A Handwritten Note on

Environmental Engineering II

CE 4141

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Never give up hope of Allah's Mercy (Quran: 12:87)

Special THANKS to-

My friend

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CONVENTIONAL SEWERAGE System

Some Important Terms:

1. **Waste water:** (→ Municipal Sewage) waste water is the liquid water conveyed by a sewer and may include domestic and industrial discharges as well as storm sewage, infiltration and inflow.

2. **Domestic (Sanitary) Sewage:** Domestic sewage is the liquid waste which originates in the sanitary convenience, e.g. water closets, urinals, baths, sinks etc. of dewellings, commercial or industrial facilities and institutions. This is sometimes also referred to as black water.

3. **Industrial wastewater:** Industrial waste water includes the liquid discharges from spent water in different industrial processes such as manufacturing and food processing.

4. **Sullage:** sullage is the liquid discharges from kitchen, wash basin etc. and excludes discharge from WCs and urinals. sullage is also known as Grey water. It is less foul than domestic sewage and can be discharged through open surface drains in un sewered area.

5. Storm water: storm water is the surface runoff obtained during and immediately after rainfall, which enters sewers through inlets. storm water is not as foul as domestic or industrial sewage and hence can be carried through open drains or channels and disposed of in natural rivers or streams without any treatment.

6. Infiltration: Infiltration is the water which enters the sewer from the ground through leaks or faulty joints.

7. Sewer: sewer is a pipe or conduit, generally closed, but normally not flowing full, which carries sewage.

8. Sanitary sewer: sanitary sewer carries sanitary sewage and is designed to exclude storm sewage, infiltration and surface ~~runoff~~ inflow. Industrial waste may be carried in sanitary sewers, depending upon its characterestics.

9. Storm sewer: storm water carries storm sewage and any other waste which may be discharged into the streets or on the surface of the ground.

2016

Q1. What is sewerage system? Describe the essential elements of sewerage system.

Sewerage system: Sewerage refers to the entire system of collection, treatment and disposal of sewage through a system of reticulation sewers.

Essential elements of a sewerage system:

1. collection: collection refers to the collection of sewage from different points of generation.

2. Transportation: Transportation refers to the conveying of sewage to any desired points through a network of sewers.

3. Treatment: Sewage treatment includes any process which may be used to favourably modify the characterestics of sewage.

4. Disposal: Disposal refers to the discharge of liquid wastes to the environment. Normally but not always, disposal implies some degree of treatment prior to discharge.

2018, 2016

* Types of Collection system:

Write down the advantages and dis advantages of seperate sewerage system, combined sewerage system and partially combined sewerage system.

or, Describe the types of collection system and write down their advantages and dis advantages.

There are three different sewage collection systems:

2008, 07, 06, 05

1. **Seperate sewage system:** In this system sanitary sewage and storm waste are collected and conveyed seperately through two different system.

Advantages:

(i) sewers are of small sizes.

(ii) only sanitary sewage is treated.

(iii) storm water can be discharged without treatment.

(iv) sewage lifting is less costly because of less volume.

Dis advantages:

(i) Two sets of sewers may prove costly.

(ii) smaller sewers may be difficult to clean.

2007, 06, 05

2. **Combined sewerage system:** In this system both sanitary sewage and storm water are collected and conveyed together through a single set of sewers.

Advantages:

(i) only one set of sewers might prove economical.

(ii) larger sewers are easy to clean.

(iii) strength of sewage diluted with storm water.

Disadvantages:

(i) increased load on treatment plant.

(ii) larger volume requires to be lifted.

(iii) Heavy rains may cause over flow and thus create a nuisance

(iv) storm water is polluted unnecessarily.

(v) More difficult to treat the waste water to high quality standard.

(vi) Flow during the dry period may cause difficulties in maintaing minimum flow.

2007/06/05

3. Partially combined or partially seperate system: In this system only one sets of sewer's is laid to carry sanitary sewage as well as storm water during low rainfall. During heavy rainfall excess storm water is carries seperately e.g. through open drains to natural channels.

Advantages:

(i) size of sewer is not very large.

(ii) Advantages of both seperate and combined systems.

(iii) Minimal solid deposition problem.

(iv) Problems of storm water discharges from homes is simplified.

Dis advantages:

(i) Velocity of flow may be low during the dry period.

(ii) Increased load on pump and treatment unit.

2018, 2014, 2012

Write down the conditions favourable for seperate system.

1. In flat areas a seperate system is economical as deep excavation is not required.

2. When sufficient funds are not avaiable for two sets of sewer system, only a sanitary sewage may be installed.

3. Where rainfall is not uniform throughout the year a seperate system is suitable.

4. In areas near rivers or streams, only a sanitary system may be installed.

5. Where pumping is required at short interval.

6. In rocky areas where large combined systems may be difficult to install.

7. If sewers are to be laid before actual development of the area, a seperate system is desirable.

2012

田 Write down the conditions suitable for combined system:

1. where rainfall is uniform throughout the year, a combined system is economical.

2. where pumping is required for both sanitary sewage and storm water.

3. where sufficient spaces is not avaiable for two seperate sets of sewer systems.

2018

田 Describe the types of sewers briefly with neat sketches:

1. Building sewer: Also called house connection, are used to convey wastewater from the buildings to lateral or branch sewers or any other sewer except another building sewer.

2. Lateral or Branch sewers: Lateral sewers forms the first element of a community sewage collection system and are usually in streets. They are used to collect sewage from one or more building sewers and convey it to a main sewer.

3. Main sewers: Main sewers are used to convey sewage from one or more lateral sewers to trunk sewers or to interceptor sewers.

4. Trunk sewers: These are large sewers that are used to convey sewage from main sewers to the treatment or other disposal facilities or to large intercepting sewers.

5. Intercepting sewers: These are larger sewers that are used to intercept a number of main or trunk sewers and convey the waste water to treatment plants or other disposal facilities.

6. Out fall sewers: These are the segments of main or trunk or interceptor sewers which lie between connections and the final point of disposal or treatment plant.

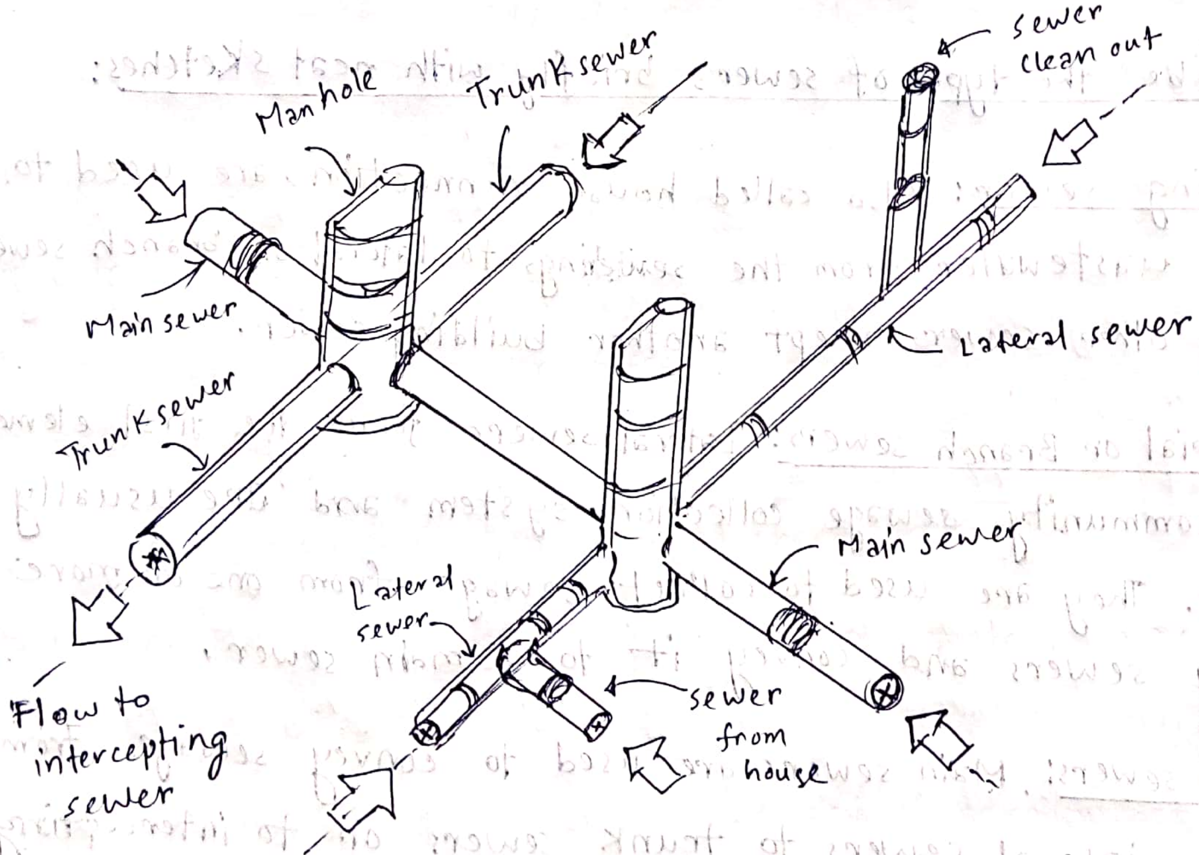


Figure: Definition sketch of different types of sewers. (Peavy et. al, 1986)

田 Write down the objectives of the design of a sanitary sewer system :

1. To ensure ease of operation.

2. To minimize maintenance requirements.

田 Write the factors that should be considered in the design of a sewer system.

Two major factors to be considered in the design of a sewer system are;

(i) The quantity of waste water flow

(ii) The flow hydraulics.

2012, 2018

田 Discuss briefly the factors that influence the estimation of waste water.

A sanitary sewer system is designed as a seperate system, which is inteded to recieve domestics, commercial and industrial waste waters and ground water infiltration. The quantity of waste water in sanitary sewer systems is influenced by the following factors:

1. Population estimate.
2. Rate of water supply.
3. Type of area served.
4. Ground water infiltration.

(1) Population estimates: The population that may be expected to live within an area at some future date will determine the quantity of waste water flow from that area. It is therefore important to make an assessment of the future population before it is possible to estimate the probable waste water flow. Population estimates are often made by using the following equation

$$P_n = P_o (1+r)^n$$

(2) Rate of water supply: Sanitary sewage and industrial wastes are derived principally from the water supply. It is fairly common to assume that the average rate of sewage flow is equal to the average rate of water consumption.

The quantity of sewage will be affected by factors affecting water use:

(i) characterestics of the population.

(ii) metering of water supply.

(iii) other factors e.g. climate, quality, pressure etc.

(3) Ground water infiltration: The presence of high water table results in leakage into the sewers, and in an increase in the quantity of waste water.

The rate and quantity of infiltration depends on a number of factors:

(i) Sewer size.

(ii) Materials of sewers.

(iii) length of the sewer below ground water table.

(iv) Nature and types of soil.

(v) Types of joint.

Components of Design Flow:

The unit quantities of waste water for which the sewer sizes have to be designed are called Design Flows and consist of the dry weather flow and the wet weather flow.

The waste water flow is not uniform throughout the day and through out the year.

It varies during the day due to the varying use of water for domestic, commercial and industrial purposes.

Variations through out the year is due to seasonal variation of rainfall and its intensity.

Due to such variations in waste water flow, the following terms are used.

1. **ADWF:** ADWF is the average of the daily dry weather flow to the sewer system when not affected by storm infiltration and reflects the waste water discharges from domestic, industrial and commercial fixtures.

2. PDWF: ~~PDWF~~ The waste water flow during the day is not uniform. During normal daily flows, two distinct peaks usually occur — the morning peak and the evening peak.

3. PWWF: PWWF is ~~the sum of~~ the maximum flow to be considered in designing the capacity of sewers. and is the sum of Maximum peak dry weather flow plus the storm contribution during wet weather period.

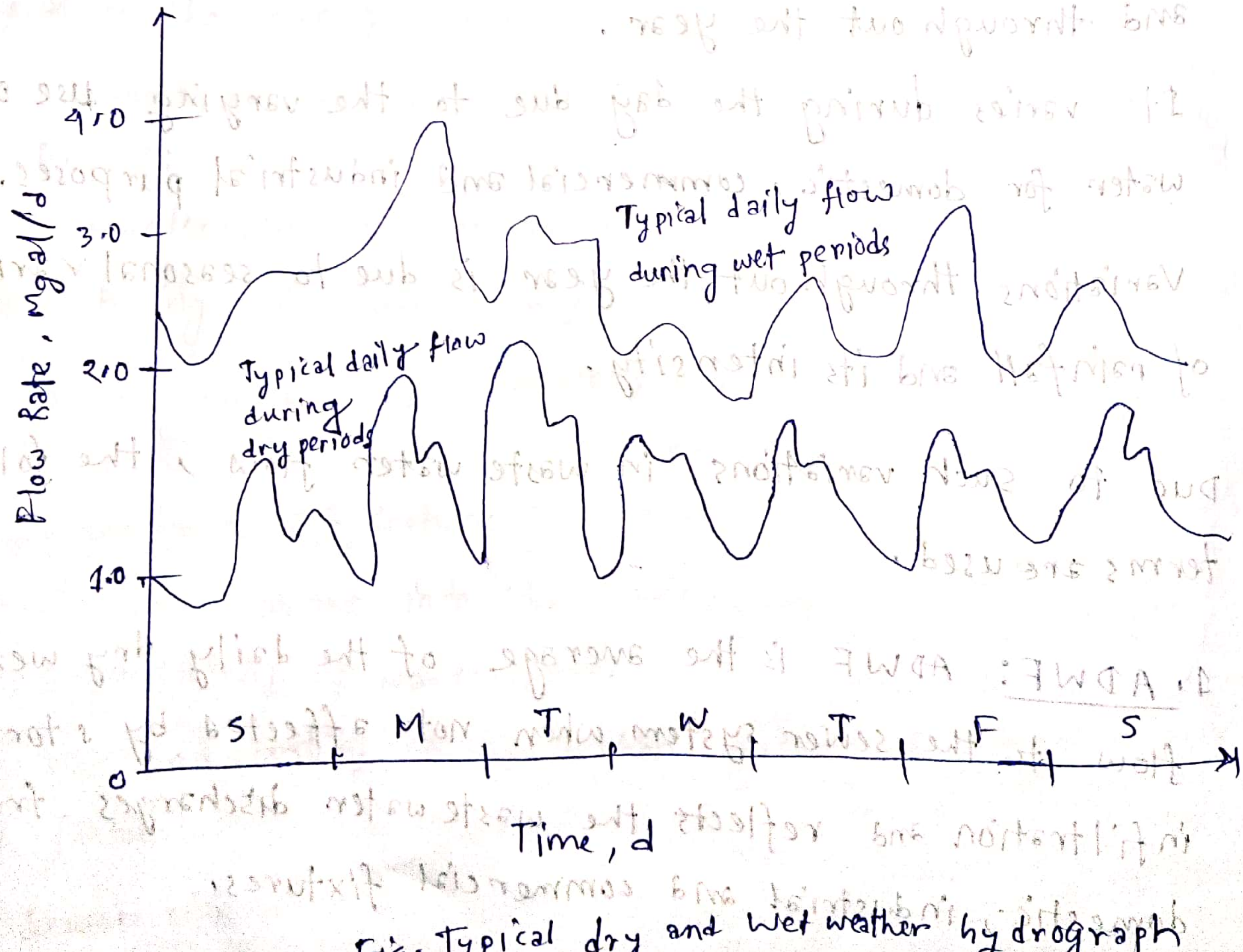


Fig. Typical dry and wet weather hydrograph

2018, 2014

Describe the procedure of estimating design water flow.

