 kg of wet sludge

$$= \frac{100}{5} \times 3900 \text{ kg of wet sludge per day.}$$

$$= 78,000 \text{ kg of wet sludge per day}$$

Assuming the sp. gravity of wet sludge as 1.02 (Density = 1020 kg/m³).

$$V_1 = \frac{78000}{1020} \text{ m}^3/\text{Day}$$

$$= 76.47 \text{ m}^3/\text{Day}$$

CLASSTIME Pg. No.
Date / /

Volume of digested sludge (V_2) at 85% m.c.

$$V_2 = V_1\left[\frac{100-P_1}{100-P_2}\right]$$

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

$$V_2 = 76.47\left[\frac{1}{3}\right] = 25.49 \text{ m}^3/\text{Day}$$

Assuming the digestion period as 30 days.

$$\text{Capacity} = \left[V_1 - \frac{2}{3}(V_1 - V_2)\right]t$$

$$= \left[76.47 - \frac{2}{3}(76.47 - 25.49)\right]30$$

$$\text{Capacity} = 1275 \text{ m}^3.$$

providing 6.0 m depth of cylindrical digestion tank.

$$\text{Cross-sectional area} = \frac{1275}{6} = 212.5 \text{ m}^2$$

$$\text{Dia of Tank} = \sqrt{\frac{2125}{\pi/4}} = 16.45 \text{ m}$$

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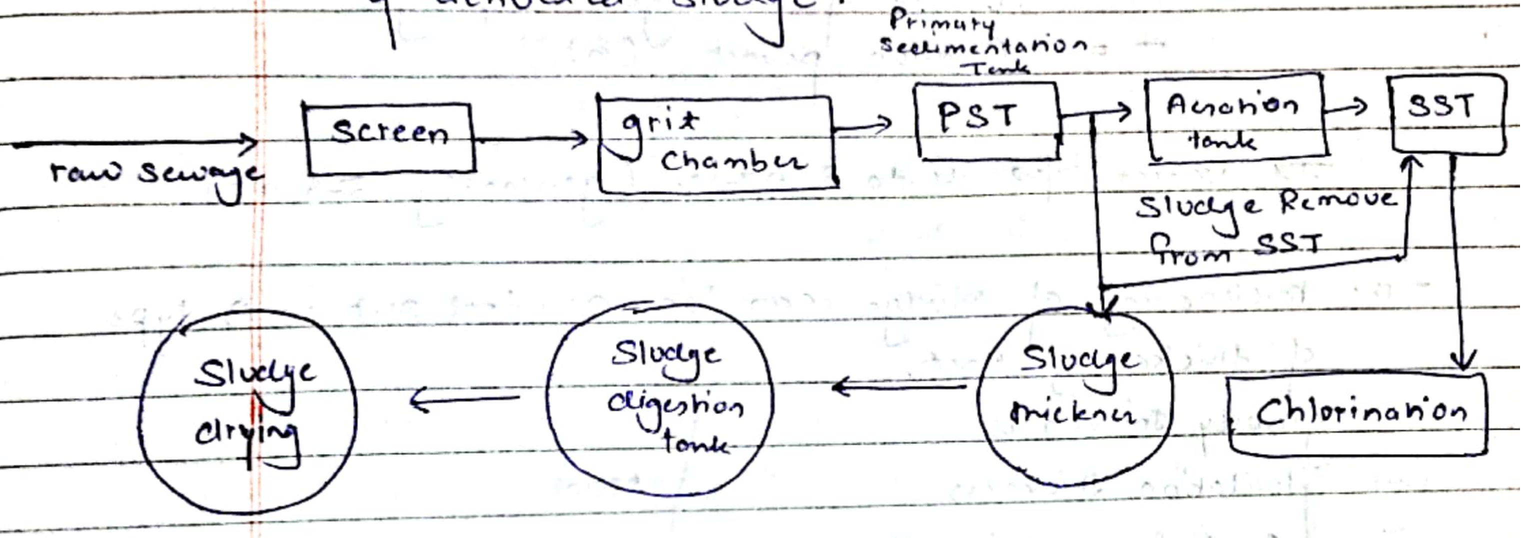
Imp

Secondary Treatement through activated sludge process

- The sewage effluent from primary sedimentation tank, which is, thus normally utilised in this process, is mixed with 20-30 percent of own volume of activated sludge.