The procedure of estimating design flow presented here is based on a rational approach fllowed by the Melbourne and Metropolitan Board of works (MMBW, 1981).

1. The design flow consists of the sum of the PDWF plus wet weather additive and may be expressed as:

$$Q = \Sigma D \cdot d + \Sigma I \cdot i$$

where, ΣD = sum of all dry weather flow components.

d = peak dry weather factor.

ΣI = basic wet weather additive.

i = appropriate infiltration factor. varies from 1 (for small areas) to 0.5 (for large areas)

sewers are usually designed to have a capacity $\geq Q$

2. The average daily dry weather flow is calculated as the sum of the flows from different types of land use from all individual parts of the catchment

$$\Sigma D = P \cdot q_r + A_c \cdot q_c + A_i \cdot q_i$$

where, P = population

q_r = residential discharge rate (say, 100-400 lpcd)

A_c = commercial area.

q_c = commercial discharge (say 0.25 – 1.5 l/sec/ha)

A_i = industrial area.

q_i = industrial discharge rate (say 0.25–0.35 l/sec/ha.)

3. Values of 'd' may vary from 3.0 for small areas to 1.7 for larger areas.

4. The basic weather additive may be expressed as:

$$\Sigma I = A_r K + A_c \times \frac{K}{4} + A_i \times \frac{K}{4}$$

where, K = ground constant

K depends on many factor. It varies with different ground types, It also varies with density of residential areas, type of sewer joint and different types of land use.

Self cleansing velocity requirement:

The minimum velocity at which no solid deposition takes place in sewer section is called self cleansing velocity.

The usual practice for the hydraulic design of circular sewers is to maintain a minimum velocity for achieving the self-cleansing action and in general minimum velocity of 0.6 m/sec.

Because of the fluctuations in waste water flows, it is not possible to maintain self cleansing velocity at all times, and during minimum flow conditions the velocity will be much less.

⊞ Non scouring velocity:

The maximum permissible velocity at which no such scouring action takes place is known as non-scouring velocity.

The non scouring velocity depends on sewer materials.

Recommended non scouring velocites are:

2.5 - 3.0 m/sec for concrete sewer.

3.0 - 3.5 m/sec for vitrified sewer.

2.0 - 2.5 m/sec for brick sewer.

3.5 - 4.0 m/sec. for cast iron sewer.

⊞ Hydraulic design of sewers:

Sewers are designed for gravity flow of waste water. there are various emperical formulae which are used in the design of sewers e.g. Chezy's formula, Manning's formula, Bazin's formula, Hazen & William's formula and so on.

However Manning's equation is the most commonly used formula in the design of sewers. Manning's equation for velocity determination is —

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

and The discharge is,

$$Q = AV$$

where, V = velocity, m/sec.

n = friction factor or Manning's roughness co-efficient varing from 0.013 – 0.015

R = Hydraulic radius

S = slope of the energy grade line.

SMALL BORE SWERAGE SYSTEM (SBS)

What is SBS system?

Small Bore sewerage system is an alternative low cost sewerage system of high cost traditional water borne sewerage system by introducing septic tank in between sanitation facilities and sewage collection and transportation system.

This is a recent sanitation technology that offers all the advantages of the conventional water borne sewerage system but at a much low cost than conventional ones.

Describe briefly the elements of SBS system with necessary sketch.

There are three basic elements to a small bore sewerage system. These are:

1. septic tank.
2. small bore sewer network.
3. Treatment plant.

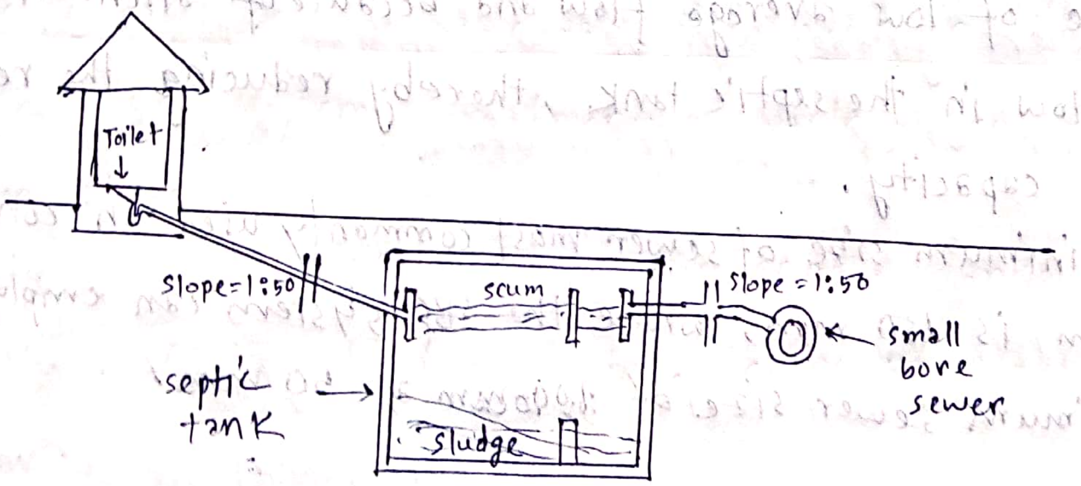


Fig. Elements of small bore sewerage system,

(E) Discuss briefly SBS sewer reticulation:

The important parameters that bring significant changes in the design of the SBS collection system are;

1. Design Flow
2. Sewer sizes
3. sewer gradient
4. Manholes and flushing point.

1. **Design flow**: Estimation of the waste water flow is an important factor in the overall design of a sewerage system.
over-estimation of the flow usually results in the sewerage system being over-designed, where as under-estimation may result in system failure.
Considerable care has therefore, to be exercised in estimating the design flow.

2. **Sewer Diameter**; In the SBS system, sewer sizes are smaller because of low average flow and because of attenuation of peak flow in the septic tank, thereby reducing the required sewer capacity.
The minimum size of sewer most commonly used in conventional system is 150 mm, while the SBS system can employ a minimum sewer size of as low as 50 mm.

3. Sewer gradients: The grades of conventional sewer are established to produce self cleansing velocities in order to avoid solid deposition in the sewer. In the SBS system, since the settleable solids in the waste water are retained and suspended solids are reduced significantly in the septic tank, it is not necessary to maintain self cleansing velocity in the sewer system. As a result the grades can be substantially reduced thereby reducing the volume of excavation to a great extent.

4. Maneholes and Flushing points: The SBS system requires less maintenance due to minimal solids content of waste water. There fore; a fewer number of manholes are installed. Flushing points are used in the system at locations where the manholes would other wise exist.

Briefly describe the waste water treatment in SBS system.

In the SBS system, treatment of waste water is performed in two stages.
Firstly, on site treatment in the septic tanks and secondly, off site treatment in a series of stabilisation lagoons.

In the septic tanks the larger particles and the settleable solids are retained, and the BOD and the suspended solids are significantly reduced. About 46 % to 60 % BOD is removed in the septic tank.

To attain a certain effluent quality, the primary effluent from the septic tanks is treated in a series of stabilization lagoons. Treatment in stabilization lagoons is simple, effective and low-cost due to lesser land area required for the SBS system.

2016, 2014, 2013

Write down the technical advantages of SBS system.

The small bore sewerage system has specific technical advantages over the conventional sewerage system as listed below:

1. sewer sizes can be reduced.
2. sewer grades can be substantially reduced.
3. sewer blockages are minimal as septic tanks retain most of the solids content.
4. volume of excavation is considerably reduced because of smaller sewers and lower sewer grades.
5. solids handling at secondary treatment site is minimum
6. Rapid construction is possible because of lesser volume of excavation and fewer number of manholes to be constructed.

2016, 2014, 2013

Write down the economic consideration of SBS system.

Although the basic principles of both the SBS system and the conventional sewerage system are similar, there will be differences in the initial capital costs and the annual maintenance costs between two systems.

Initial capital costs: A reduction in the capital costs in the SBS system due to:

(i) reduction in sewer sizes.
(ii) reduction in minimum grades.
(iii) reduction in the volume of excavation.
(iv) reduction in the number of mane holes.
(v) reduction in the hydraulic and organic loading of waste water.
(vi) less costly pumps with minimal solids handling required.

An increase in the capital costs in the SBS system due to -

(i) installation of septic tank.
(ii) installation of flushing points.

Annual maintenace cost: An reduction in the maintenance cost due to :-

(i) fewer manholes.

(ii) less frequent cleaning of sewer.

(iii) no sludge handling is required.

An increase in the maintenance costs in the SBS system due to —

(i) desludging of septic tanks 3 to 5 times per year.

(ii) regular flushing of sewers.

2011, 2008

Q. Justify the scope of introducing SBS system in Bangladesh.

In the absence of expensive conventional sewerage systems, septic tanks and pour-flush sanitation system are largely used in urban centers, including the major cities of Bangladesh. However, septic tank effluent disposal has generally been very poor. It is not uncommon to see, particularly in the country townships, septic tank effluents being discharged into open ditches without being aware of the effluent quality and their detrimental effects on the living environment.

Even in large cities, due to adverse ground conditions and high ground water table particularly during wet periods, septic tank effluent can not be disposed of properly. Septic tank effluent soakage constitute active sources of ground water pollution.

Application of small bore sewage systems has recently been initiated in Bangladesh. Several SBS schemes have been installed in low-income housing, areas at Mirpur in Dhaka. The first signs of SBS systems use in Bangladesh is certainly encouraging.

However important aspects that require careful consideration for successful application of SBS system:

(i) proper design and construction of interceptor tanks and sewer network.

(ii) regular desludging of interceptor tank.

(iii) prohibition of illegal connection to the SBS sewer network.

(iv) proper treatment of collected effluent before final disposal.

2011, 2008

四 Differentiate between conventional sewerage system and small bore sewerage system.

Conventional Sewage System	Small bore sewerage System
1. large diameter sewers are used	1. smaller diameter sewer is used
2. It is necessary to maintain self-cleansing velocity in the sewer system.	2. It is not necessary to maintain self-cleansing velocity in the sewer system.
3. High sewer grade is required compared to SBS system	3. low sewer grade can be provided.
4. Large volume of excavation is required compared to SBS.	4. Volume of excavation is reduced in SBS system
5. It require high maintenance.	5. It requires less maintenance.
6. It may require more number of man holes compared to SBS.	6. It requires fewer number of man holes.

Simplified Sewerage System

What is simplified Sewerage system?

Simplified sewage, also called shallow sewarage, is low-cost sanitation technology particularly suited to high density, low-income urban areas in developing countries.

It is designed to recieve all household waste water without settling in solid interceptor tanks or septic tanks as is done in the case of SBS systems.

It is essentially similar to conventional sewarage, but without any of the later's conservative design features.

Small diameter sewers used to convey the sewage are laid at shallow gradients.

These sewers are often laid inside housing block, where the system is known as condominal sewerage. They may also be laid outside the housing block, usually under side walk rather than in the middle of the road.

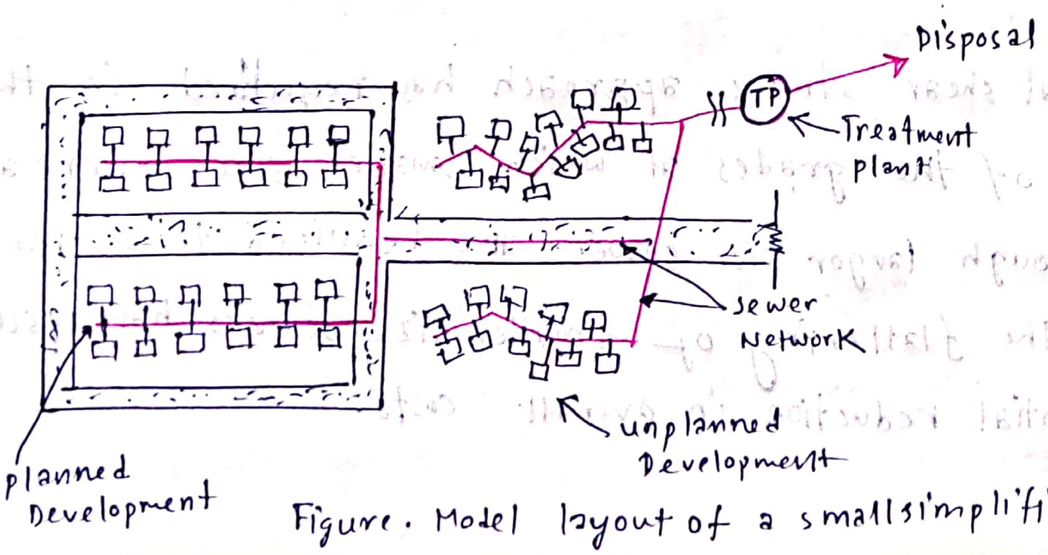


Figure. Model layout of a small simplified sewarage scheme

Outline the design principles of simplified sewerage system.

Sewer design must be such that deposition of organics and other materials is minimized to avoid blockage of the sewer line. As such, sewers are graded to attain self cleansing velocity to avoid deposition.

A recent trend is to apply a critical shear stress (tractive tension) approach instead of minimum velocity theory in the hydraulic design of sewer. The critical shear stress of sediment particles is considered as the minimum shear stress necessary for the initiation of motion of particle. Its magnitude depends on a number of factors including the densities of the particle and the fluid, the size of the particle and the viscosity of the fluid.

The average shear stress over the critical area of the wetted perimeter must be equal to or greater than $1.47\ N/m^2$

The critical shear stress approach has resulted in the flattening of the grades at which smaller size sewers are laid. Although larger size sewers are required to be more steeply. The flattening of smaller size sewers has resulted in substantial reduction in overall costs.

The design of simplified sewerage (in Brazil) is based on a tractive tension of 1 N/m² and a minimum flow depth of 0.2 relative of the sewer diameter.

The design slope is thus determined by:

$$I_{min} = 0.0056\ Q_i^{-\frac{6}{13}}$$

where, I_{min} = minimum sewer slope, m/m

Q_i = initial waste water flow, litres / sec.

Based on the minimum sewer grade, the diameter of the sewer is determined using the projected final flow and limiting the ratio of depth of flow to the sewer diameter,

$d/D \le 0.8$

In simplified sewerage, the usual limits for d/D is $0.2 < d/D < 0.8$.

A hydraulic design chart for simplified sewers based on Manning's equation, simplifies the determination of sewer diameter by relating d/D to $Q_f/I_{min}^{0.5}$ and $V/I_{min}^{0.5}$, where Q_f is the final flow in m3

The exact or a nearer value of $Q_f/I_{min}^{0.5}$ is located in the design chart where d/D does not exceed 0.8.

The final velocity V_f is computed from the corresponding $V/I_{im}^{0.5}$ value in the chart.

Describe the suitability of simplified sewarage system.

Simplified sewarage systems offer a new cost saving approach primarily based on rational changes in conventional sewer design standard. Experiences have shown that:

1. Simplified sewerage could be a viable lower-cost alternative to conventional sewerage systems particularly for the developing countries.

2. Design modifications in simplified sewerage are based on sound engineering principles without jeopardizing the level of service.

3. cost could be 30 to 50% less than conventional sewerage thus allowing service coverage to be expanded.

Scanned by CamScanner

CONSTRUCTIONS OF SEWERS

2018, 2014, 2013

☐ Write down the steps to be followed for construction of sewarage system.

or, Describe the laying and Testing procedures of sewers.

1. Collection or preparation of map of community that to be served.
2. Preparation of Layout map of sewer network following the road network.
3. Investigation of subsoil if necessary by excavating the bore holes along the network.
4. selecting the suitable location of manhole.
5. setting the center line of sewer network on the ground according to map.
6. Mark the center line by driving pegs at interval of 7.5 m or 15 m.
7. Excavating the trench following the center line.
8. Protecting the side of trench with timber if necessary.
9. Dewatering from the trench if water met during excavation with suitable method.
10. Providing concrete bedding of sewer if bottom of trench is soft.
11. Laying the sewer segments in the trench.
12. joining the sewer.
13. checking of sewer.
14. Filling of Trench.

Q. Describe the method of setting the center-line of sewer network.

Two methods are employed for the purpose of setting the center line:

First Method:

A line parallel to the sewer is marked on one side. This is known as an offset line and it is usually marked at a distance of D which is about one-half the trench width plus 600 mm.

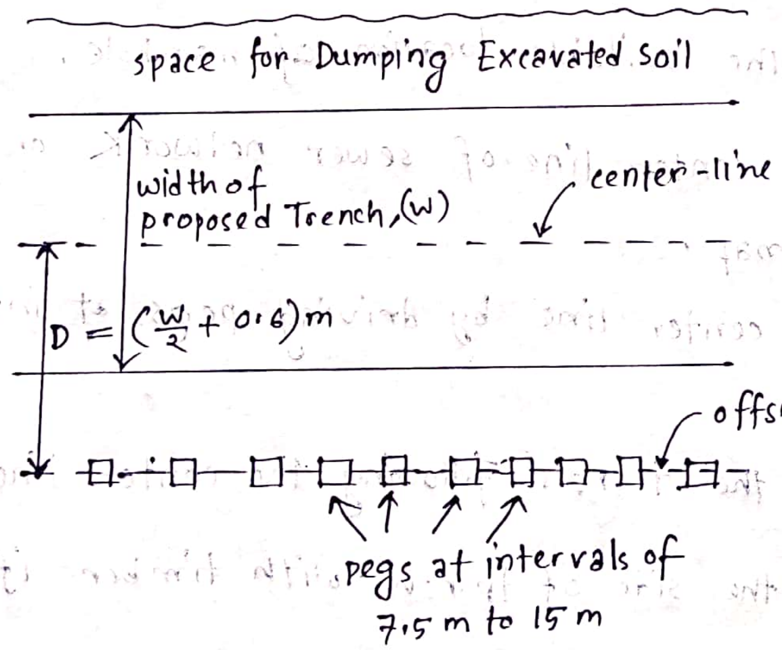


Fig. Offset Line Method

The temporary bench mark at the intervals of about 200 m to 300 m should be established along the center line by carrying the levels from a permanent bench mark.

The offset line helps in locating the sewer center line when excavation is carried out to lay sewers.

Second Method:

Two vertical posts are driven in to the ground at a known distance from the centerline peg.

One horizontal rail, known as the slight rail, is fixed between these posts at a convenient height from the ground level.

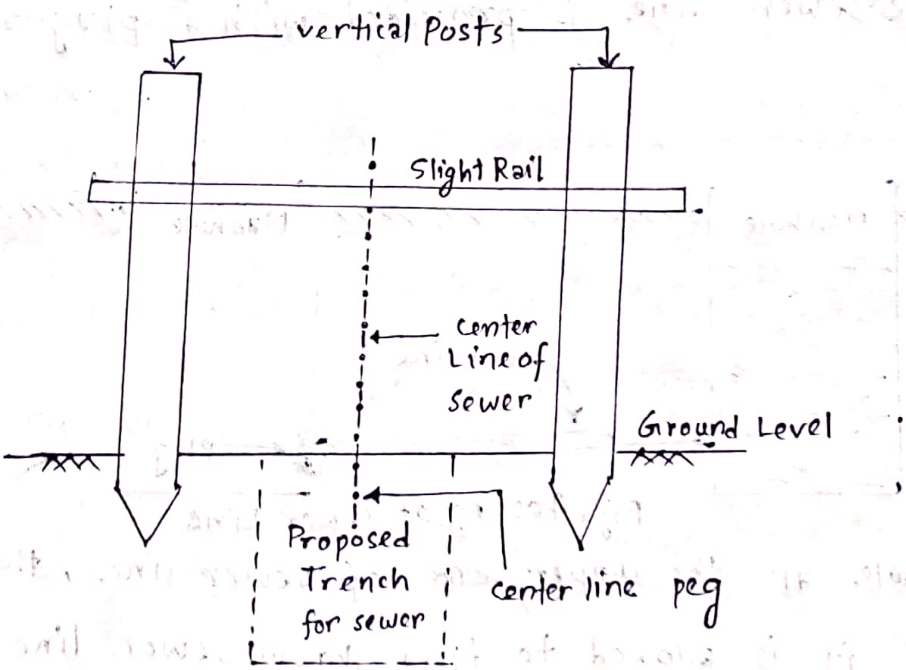


Fig. Slight Rail Method

⇒ The first method is adopted for short duration of time, mainly to avoid inconvenience to traffic when excavation of trench is going on.

⇒ The second method is to be adopted for all cases for taking the levels of invert of proposed sewer line.

2018

Q. How can you check the appropriateness of depth of excavation and joint of sewer segment?

joints of sewer segment checking:

To carry the test for water tightness of joints, A length of sewer line between two man holes is taken and the lower end of the sewer line is provided with a plug as shown in figure:

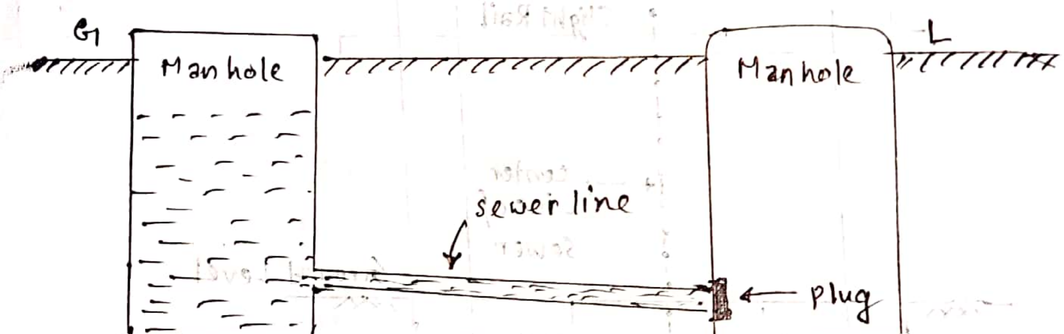


Fig. Testing of sewer Line

In the man hole at the upper end of sewer line, the water is filled in and it is allowed to flow throw sewer line. The depth of water in the man hole is maintained at about 1·50 m.

The sewer line is watched by moving along the trench and the joints which have sweated are repaired.

Depth of excavation checking:

In order to check up the invert levels of sewer's, the boning rod or traveller is used.

The boning rod consists of cross head at top and shoe at bottom as shown in figure:

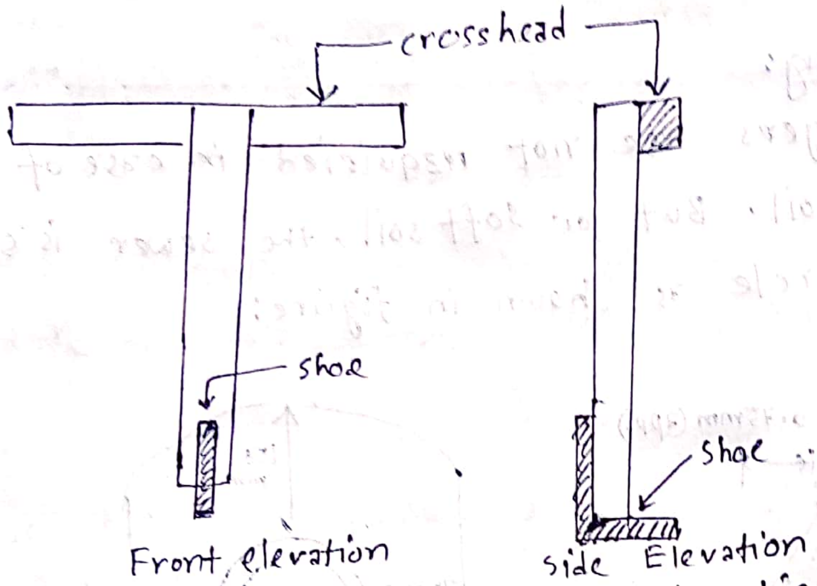


Fig. Traveller or boning rod.

A string or cord showing the center line of sewer is fixed between two slight rails, as shown in figure:

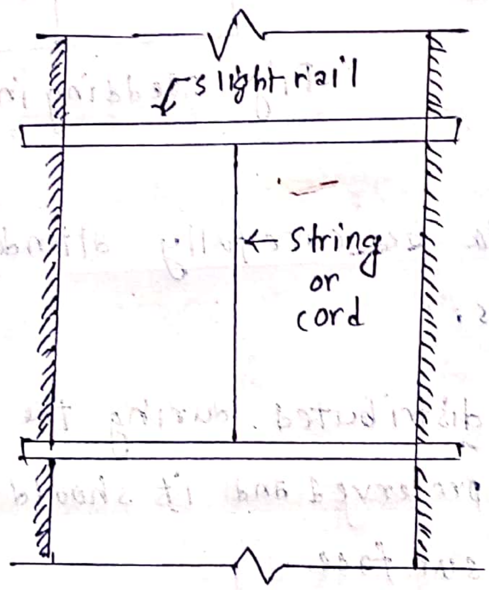


Fig. Plan of trench for sewer

The boning rod is placed with its shoe touching the invert of sewer. The verticality of boning rod is checked by hanging a plumb bob from top.

If the top of boning rod is touching the string or cord; the sewer is laid at proper gradient.

Method of Bedding:

The bedding layers are not requiried in case of of rocky or hard soil. But for soft soil, the sewer is supported on layers of concrete as shown in figure:

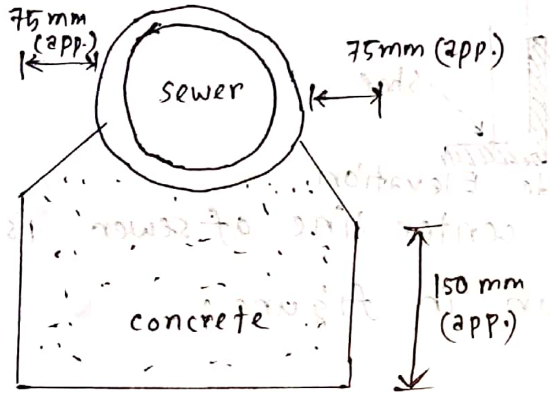


Fig. Normal Method of Bedding.

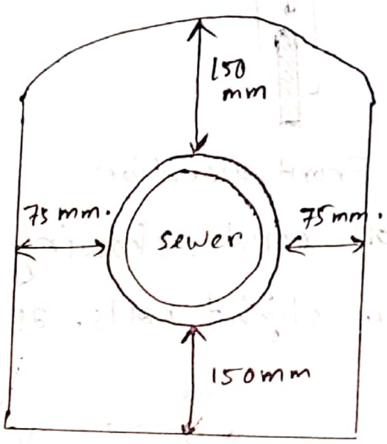


Fig: Bedding in soft soil

2013

State the points to be carefully attended/noted during the laying of sewers.

1. The metal of road distributed during the laying of sewer line should be carefully preserved and it should be reused while re-installing the road surface.
2. The sewer line may be laid preferably near the center line of road.
3. The sewer line should be provided with suitable appurtenance as required.
4. whenever possible, the sewer line should avoid electric cables, foundations of structures, water pipe lines etc.

2016, 2014

Q. Briefly Describe the factors are to be carefully considered for the selection of sewer materials.

1. Cost: The cost of the material of sewer should be moderate and reasonable.

2. Durability: the material of sewer should be durable so that the replacement of sewers is not carried out too frequently.

3. Imperviousness: The material should be impervious in nature.

4. Resistance to abration: The material for sewer should possess enough resistance to abrasion.

5. Resistance to corrosion: The material of sewer should capable of offering resistance to the corrosion.

6. Strength: ~~The sewers are generally laid under~~ The material of sewer should be strong enough to bear heavy external loads in addition to the internal stresses.

7. Weight: The material of sewer should possess moderate weight so as to make easy the handling and carrying of sewers.

2013

Q. Briefly discuss the sewers of different materials.

Following are the various materials which are used for sewers:

1. Asbestos cement sewers: These sewer are made from a mixture of asbestos fiber and cement.

2. Brick sewers: The earliest forms of sewers were made of bricks. At present, they are not favoured mainly because of involving more labour in the construction of such sewers.

3. cast-iron sewers: The cast iron sewer possess high strength and they are durable.

4. cement concrete sewers: The cement concrete sewer may be plain or reinforced.

5. corrugated iron sewers: The corrugate iron sewers are mainly used for carrying storm water only.

6. plastic sewers: The use of plastic as sewer material is still in elementary stage. It has becoming more popular for carring water than carrying sewage.

7. steel sewers: The steel sewers are used mainly at places where imperviousness, lightness and resistance to high pressure is required.

8. stonware sewers: The stoneware sewers are also known as the vitrified clay sewers or salt-glazed sewers. They are prepared from clays and shales.

2006

Why circular section is considered better than other sections.

1. It affords the least perimeter and hence the construction material required is minimum.

2. There are no corners and hence the chances of deposition of organic matter are reduced to the minimum.

3. They are easy to manufacture or construct and handle.

4. They are subjected to hoop compression and hence for concrete sewers, the concrete required is minimum.

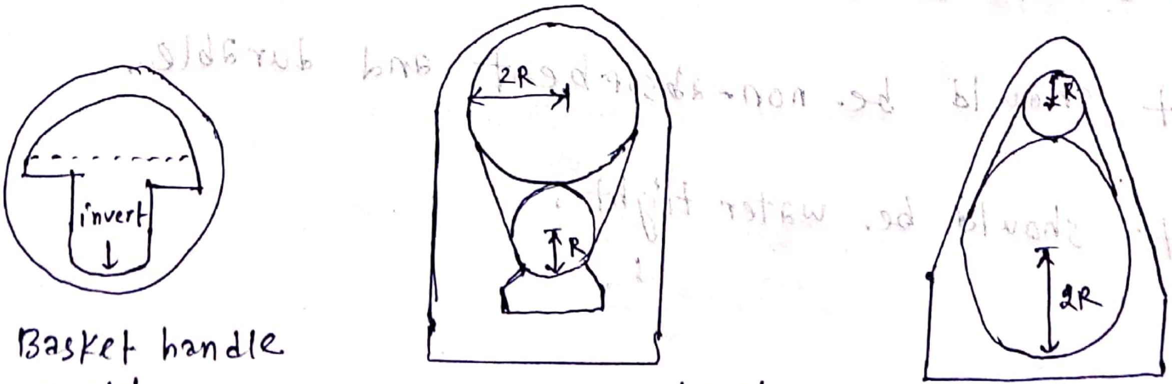
5. They possess excellent hydraulic properties.

For what reasons non-circular sewers are used?

1. To bring down the cost of construction.
2. To improve the velocity of flow.
3. To secure more structural strength.
4. To simplify the process of construction.