- Removes upto 80-95% of BOD, Bacteria upto 90-95%. thats why this is most effective process.
- for activated sludge process the oxygen play the important role.
- for activated sludge process the overflow rate is about 40,000 litre per square of plan Area per day.
- The depth is about 2.4m
- Detention time is 1.4 hour
- There is 2 methods for introducing the air into the aeration tank.

(i) Diffused air aeration | Air diffusion
(ii) Mechanical aeration
(iii) Sometimes, a combination of both may also be used which may then be called as combined aeration.

Capacity of aeration tank

$$\boxed{V = \frac{QT}{24}}$$

where V = capacity of the aeration tank (m^3)
Q = volume of sewage (m^3/Day)
T = Aeration period (h)

It varies b/w 4 to 8 hours. (generally 5-6 hrs)

The thickening of sludge can be carried out in 3 type of thickening unit.
(i) gravity thickeners
(ii) floatation thickners
(iii) centrifugal thickeners.

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* Hydraulic potential time as Aeration tank Period
* BOD loading per unit volume of aeration tank as volumetric loading.
* Food to microorganisms ratio
$\frac{\text{food}}{\text{microorganism}}$
* Sludge Age

Aeration period/ HRT/ Det. Time = $\frac{\text{Volume of the tank}}{\text{Rate of sewage flow in tank}}$

$$\boxed{t = \frac{V}{Q} \cdot 24}$$

Q = Quantity of wastewater flow into the aeration tank, excluding the quantity of recycled Sludge. (m^3/Day)

t = aeration period in hours
V = Vol. of aeration tank (m^3)

CLASSTIME Pg. No.
Date / /

∴ Volumetric BOD loading or Organic loading

$$= \frac{\text{Mass of BOD applied per day to the aeration tank through influent sewage in gm}}{\text{Volume of the aeration tank in } m^3}$$

$$= \frac{Q \cdot Y_0 \,(gm)}{V\,(m^3)}$$

1 mg = 0.001g
1L = 0.001 m^3

Q = Sewage flow into the aeration tank in m^3.
Y_0 = BOD_5 in mg/l (or gm/m^3) of the influent sewage.
V = Aeration tank volume in m^3.

∴ F/M ratio

$$= \frac{\text{Daily BOD load applied to the Aerator System in gm}}{\text{Total Microbial mass in system in gm}}$$

* The BOD applied to the aeration system is equal to = Y_0 mg/L or gm/m^3

* The BOD load applied to aeration system (F) is equal to = $F = Q \cdot Y_0$ gm/Day

* total microbial mass is also called as 'mixed liquor suspended solid (MLSS) with volume of the aeration tank (V)

$$\boxed{\text{ratio } \frac{F}{M} = \frac{Q_0 Y_0}{V \cdot X_t}}$$

∴ X_t is MLSS in mg/L

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* Sludge age (θ_c)

$$= \frac{\text{mass of suspended solid (MLSS*) in the system (M)}}{\text{Mass of solids leaving the system per day}}$$

* Mass of solid 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 solids removed from the system per day

$= (i) + (ii)$

$= Q_w X_R + (Q - Q_w) X_E$

Sludge age, $\theta_c = \dfrac{V \cdot X_T}{Q_w \cdot X_R + (Q - Q_w) X_E}$

Q_w : Volume of wasted sludge per day
Q : Sewage inflow per day
X_E : Conc of solid in the effluent in mg/L
V : Volume of Aerator

* Oxygen plays important role in activated sludge process.