2011, 2006

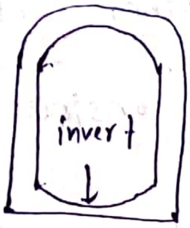
Non-circular shapes that are used for sewers:



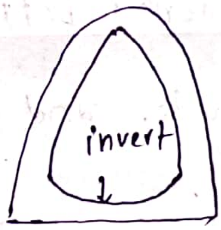
(1) Basket handle section

(2) standard egg-shaped section

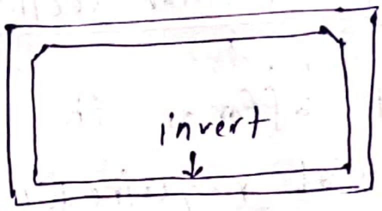
(3) Inverted egg-shaped section.



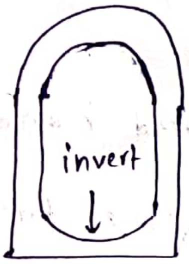
(4) Horse-shoe section



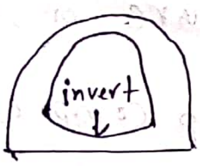
(5) Parabolic section



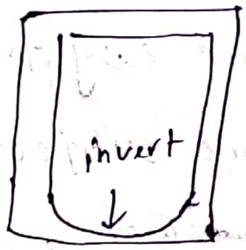
(6) Rectangular section



(7) semi-circular section



(8) semi-eleptical section



(9) U-shaped section.

Ⓗ Requirements of a good sewer joint:

1. It should be capable of resisting the effect of acidic, alkaline or gaseous actions of sewage.
2. It should be cheap and economical.
3. It should be easy to construct.
4. It should be flexible in nature.
5. It should be non-absorbent and durable.
6. It should be water tight.

2018

Discuss different types of sewer joints with necessary sketches.

Depending upon the manner of making a joint, the following are the five types of joints:

(1) Cement mortar joints:

In this type of joint, the cement mortar of proportion 1:1 or 1:2 is inserted between the spaces of the bell end and spigot end.

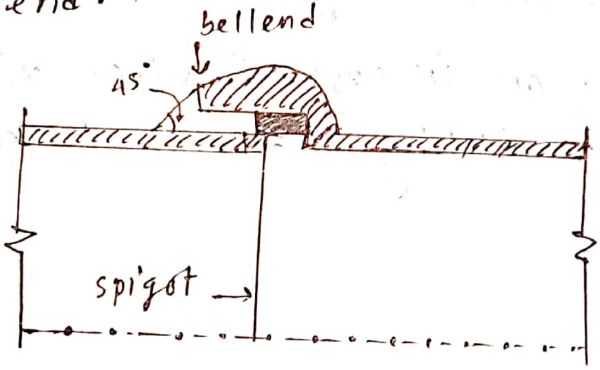


Fig. cement mortar joint

(2) Collar joints:

In this type of joint, the ends of sewer are plain. The ends of sewer are placed near each other and then a collar of slighty bigger diameter is placed over the ends of sewer. These joints are used for large diameter sewers.

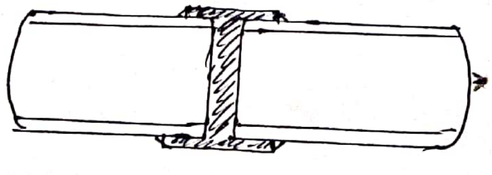


Fig. collar joint

(3) Flexible or Bituminous joints: In this type of joint, the bitumen is used instead of cement mortar. These joints are flexible.

(4) Mechanical joints: In this type of joint, the mechanical devices such as flanged rings, bolts etc. are used to keep the two ends of sewer together.

(5) open joints: In this type of joint, the ends of sewer are placed together or in case of pipes with bell and ~~and~~ spigot ends, no filling material is inserted in annular space formed between bell and spigot ends.

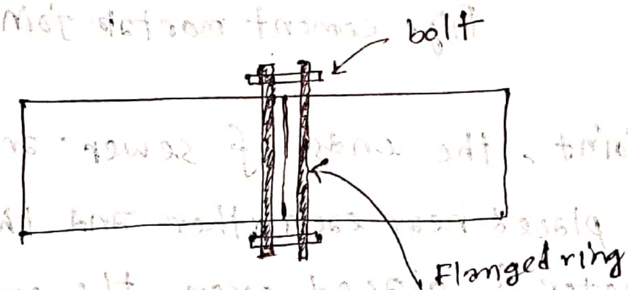
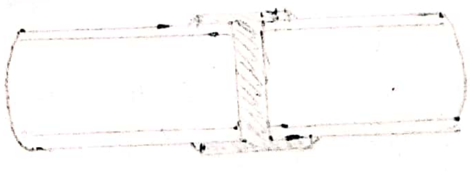


Fig. Mechanical joint



PRIMARY TREATMENT OF SEWAGE

Classification of Treatment of sewage:

The treatment of sewage is classified broadly into the following three categories:

(i) Primary Treatment.

(ii) Secondary Treatment.

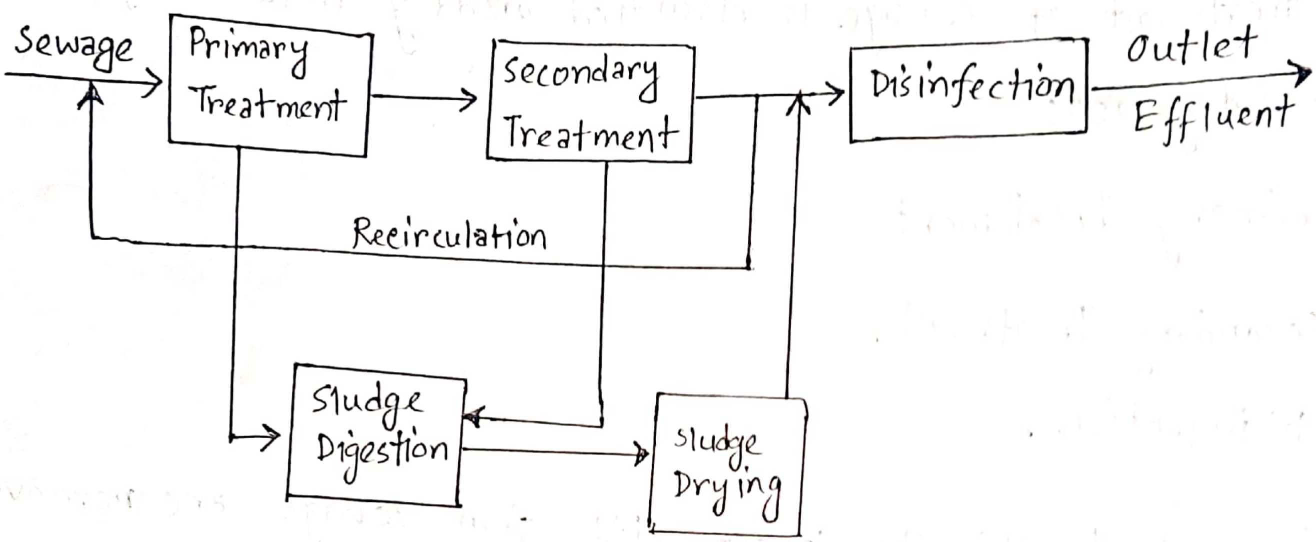
(iii) Disinfection.

1. Primary Treatment: The larger solids from sewage are removed during the treatment process. The more complex compounds are broken up and converted to simple compounds by decomposition.
Primary treatment unit includes screens, grit chambers, detritus tank, skimming tanks and sedimentation tanks, with or without the use of chemicals.

2. Secondary Treatment: The sewage is treated exhaustively and it is completely purified by filtration or activated sludge process.

3. Disinfection: This is an auxiliary or additional treatment. The disinfection is generally carried out by chlorination to kill some of the bacteria which remains in the effluent of sewage.

Typical Flow Diagram of Sewage Treatment



Screen

Purpose: The main purpose of the installation of screens is to remove the floating matter of comparatively large size. Screens are provided to prevent the pumps and other equipments from possible damage due to floating matter of sewage.

Location: The screens should preferably be located just before the grit chambers. The screens are usually placed in an inclined position with an angle of of about 30° to 60° with the direction of flow.

Types: The screens are classified in three ways:

1. Based on size of openings:

(i) Course screen: spacing between bars is about 40 mm or more.

(ii) Medium screen: spacing between bars is about 6 mm to 40mm.

(iii) Fine screen: spacing between bars is less than 6 mm.

2. Based Upon the fixing Arrangement:

(a) Fixed or stationary screens: These screens are permenently set in position.

(b) Movable screens: These screens are stationary during their operating period. But they can be lifted up and removed from their position for the purpose of cleaning.

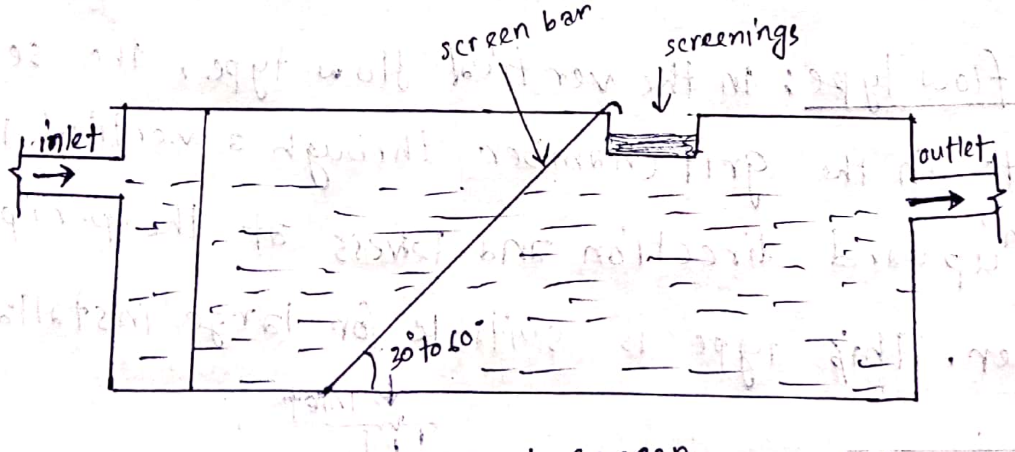


Fig: Fixed screen

3. Based upon the method of cleaning:

(a) hand cleaning and (b) Machine or mechanical cleaning.

Grit Chambers

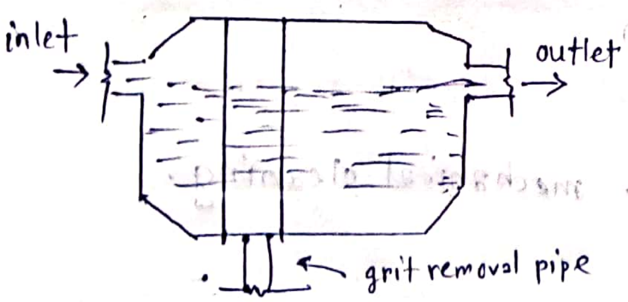
Purpose: The purpose of providing grit chamber in the sewage treatment process is to remove grit, sand and such other inorganic matter from sewage.

Location: In general, the grit chambers are placed after pumping stations and before the screens. But there is no fixed rule regarding the location of grit chambers.

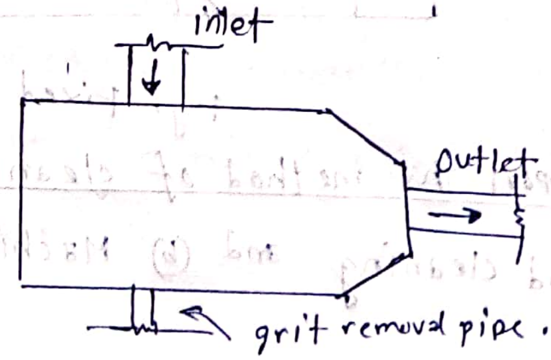
Types of Grit Chamber: The grit chamber may be of horizontal flow type or vertical flow type.

1. **Horizontal flow type:** This type is more popular and it is generally adopted. In the horizontal flow type, the sewage enters and leaves the grit chamber in the horizontal direction.

2. **Vertical flow type:** In the vertical flow type, the sewage is brought in the grit chamber through a vertical pipe. It flows in upward direction and leaves at the periphery of chamber. This type is suitable for large installations.



• Horizontal flow type



vertical flow type

Scanned by CamScanner

Design Aspects of Grit chamber:

(1) Cleaning interval: It usually varies one to two weeks.

(2) Depth: Typically a grit chamber may have a depth of 3-4 ft.

(3) Length: A length of about 40 to 60 ft should be provided.

(4) Detention period: The grit chambers are designed for a detention period of 30 to 60 sec.

(5) Velocity of flow: The velocity of flow in grit chamber is kept between 200 mm to 300 mm per second.

A chamber with a depth of 4 ft, a length of 60 ft and a detention period of 45 second would remove all the particles having settling velocity greater than 0.088 fps. This corresponds to all particles larger than about 0.02 mm.

Detritus Tank

Purpose: The purpose of detritus tank is the same as that of a grit chamber. In fact, a detritus tank may be considered as a grit chamber having such velocity of flow that an appreciable amount of organic matter also settle down at its bottom together with the grit.

Design aspects:

(1) Depth: the overall depth of detritus tank varies from 2.50 m to 3.50 m.

(2) Detention period: the detritus tanks are designed for a detention period of about 3 to 4 minutes.

(3) Velocity of flow: The velocity of flow in detritus tank is kept between 200mm to 400mm per seconds, the usual provision being 300 mm per second.

The other details of detritus tank are similar to those of grit chamber.

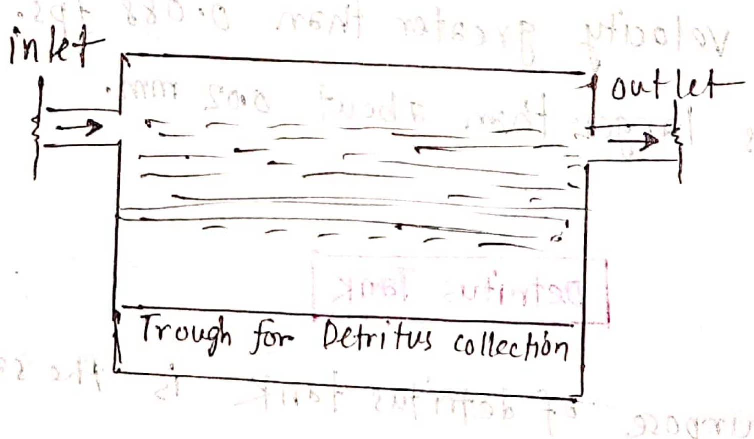


Fig. Detritus tank.

Skimming Tanks:

Purpose: The sewage contains floating substances. The object of installing a skimming tank is to remove such floating substances which include greases, soaps, wood pieces, fruit skins etc.

Design Aspects: 2015, 2012

(1) **Air diffusers:** For efficient working of the skimming tanks, the air diffusers are provided at the bottom of tanks.

(2) **Collection of floating substances:** The floating substances collected at the top of tank are removed either with hand or with the help of some mechanical equipment.

(3) **Depth:** The depth is commonly between 1-2 m.

(4) **Detention period:** The skimming tanks are designed usually for a detention period of about 3 to 5 minutes.

(5) **Shape:** The shape of skimming tank is generally elliptical or circular.