Design Parameter for conventional Activated sludge Process

Parameter / loading	Design values
* MLSS	1500 - 3000 mg/L
* F/M	0.4 - 0.2
* HRT	4 - 8 hrs

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* volometric loading as gram of BOD applied per m^3 of tank	800-700
* Sludeage (SRT) θ_c (Sludge Rotation time) or MCRT (mean cell Residence Time)	5-15 Days
* $Q_R \rightarrow$ Vol. of the return sludge; $Q \rightarrow$ vol. of influent sludge	0.25 - 0.5
* Kg of O_2 required per Kg of BOD removed	0.8 - 1.1
* Air required per kg of BOD_5	40 - 100 m^3

$$\boxed{\theta_c = \frac{V \cdot X_T}{Q_w \cdot X_R}}$$

X_T = conc. of solid in the influent of the aeration tank called the MLSS (mixed liquor suspended solid)

X_R : conc. of solid in the removed sludge or in the wasted sludge (both being equal) mg/L

Q. 9.29 An avg. operating data for conventional activated sluage treatement plant is as follow.

(1) waste water flow 30000 l/day

(2) Influent BOD 250 mg/L

(3) Vol. of Aeration tank 10000 m^3

(4) Effluent BOD 20 mg/Ltr

(5) MLSS 2500 mg/Ltr

(6) Effluent suspended solid 30 mg/Ltr

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Date / /

(7) waste Sludge suspended solid 9700 mg/L
(8) Quantity of waste sludge 220 m^3/day

Calculate the aeration period in hrs (HRT), F/M ratio, Percentage efficiency of BOD removal sludge age in days.

$Q = 35000\ m^3/d$ $V = 10900\ m^3$
$Y_0 = 250\ mg/L$ $X_E = 30\ mg/L$
$X_T = 2500\ mg/L$ $Y_E = 20\ mg/L$
$X_R = 9700\ mg/L$ $Q_W = 220\ m^3/Day$

(i) Aeration period in hrs

$$t = \frac{V}{Q} \cdot 24$$

$$t = \frac{10,900}{35000} \times 24 = 7.5\ \text{hour}$$

(ii) F/M ratio

F = Mass of BOD applied to aeration system

$= Q \cdot Y_0 = 35000 \times 250\ gm/Day$

$= \frac{35000 \times 250}{1000} = 8750\ kg/Day$

M = Mass of MLSS

$= V \cdot X_T = 10900\ m^3 \times 2500\ mg/L$

$= \frac{10900 \times 2500}{1000} = 27,250\ kg$

F/M ratio $= \frac{8750}{27250} = 0.32$ kg BOD per day/kg of MLSS.

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(iii) Percentage efficiency of BOD removal

$$= \frac{\text{incoming BOD} - \text{outgoing BOD}}{\text{incoming BOD}}$$

$$= \frac{250-20}{250} \times 100$$

$$= 92\%$$

(iv) Sludge Age in days (θ_c)

$$\theta_c = \frac{V \cdot X_T}{Q_w \cdot X_R + (Q - Q_w) \cdot X_E}$$

$$= \frac{27250}{\frac{220 \times 9700}{1000} + \frac{(3500-220)30}{1000}}$$

$$= \frac{27250}{3177.4} = 8.58 \text{ days.}$$

CLASSTIME Pg. No.
Date / /

11|11|24

Septic tank

- A septic tank may be defined as primary sedimentation tank with a longer detention time (12-36 hrs)

Imp
- The digested sludge from the tank is periodically removed at interval of 6-12 months and no more exceeded by 3 yr.

- Septic tanks are generally provided in areas where sewer have not been laid.

⇒ Construction Details

(i) Capacity of septic tanks: The volume of liquid which a septic tank can accommodate is called its capacity.

capacity : 40-70 litres/capita/Day.

But when sullage is also discharged in to the septic tank then capacity 90-150 litre/capita/Day.

Imp
- The rate of accumulation of sludge has been recommended as 30 litre/person/year.