Short detention time 300 to 500 sec and high velocity of horizontal flow are commonly preferred and flocculation when necessary is promoted by the addition of chemicals such as iron and aluminium salts.

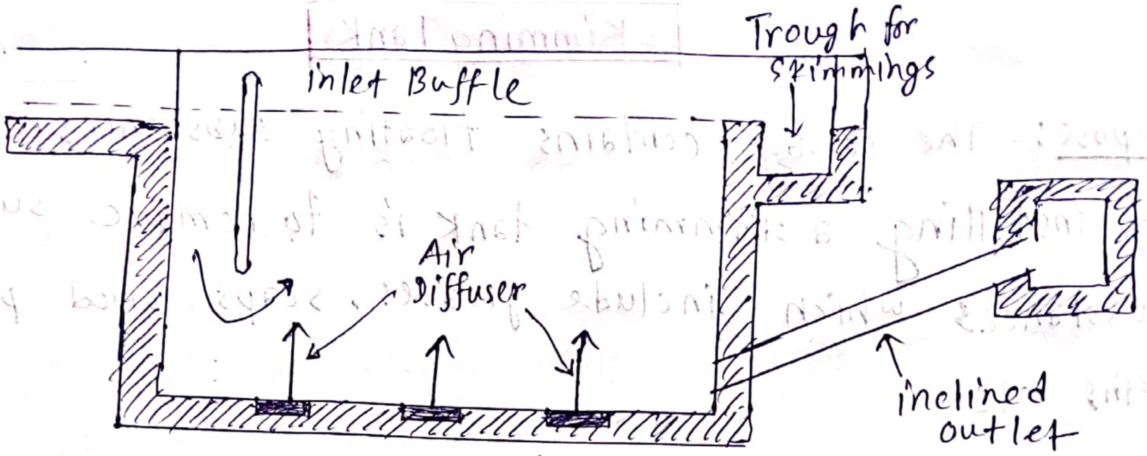


Fig. Skimming Tank

Plain Sedimentation Tank

2015, 2013

Q. What are the objectives of plain sedimentation?

The sedimentation tanks are also known as the settling tanks or clarifiers. Following are the objectives of installing sedimentation tank.

1. The process of sedimentation reduces the strength of sewage to the extent of about 30% to 35%.

2. the quality of settleable solids in the sewage is reduced to the extent of about 80% to 90%

3. There is reduction in B.O.D to the extent of about 30% to 35%.

4. the sewage after being treated in the sedimentation tanks becomes fit for the treatment process.

2015, 2012, 2008

Q) Write down the sedimentation process of plain sedimentation tank briefly.

When the velocity of flow is decreased or when sewage is allowed to stand at rest, the suspended particles carried by the sewage tend to settle at the bottom of tanks.

The material collected at the bottom of sedimentation tank is known as sludge.

The partially treated sewage is known as effluent.

Q) Describe the type of sedimentation tank Briefly.

The sedimentation tank can be classified in three ways:

(1) According to the shape and size or direction of flow:
- (i) Rectangular Tank.
- (ii) Circular Tank.

(2) According to Location:
- (i) Primary sedimentation tank or primary clarifier.
- (ii) Secondary sedimentation tank or secondary clarifier.

(3) According to nature of working:
- (i) Fill and Draw Type.
- (ii) Continuous flow Type.

Rectangular sedimentation Tank: In a rectangular horizontal flow tanks, the sewage enters at one end and leaves the other end. In rectangular tank, outlet structure is generally composed of finger launders running parallel to the length of the tank.

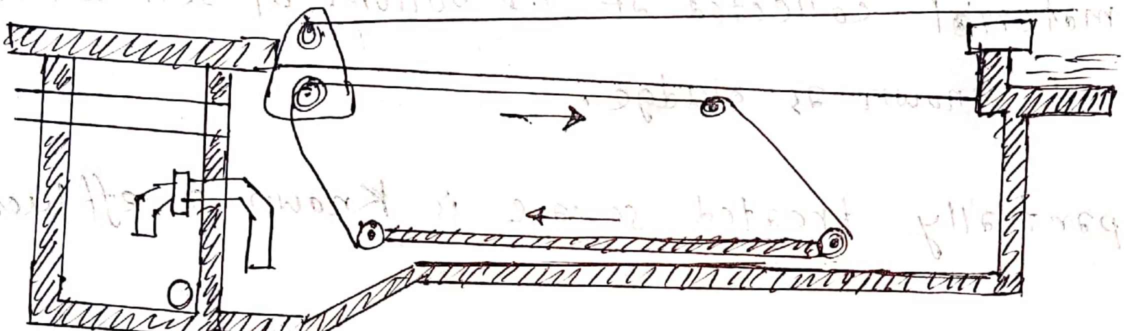
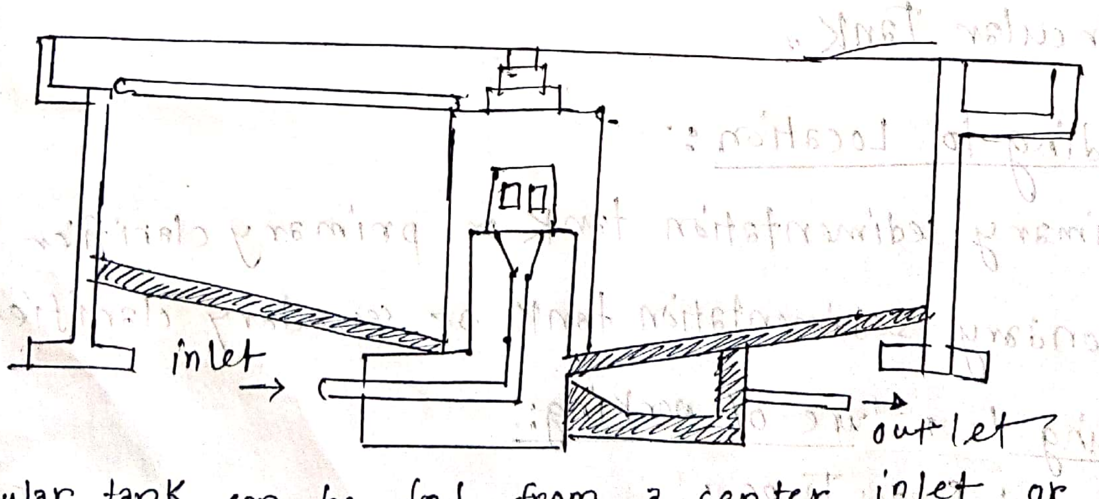


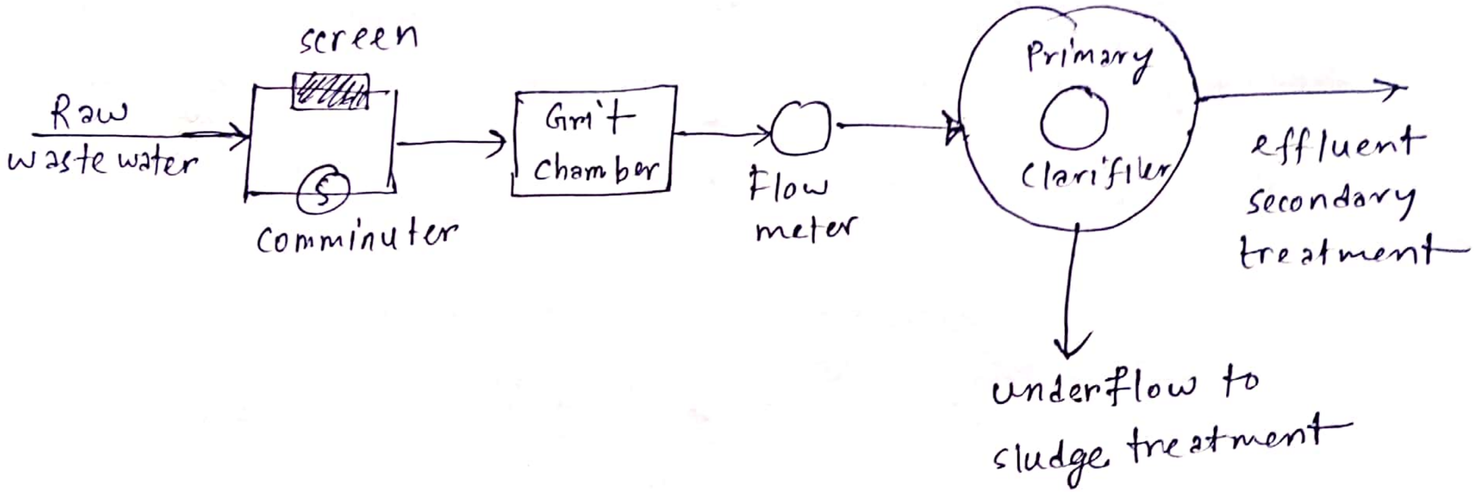
Fig. Rectangular Sedimentation tank

Circular Sedimentation tank: Sewage enters at the center and flows towards periphery. Practically circular sedimentation tanks are widely used.



Circular tank can be fed from a center inlet or from multiple peripheral ports or peripheral launders.

[5] Draw typical flow Diagram of primary treatment process.



Secondary Treatment of Sewage

Secondary Treatment:

Secondary treatment usually consists of biological conversion of dissolved and colloidal organics into biomass that can be subsequently be removed by sedimentation.

The main function of secondary treatment of sewage is to convert the remaining organic matter into stable form by oxidation or nitrification.

Classification of secondary Treatment:

The secondary treatment of sewage may broadly be classified in to the following two categories:

(i) Filtration.

(ii) Activated Sludge Process.

Filtration

Filtration: Filtration is the process of removing organic matter by retaining over a filter bed while the sewage is allowed to passing through.

The filter's which are used in secondary treatment of sewage are of following types:

(i) Contact bed filters.

(ii) Intermittent sand filter.

(iii) Trickling filter.

Contact Bed filters

2016, 2015

Briefly Describe the contact Bed filter and its working procedure:

Contact Bed filter: The sewage effluent is kept in contact with filtering media for some period.

As the sewage effluent passes through the filtering media, an organic film is produced around the particles of filtering media.

A large number of aerobic bacteria present in the film carries out the oxidation of organic matter.

In second stages, when the bed is standing empty, the filter obtained oxygen from the atmosphere and the organic matter caught in the voids of filtering media gets oxidation.

Working procedure: The complete cycle of operating a contact bed is usually carried out in the following four stages:

(1) The tank is filled with sewage effluent which may take about 2 hours.

(2) The sewage effluent is allowed to stand for a period of about 2 hours.

(3) The tank is the emtied and the sewage effluent is allowed to flow through the effluent pipe without disturbing the organic film of the bed. It may requires about two hours.

(4). The contact bed is allowed to stand empty for a period of about 6 hours.

田 Construction of Contact Beds:

- A contact bed is a water tight tank. It is filled with the filtering media which may be of gravel, ballast or broken stone.
- The size of particles of media varies from 15 mm to 40 mm.
- The depth of bed is about 1m to 1.8 m and area generally does not exceed 0.2 ha.
- The beds are usually designed for a dosing rate of 300 to 500 liters per loading per m^3.

2016.

田 Write down the advantages and disadvantages of contact bed filter.

Advantage:

(i) It is possible to operate without exposing the sewage effluent to view.

(ii) It consumes relatively small amount of head.

(iii) There is no nuisance of filter flies.

(iv) The undersirable odour is also less as compared to that in case of trickling filter.

Disadvantages:

(i) For efficient working of the contact beds, the primary treatment of sewage effluent is essential, otherwise the beds will be easily clogged.

(ii) The cost of the contact beds is more as compared to that of trickling filter.

(iii) The operation requires skill supervision.

(iv) The rate of treatment of sewage is very low.

(v) It requires long rest period.

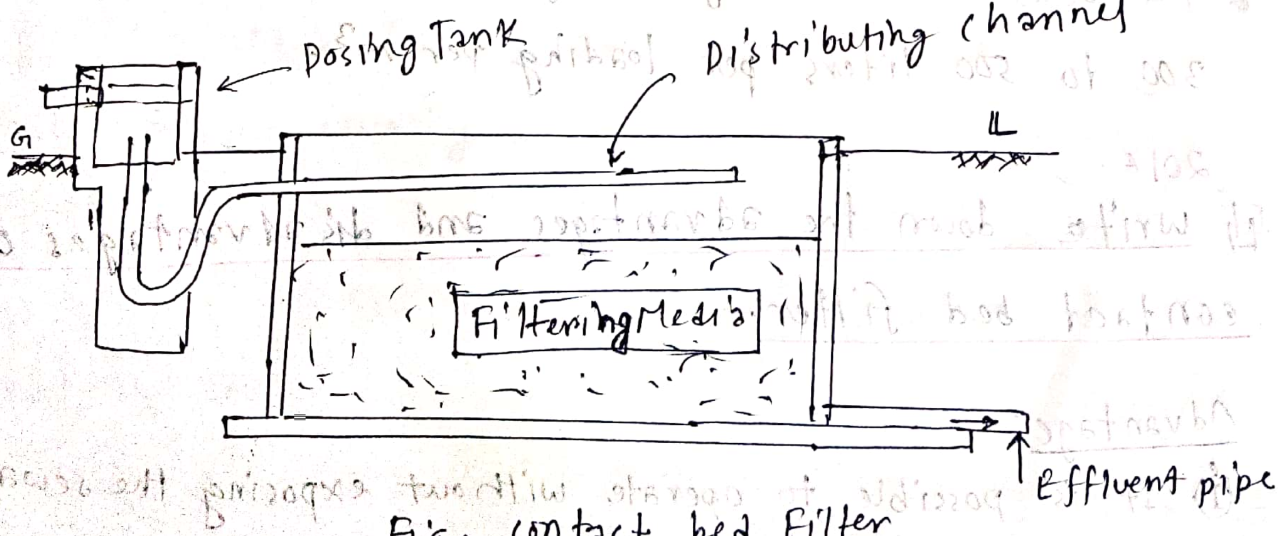


Fig. contact bed Filter

(7) Intermittent Sand Filter.

Intermittent Sand Filter: The process of intermittent sand filtration is also known as the land filtration.

In this process, the effluent is applied on intermittent sand filters at regular interval. The sewage is purified, by the aerobic bacteria. During the period of rest, the atmospheric air will be carried up to the voids of sand ~~filter~~ particles so as to establish fabourable conditions for aerobic bacteria.

Construction of Intermittent sand Filter:

- It is generally rectangular and the ratio of length to width is about 3 to 4.
- The area of one unit varies from 0.2 ha. to 0.4 ha.
- The effective size of sand should be between 0.2 mm to 0.5 mm and uniformity co-efficient should not exceed 5.
- The thickness of sand layer is kept as about 750 mm to 900 mm.
- A layer about 150 mm to 300 mm depth of gravel is provided at the bottom of sand layer.

4 Write down the advantages and disadvantages of Intermittent sand filter.

Advantages:

(1) The quality of effluent obtained from this filter is very clean and it generally does not require any further treatment except chlorination in some cases.

(2) The oxidation of organic matter of sewage is brought about by the aerobic bacteria, and as the sewage is applied intermittently, there are less chances for anaerobic condition to develop.

(3) It does not require any skill supervision constantly.

Disadvantages:

(1) The process of sewage treatment is very slow.

(2) The process requires relatively large area of land for the construction of filter.

(3) These filter can not be adopted for very cold climate as there are chances of the sand surface being frozen.

Trickling Filter

2014, 2013.

Discuss about Trickling filter with its advantages and dis advantages.

Trickling filter:

These are also known as as the percolating filter or sprinkling filters.