- The minimum capacity of a septic tank for about 8 to 10 persons, may be kept 2,250 litres when all liquid waste are discharged into the tank and 1400 litres when only water closet wastes are discharged

Imp
- The detention period for septic tank generally 12-36 hrs. but is commonly adopted as 24 hrs.

CLASSTIME Pg No.
Date / /

Imp

- Septic tank are usually rectangular with their length at about 2 to 3 times the width. The width should not be less than 90 cm, The depth of the tank generally ranges b/w 1.2 to 1.8 m.

9.33

Q Design the Dimension of a septic tank for a small colony of 150 person provided with an water supply from municipal at a rate of 120 litre per person per Day. Assume suitable data if needed.

The quantity of water supplied = Per capita rate x Population
= 120 x 150
= 18,000 l/Day

Assuming 80% of water supplied becomes sewage
= 18000 x 0.8
= 14,400 l/Day

Assuming detention time 24 hours
Quantity of sewage = $14,400 \times \frac{24}{24}$

= 14,400 litres

Assuming the rate of deposited sludge as 80 L/capita/yr and assuming period of cleaning 1yr.

The volume of sludge deposited = 80 x 150 x 1 = 4500 litres

Total Required capacity of tank
⇒ Capacity for sewage + Capacity for sludge
⇒ 14,400 + 4500 = 18,900 litres
= 18.9 m³

Assuming 1.5m as depth

Cross section area = $\frac{18.9}{1.5} = 12.6\ m^2$

ratio of length to width is kept as 3:1.

$3 \cdot B^2 = 12.6$

$B = \sqrt{\frac{12.6}{3}} = 2.05m \approx 2.1m$

length = 6m

Dimension of the septic tank

$6 \times 2.1 \times (1.5 + 0.3)$ $\qquad$ $0.3 \rightarrow$ free board

12/11/24

- Sewage: The mixture of water and waste products, called as sewage.

- Sewerage: The term sewerage is applied for collecting, treating and disposal of sewage.

Types of sewage

(i) Domestic sewage: consist of liquid waste originally from urinals, latrines, bath rooms, kitchen sinks, wash basin, etc of the commercial, or industrial buildings.

(ii) Industrial sewage: consist of liquid waste originating from the industrial process of various industries, such as Dying, paper making etc.

Imp

Types of sewerage

(i) Seprate Sewage System: This system has to seprate sets of pipe one for carrying sewage and another for stormwater.

Combined Sewage System : This system carries both sewage and storm water in single pipe to the treatement plant.

Maximum Daily flow = 2 times the avg daily flow
Maximum hourly flow = 1.5 times the max. daily
= 3 times avg daily

Peak sewage flow

$$\boxed{Q_{max} = \frac{18+\sqrt{P}}{4+\sqrt{P}} Q_{av}}$$

P in thousands

Min daily flow = 2/3 × avg daily
Min hourly flow = 1/2 × Min daily flow
= 1/3 × avg daily

Chezy's Formula :-

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

V : velocity of flow in channel (m/sec)
r : hydraulic mean radius of channel / hydraulic mean depth of channel $= \frac{a}{p}$
where a is the area of channel and p is the wetted perimeter of channel.
For a circular sewer running full, r is given by

$r = \frac{D}{4}$ D is diameter of sewer.

S : hydraulic gradient / head drop
C : chezy's coff.

$$Q = A.V$$

where A is flow area of x-section of the channel. and V is flow velocity channel.

→ Manning's formula!

$$V = \frac{1}{n} . r^{2/3} . s^{1/2}$$ n: manning coff.

Table 4.5: Sewer Gradient required to generate self-cleansing velocities in different sized pipes (running full)

Table 4.6: NBO Recommendation for small Sewers

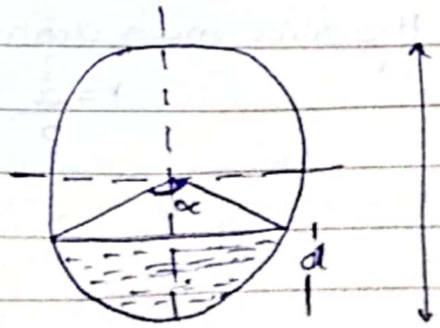
Dia of sewer in mm	Gradient required to generate self cleansing velocity	Velocity generated in the sewer when running half full, for which depth, small sewer are usually designed
100	1 in 60	0.58 m/sec
150	1 in 100	0.61 m/sec
225	1 in 120	0.79 m/sec

Design of circular sewage

(i) when sewer is running full

Area of cross-section

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



CLASSTIME Pg. No.
Date / /

wetted parameter (P) = πD

Hydraulic mean depth (R) = $\frac{A}{P} = \frac{D}{4}$

The depth at partial flow

$$= d = \left[\frac{D}{2} - \frac{D}{2}\cos\frac{\alpha}{2}\right]$$

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

α: central angle in degree

Proportionate depth

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

- Area of cross section while running partially full

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

- Proportionate area

$$\frac{a}{A} = \left[\frac{\alpha}{360^\circ} - \frac{\sin\alpha}{2\pi}\right]$$

- wetted perimeter while running partially full

$$p = \frac{\pi D \cdot \alpha}{360^\circ}$$

- Proportionate perimeter

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

- Hydraulic mean depth (HMD), while running partially full

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

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Proportionate HMD

$$\frac{r}{R} = \left[\frac{1 - 360' \sin\alpha}{2\pi\alpha}\right]$$

velocity of flow given by Manning's formula

velocity, when running full

$$V = \frac{1}{N} \cdot R^{2/3} \sqrt{S}.$$

Proportionate velocity

$$\frac{v}{V} = \frac{r^{2/3}}{R^{2/3}} = \left[\frac{1 - 360' \sin\alpha}{2\pi\alpha}\right]^{2/3}$$

Proportionate Discharge

$$\frac{q}{Q} = \frac{va}{VA} = \frac{a}{A} \cdot \frac{v}{V}$$

$$= \left[\frac{\alpha}{360} - \frac{\sin\alpha}{2\pi}\right] \left[\frac{1 - 360' \sin\alpha}{2\pi\alpha}\right]$$

Table 4.8 : Proportionate value of hydraulic elements for circular sewer when flowing partially full

A 350mm dia sewer is to flow at 0.35 depth on a grade ensuring degree of self-cleansing ~~velocity~~ at full depth at a velocity of 0.8 m/sec. Find
the required grade
associated velocity
Rate of discharge depth.
Given
(i) Manning's rugosity coff = 0.014
(ii) Proportionate area = 0.315
(iii) " wetted perimeter = 0.472
(iv) Propiate HMD = 0.775

CLASSTIME Pg. No.
Date / /

(i) At full depth

$$V = \frac{1}{N} \cdot R^{2/3} \sqrt{S}$$

$$0.8 = \frac{1}{0.014} \left(\frac{0.35}{4}\right)^{2/3} \cdot \sqrt{S}$$

$$\sqrt{S} = 0.0568$$

$$S = 3.234 \times 10^{-3}$$

(i) gradient

$$S_s = \left(\frac{R}{r}\right) S$$

$$= \frac{1}{0.775} \times 3.234 \times 10^{-3}$$

$$= 4.2\%$$

(ii) Velocity generated at this gradient at 0.35 depth

$$V_s = \frac{N}{n} \left(\frac{r}{R}\right)^{1/6} \cdot V$$

$$= 1 \times (0.775)^{1/6} \times 0.8$$

$$= 0.765 \text{ m/sec}$$

(iii) Discharge q_s

$$q_s = a \cdot V_s$$

$$= 0.315 \times \frac{\pi}{4} \times (0.35)^2 \times 0.765$$

$$= 0.023 \text{ m}^3.$$

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