The sewage is allowed to sprinkling or to trickle over a bed of course, rough, hard material and it is then collected through the under-drainage system.

The oxidation of the organic matter is carried out under aerobic condition.

A bacterial film known as bio-film is formed around the particles of filtering media and for the existance of this film, the oxygen is supplied.

Advantages:

(i) The effluent is highly nitrified and stabilized.

(ii) The mechanical wear and tear is small.

(iii) The moisture content of sludge is as high as 99% or so.

(iv) The operation requires less electrical power.

(v) It is flexible in operation.

(vi) It may reduce the BOD and colloidal matter of about 75% and 80% respectively.

(vii) The working is simple and does not require skilled supervision.

Disadvantages:

(i) The construction cost is high.

(ii) The loss of head is high and required syphonic dosing tank.

(iii) The process requires primary treatment of sewage and hence raw sewage can not be treated by this process.

(iv) It requires large land area.

(v) It may develop fly nuisance and bad odour.

Q. Write down the construction features of trickling filter.

- Trickling filter may be circular or rectangular in shape.
- The filter media of a trickling filter may consist of crushed rock or clinkler or specially manufactured material.

- The size of the particles varies from 30 mm to 80 mm.
- The floor of a trickling filter is generally made of R.C.C. and its thickness is about 100 mm to 150 mm.
- The slope of the floor may be towards the central drain or toward the periphery of filter as design of the under drainage system.

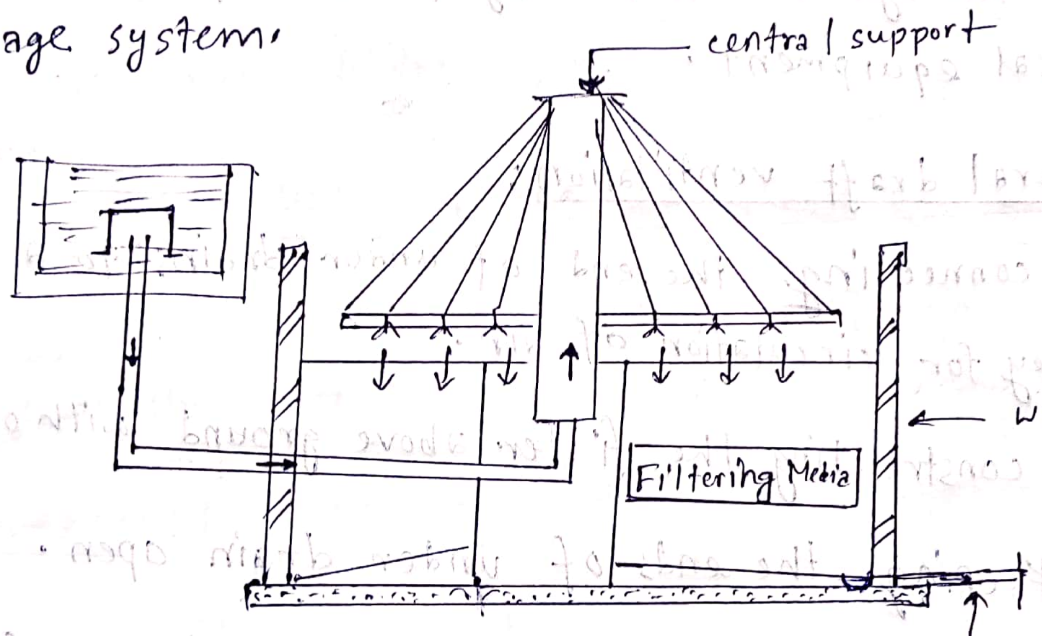


Fig. Circular Trickling Filter

- Quality of filtering material:

Property	Requirement
(i) crushing property	≮ 100 N/mm²
(ii) Hardness	≮ 12
(iii) Percentage wear	≯ 4
(iv) Specific gravity	≮ 2.6

- **ventilation of trickling filter:** 2018

Ventilation should be provided for the successful working of the trickling filter. The methods are:

(i) **The forced ventilation:** It may be provided in case of deep filters. It consists of forcing air vertically upwards through the filter by the use of fans or other mechanical equipment.

(ii) **Natural draft ventilation:**

(a) By connecting the end of under drains to a chimney for circulation of air.

(b) By constructing the filter above ground with open sides.

(c) By keeping the ends of under drain open.

(d) By providing vent pipes at the periphery of filter.

(iii) The under drain and effluent channel are designed to flow partially full.

- **Distributors:** The function of a distributor is to spread the effluent evenly on the filter media.

The distributors may be divided into two categories:

(i) Movable distributor

(ii) Fixed distributor.

Movable distributor may be further classified as:

(i) Rotary distributor.

(ii) Rectilinear distributor.

2011

④ Mention the design aspects of the trickling filter:

(1) Depth: The effective depth of trickling filter is generally kept between 1.8 m to 2.9 m.

(2) Number: The minimum two trickling filter unit

(3) Rate of filter loading:

(a) Kg of BOD per volume of filter bed: 1000 to 2200 Kg of BOD per hectare-meter per day.

(b) Kg of BOD per volume of filter media: 15 to 30 Kg of BOD per day per 100 m^3 of filter material.

(c) surface area of filter bed: 25-40 million liters per hectare of surface area per day.

(d) Volume of filter bed: 7.5 - 22.5 million liters per hectare-meter per day.

2007, 06, 05

Q) Draw typical flow diagram of single and Double stage trickling filter.

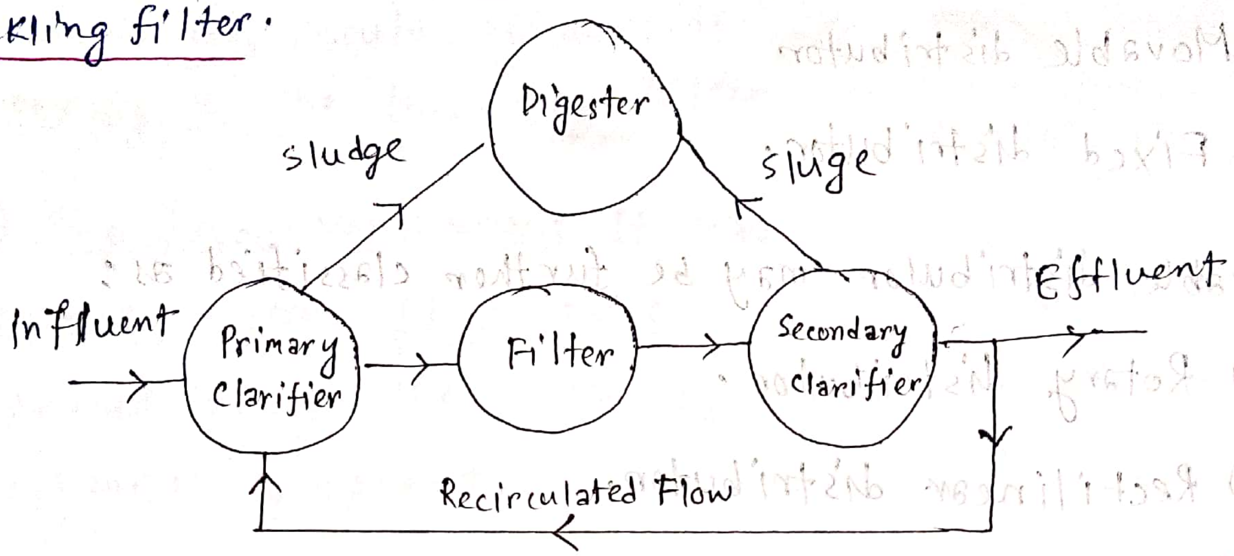


Fig: Single stage Trickling Filter.

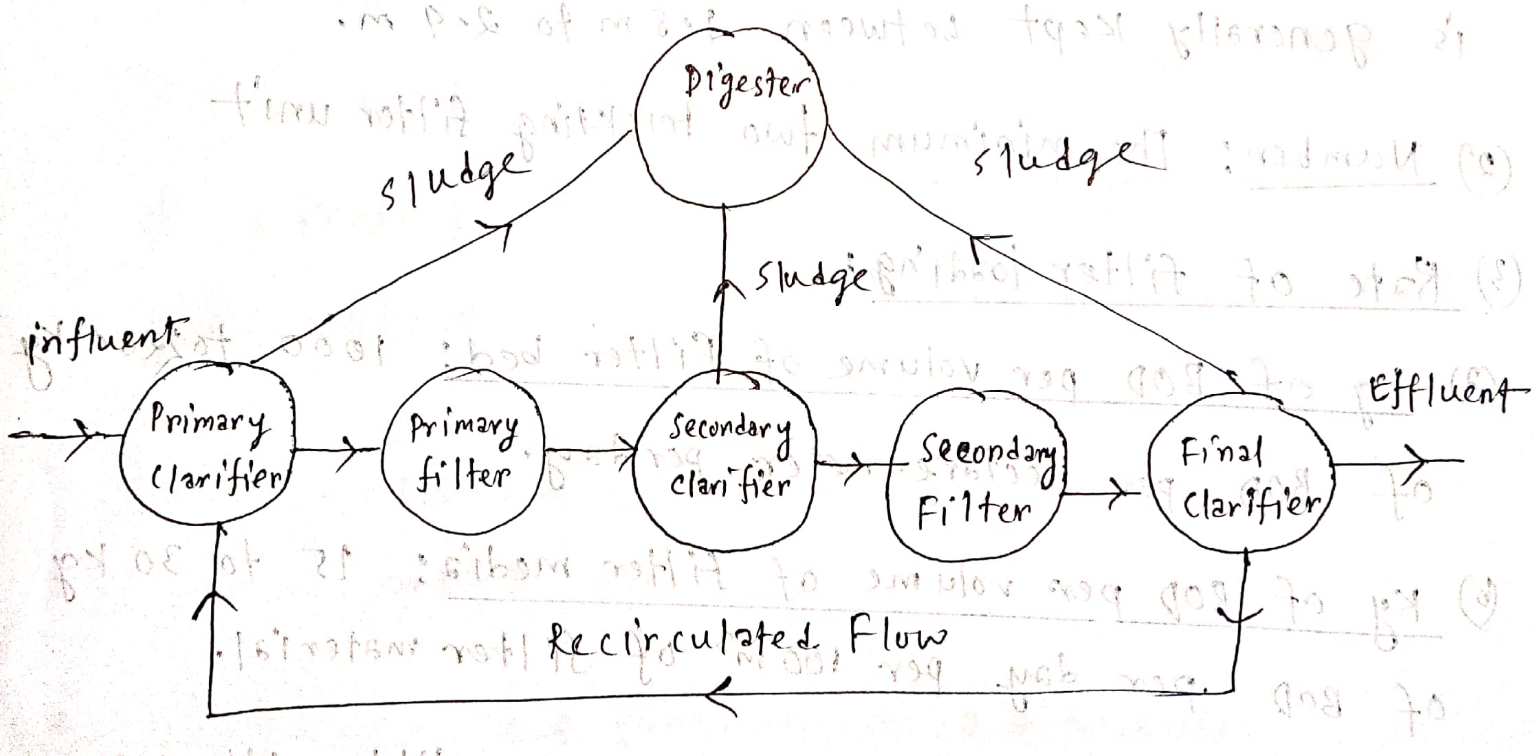


Fig. Double stage Trickling filter.

Activated Sludge Process.

What is activated Sludge Process? 2011

The term Activated Sludge Process is used to indicate the sludge which is obtained by settling sewage in presence of abundant oxygen. The activated sludge is biologically active and it contains a great number of aerobic bacteria and other micro-organisms which has got an unusual property to oxidize the organic matter.

State the properties of activated sludge process. 2011

1. It contains fertilizing constituents.
2. Moisture content is about 95% to 97%
3. The colour of activated sludge indicates the degree of aeration
   - (i) under aerated – light brown.
   - (ii) Well aerated – golden brown.
   - (iii) Over aerated – muddy brown.

Write down the action/effect of activate sludge.

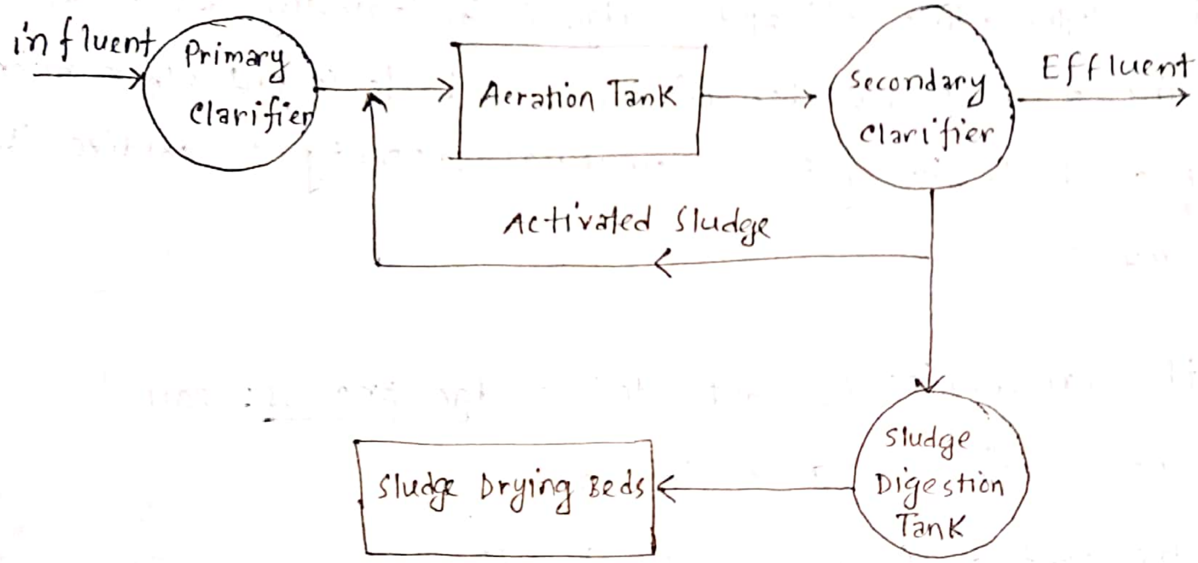
When activated sludge is mixed properly with sewage containing sufficient quantity of oxygen, the micro-organisms present in the activated sludge multiply rapidly. As a result of this phenomena, the following effect takes place:

(i) Organic solids present in sewage are rapidly oxidized;

(ii) suspended and colloidal matters coagulate and they form a readily settleable precipitate.

2014

Draw treatment process flow diagram of Activated Sludge Process:



2014,10,09,07

Describe the treatment processes of activated sludge process

or, Explain basic operations involved in activated sludge process.

(1) Mixing of activated sludge: The activated sludge is mixed properly with raw or settled sewage. The activated sludge is added to the effluent of primary clarifier.

(2) Aeration: The mixed liquor containing activated sludge and effluent is agitated or aerated in the aeration tank or aeration chamber.

(3) settling in secondary clarifier: The mixed liquor after agitation is taken to the secondary clarifier. The sludge is allowed to settle in this tank. The settled sludge is the activated sludge and a portion of it is sent for circulation. The extra activated sludge is taken to the sludge digestion tank and then to the sludge drying beds for the further treatment.

2012

Compare the activated sludge process and trickling filter system.

The biological oxidation is carried out either by activated sludge process or by trickling filters. The basic difference between the process should be carefully noted:

Activated Sludge Process	Trickling Filter System
The bacterial film is contained in the fine suspended matter of sewage and this film is kept moving by constant agitation.	The bacterial film is formed around the particles of contact materials and it is stationary

The activated sludge process and trickling filters help in achieving more or less the same standard of purification.

The adoption of these process entirely depends on local conditions and practical consideration.

2013

Write down the advantages and disadvantages of activated sludge process:

Advantages:

(i) The installation cost is low.

(ii) The effluent of good quality is obtained.

(iii) The process require small area of land and hence the design may be made compact.

(iv) There is comparatively very small loss of head through the treatment plant.

(v) There is freedom from fly and odour nuisance due to high degree of treatment.

Disadvantages:

(i) There are adverse effect on working process due to sudden increase of volume or change in characterestics of influent.

(ii) The cost of operation is relatively high.

(iii) Sludge production is huge which requires suitable method for its disposal.

(iv) The process is sensitive to certain types of industrial wastes.

(v) The process requires skilled supervision.

Methods of Aeration:

Following are the three methods which employed for the purpose of aeration in the activated sludge process:

(i) Diffussed Air aeration.

(ii) Mechanical aeration.

(iii) Combination of Diffused air aeration and mechanical aeration.

Diffused air aeration:

- In this method of aeration, the compressed air is blown through the sewage.
- In order to diffuse air properly through the body of sewage, the diffuser are required. Diffusers are of two types - (i) Plate diffuser (ii) Tube diffuser.
- Rate of diffusion of air through diffusers varies 0.50 to 1.00 m^3 per minute per m^2.
- Generally the aeration period varies from 3 to 6 hours, the common being 4.5 hours.
- About 6000 m^3 to 9000 m^3 of free air will be required per million litres of sewage to be treated.
- Two types of aeration tanks are generally used in the diffused air aeration:

(i) Ridge and Furrow Type Tank

(ii) Spiral flow type tank

(i) Ridge and Furrow Type Tank:

The air diffuser plates are placed in the furrows and the air is supplied to the diffuser by header pipe through air distributing pipes as shown in figure.

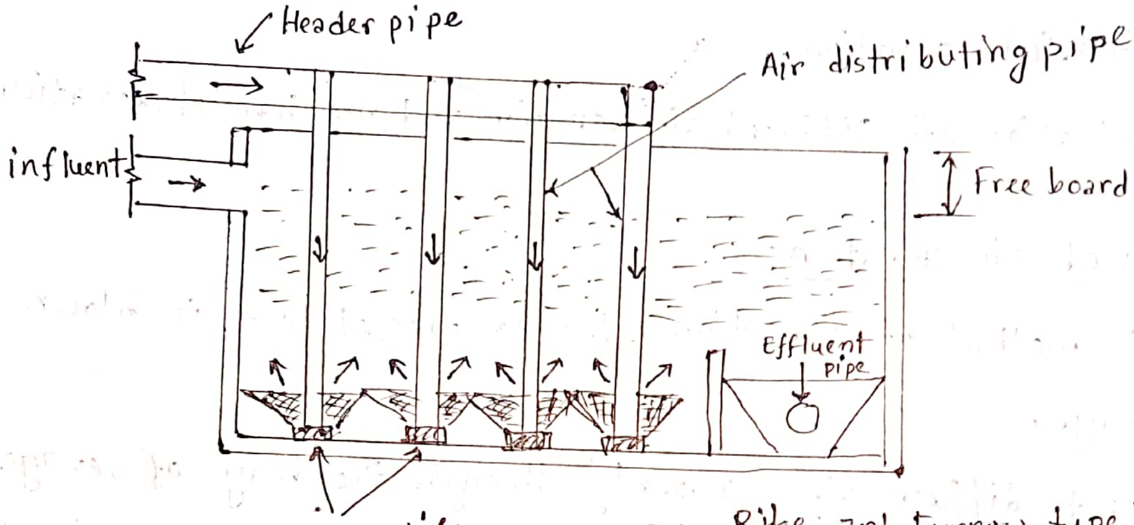


Fig. Ridge and Furrow type Tank

The air diffuser plates are provided at right angle to the direction of flow and the compressed air released from the plates forms air bubbles which cause the required aeration.

Tank Dimension:

Length : 10m-12m

Wide : 3m - 5m

Deep : 3m - 5m

Free board : 600mm.

(2) Spiral flow type tank:

The diffused air may be supplied through plate diffusers or tube diffusers.

This type of aeration tank requires small quantity of compressed air at low pressure.

The spiral motion setup by the compressed air released through the tube diffusers causes the required aeration.

Tank Dimension:

more or less same as that of ridge and furrow type tank.

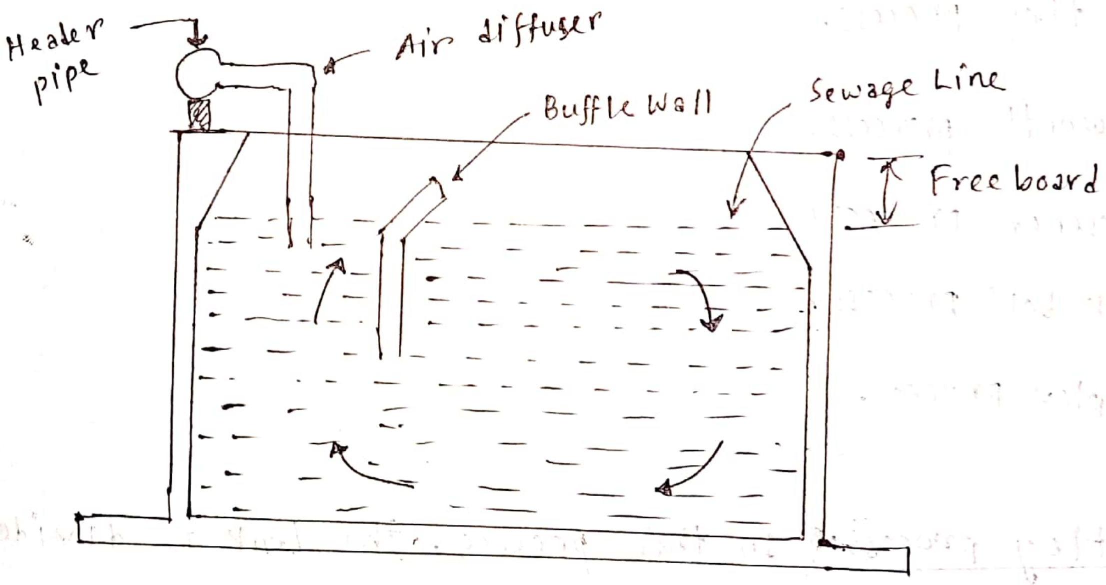


Fig. Spiral flow type aeration tank.

Mechanical Aeration:

- This is also Known as the surface aeration.
- In this method the surface of sewage in the aeration tank is agitated with the help of some mechanical equipment to encourage the absorption of oxygen from atmosphere.
- Aeration period in this method generally varies 6 to 8 hours.
- Methods of aeration: In mechanical aeration system, various processes have been developed to achieve required aeration:

(i) Hartley process.

(ii) Haworth process.

(iii) Kessener process.

(iv) Link belt process.

(v) Simplex process.

(i) Hartley process: In this process, the tank is divided into channels and at one of the ends of each bend, the partially submerged vertical paddles are provided.

The paddles are not truly vertical. But they are slightly inclined from the vertical direction.

The diagonal flat baffle plates are provided in the channels to increase the efficiency of aeration tank.

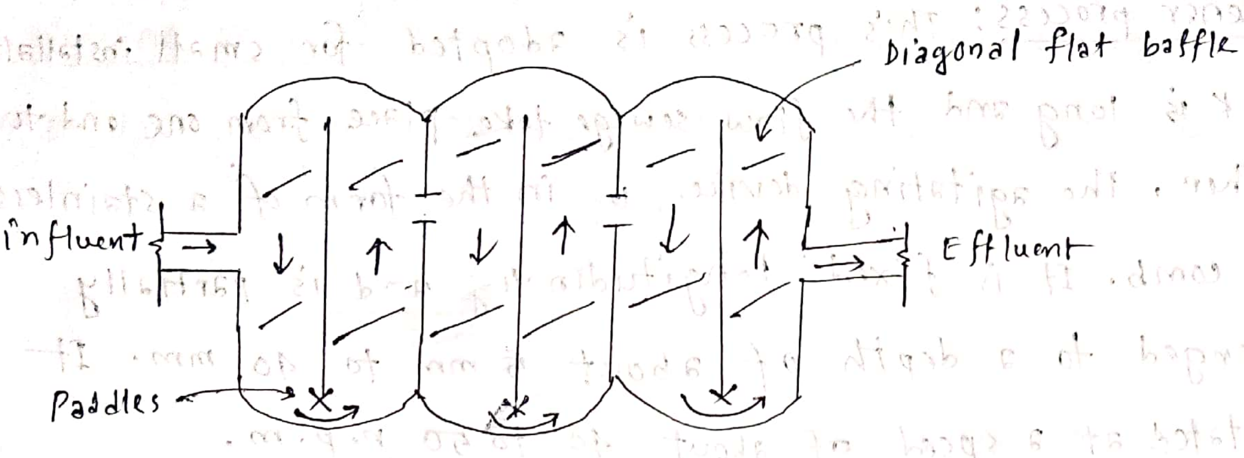


Fig. Hartley Process.

(ii) Haworth process: This process is nearly similar to the above process.

The tank is divided into suitable lengths and the paddles rotate on horizontal shaft.

The paddles are arranged in a staggered fashion.

The spiral motion is caused by the rotation of paddles and the required aeration is achieved.

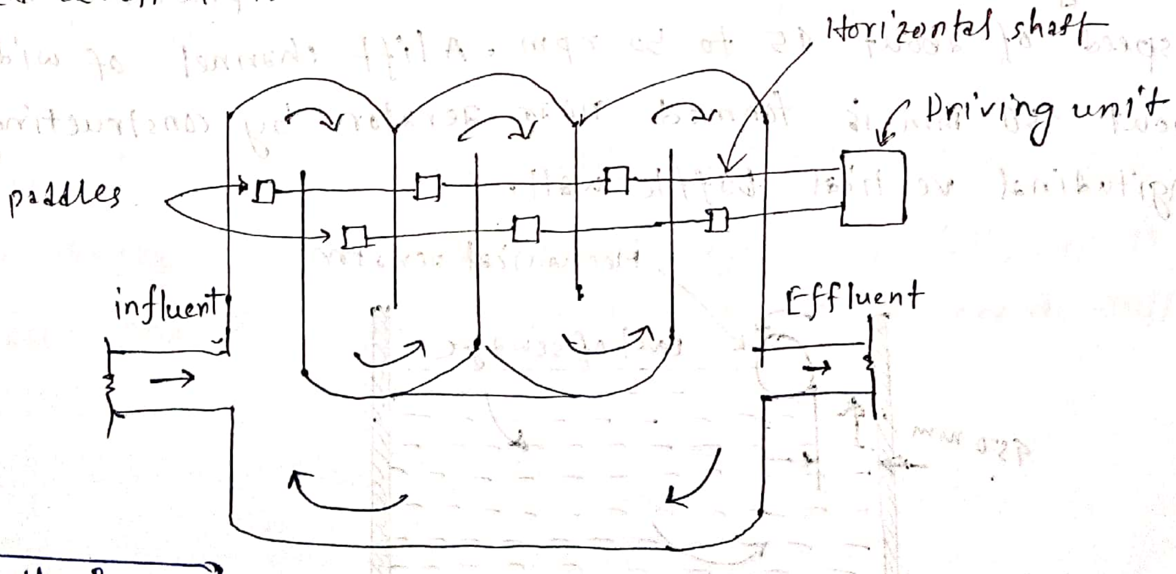


Fig. Haworth process.

For the Both Process

The channels are about 1.2 m to 2 m wide and 1.2 m deep. the speed of paddles is about 15 r.p.m. and the aeration period is quite long, about 15 hours or so.

(3) Kessener process: This process is adopted for small installations. The tank is long and the flow sewage take place from one end to the other. The agitating device is in the form of a stainless steel comb. It is fixed longitudinally and is partially submerged to a depth of about 5 mm to 40 mm. It rotates at a speed of about 40 to 50 r.p.m.

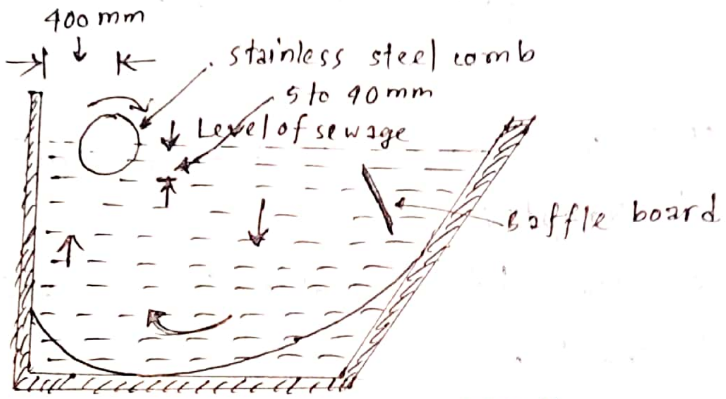


Fig. Kessener process

(4) Link-Belt process: In this process, the tank is rectangular and revolving paddles fixed near one side. The paddles rotates at a speed of about 45 to 50 rpm. A lift channel of width of about 450 mm is formed near aerator by constructing a longitudinal vertical baffle wall.

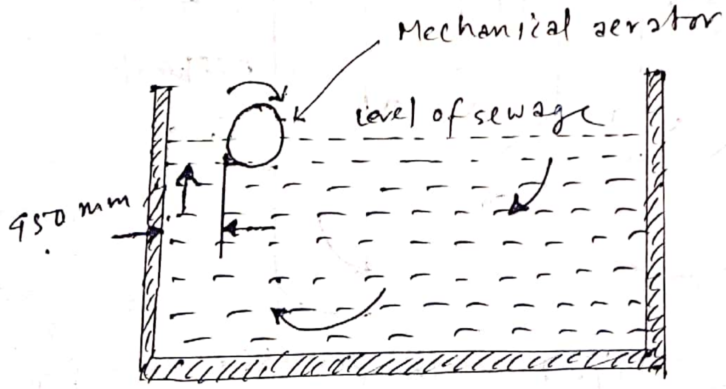


Fig. Link belt lift channel.

(5) Simplex process: In this process, the aeration tank is generally square with hopper bottom. as shown in figure:

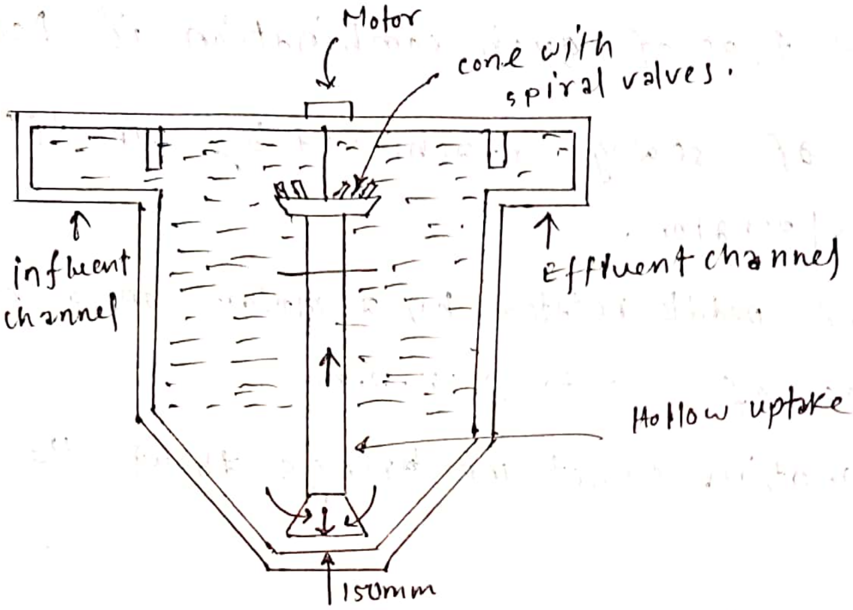


Fig. Simplex process.

At the center of each tank, a hollow uptake tube is suspended from the top with a distance of about 150 mm from the bottom of the tank. A cone with spiral vanes is provided at the top of tank. The speed of rotation is about 60 r.p.m.

The rotation of cone causes the suction effect and the sewage is sucked through uptake tube. The sewage then falls on the top surface and air bubbles are formed which creats sufficient aeration.

Combination of diffused air aeration and mechanical aeration:

In this system, the diffused air aeration and mechanical aeration are combined in a single unit.

The well known type of such combination is Dorroco Aerator.

The aeration of sewage is achieved by air diffuser as well as mechanical aerator.

The submerged paddle rotated by a motor on a horizontal shaft with a speed of 10 to 12 r.p.m.

The spiral motion so set up brings about the required aeration.

Advantages of such combination:

1. The aeration is very efficient
2. The detention period is reduced. It is about 3 to 4 hours.
3. The quantity of compressed air required is less as compaired to the diffused air aeration.

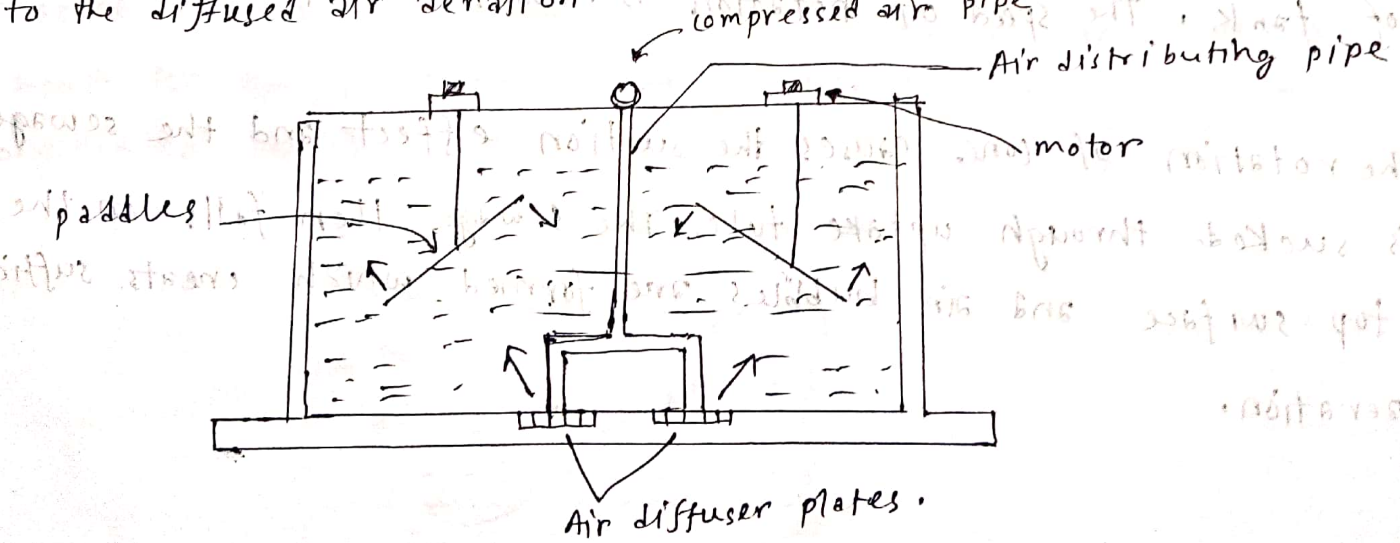


Fig. Dorroco Aerator.

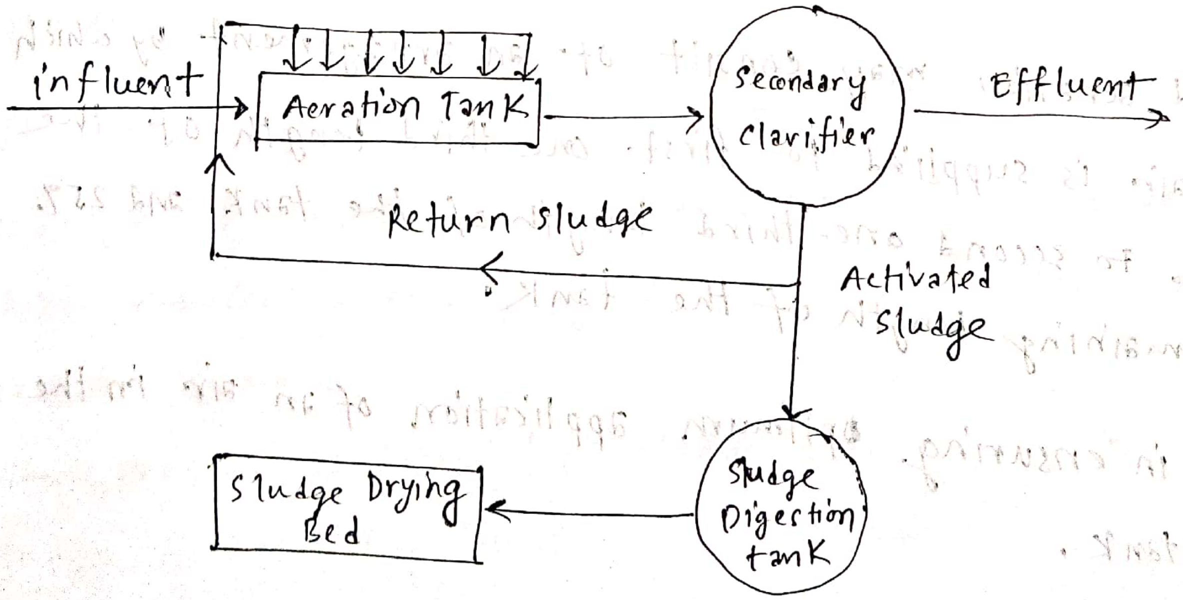
Modification of Activated Sludge process:

Discuss briefly step aeration. Draw flow chart of step aeration process.

One of the modification of activated sludge process is the step aeration.

In this process, the activated sludge is brought near the inlet end of the aeration tanks. But this activated sludge is not added to the influent at a time or in a single dose as conventional procedure. It is added along the aeration tank in stages as required.

Flow chart:



write down the advantages of step aeration process.

(i) It has considerable capacity to absorb the shock of organic loadings.

(ii) It helps in reducing the aeration tank volume appreciably without sacrificing the efficiency of BOD removal.

(iii) It results in a uniform air requirement along the entire length of the tank. It is thus possible to use the uniform air supply of the conventional plants in most efficient manner.

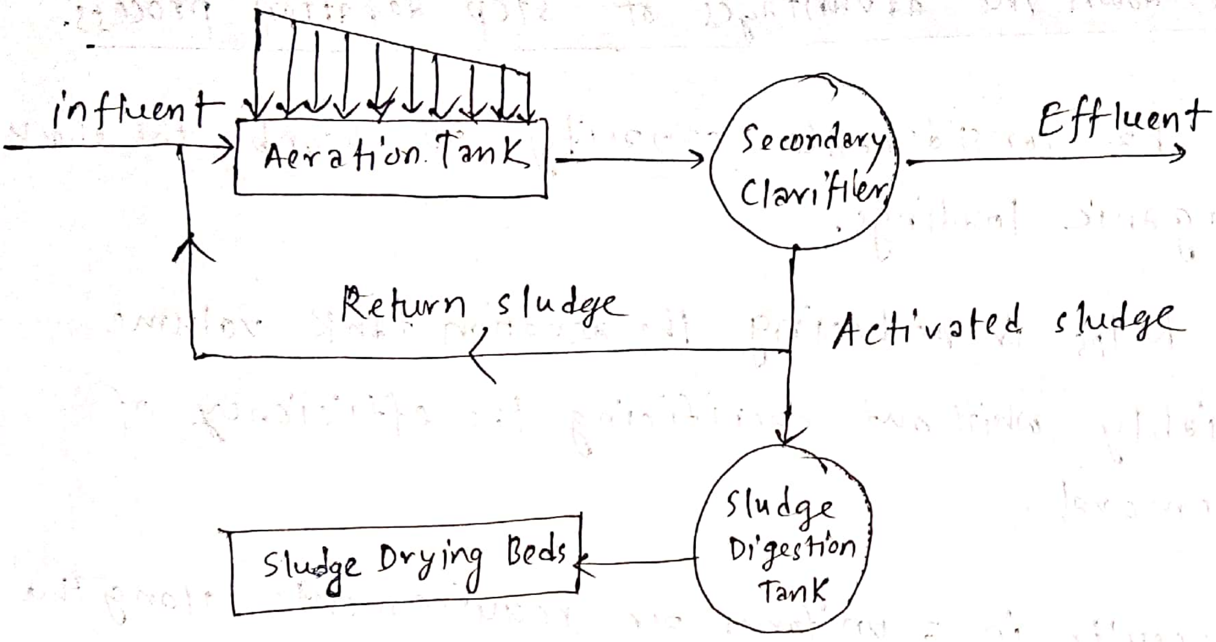


Fig. Flow diagram of tapered aeration

Describe Extended aeration:

- This is also another modification of the activated sludge process.
- It uses long aeration periods of 24 to 48 hours.
- The process operates in the endogenous respiration zone which requires a relatively low organic loading and long aeration time.
- The process produces less sludge volume and the digested sludge is relatively inoffensive in nature.
- The sludge produced is thus capable of being taken directly to the sludge drying beds.
- The process is used extensively for prefabricated package plants for small communities, institutions, schools etc. having low sewage flow.

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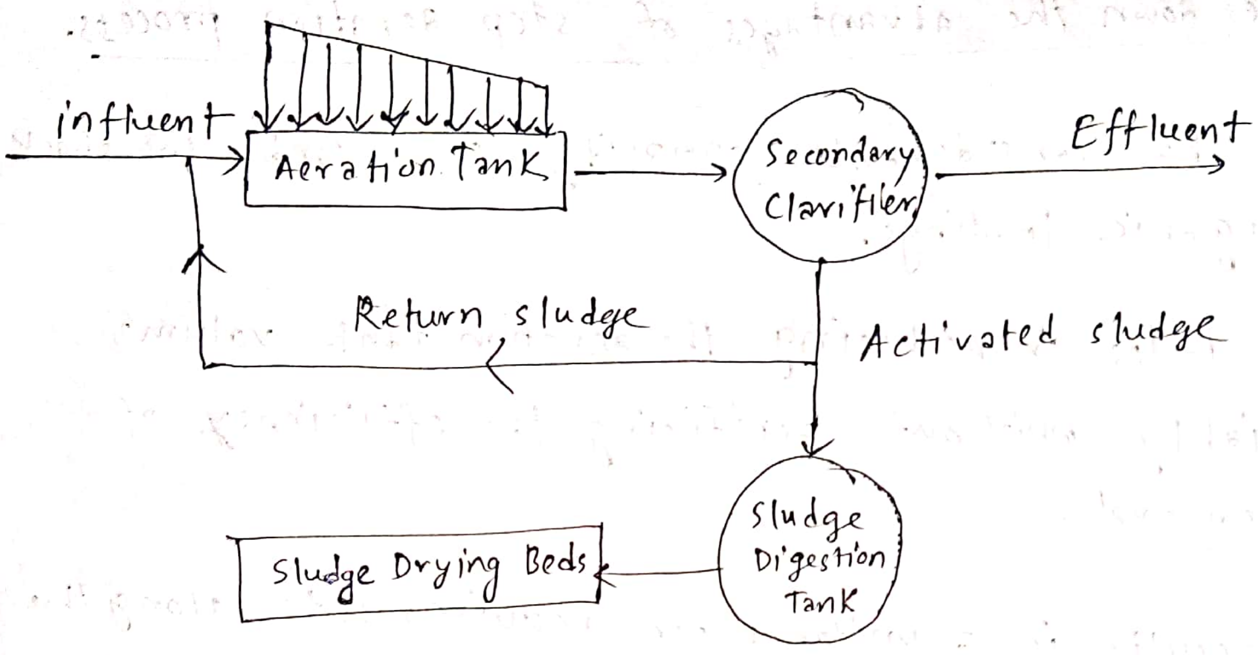

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2008, 07, 06

What do you mean by sludge bulking? What are the factors for development of sludge bulking?
or, Write down the reasons of sludge bulking. 2012

An excellent activated sludge, when overloaded, becomes sick and it results in the sewelling of the sludge in volume. This phenomena is known as the sludge bulking and during this phenomena, the sludge assumes unusual great volume. The occurance of sludge bulking indicates presence of unsatisfactory conditions in the activated sludge process.

Following factors assist the development of sludge bulking:

(i) Accumulation of sludge at the bottom of aeration tank
(ii) Aeration below the required degree.
(iii) Presence of harmful industrial waste.
(iv) sudden chance in the character of sewage, and
(v) Unusual detention of sludge in the clarifiers.

What care should be taken for sludge bulking problem.

When sludge bulking occurs, the sludge does not readily settle down. But it remains in suspension in secondary clarifiers and it is even seen in the effluent of the secondary clarifiers. The quality of effluent is thus seriously affected and hence following care should be taken:

(i) Chlorination of sewage.

(ii) Prolonged aeration.

(iii) Raising of pH value of sewage to about 8, or so by adding lime.

(iv) Re-aeration of returned activated sludge.

(v) Reduction of sewage flow to aeration tank for short period.

(vi) Reduction of suspended solids in the sewage.

2012, 08

What are S.V.I and S.D.I ?

S.V.I: The term Sludge Volume Index or S.V.I is used to indicate the degree of concentration of sludge and it reflects the physical state of sludge.

$$S.V.I = \frac{\text{\% of sludge by volume}}{\text{\% of suspended solids by weight}} \times 100$$

S.D.I: The term sludge density Index or. S.D.I is sometimes used in place of S.V.I and it is given by the following equation:

$$S.D.I = \frac{\text{\% of suspended solids by weight}}{\text{\% of sludge by volume}} \times 100$$

Accumulation of volatile suspended solids

The accumulation of volatile suspended solids (vss) is given by:

$$V_a = (r V_i + p X_r) - qV$$

where, V_a = Accumulation of mass of VSS per unit time

V_i = Mass of VSS in influent

V = Total mass of VSS

X_r = Mass of ultimate B.O.D removed per unit time.

p = synthesis contant = 0.55

q = Endogenous respiration constant = 0.15

r = Non-bio degradable fraction of VSS in influent

Requirement of oxygen:

For supplying energy to the system for synthesis and to permit endogenous respiration, the oxygen will be required and its requirement per unit time is worked out with the help of the following equation:

$$O_2 = 0.39\, X_r + 1.42\, qV$$

SEWEGE TREATMENT

Imhoff Tank

Write short Note on Imhoff Tanks:

A type of sludge digestion tank was found out by a German scientist Mr. Karl Imhoff in 1906. These are known as Imhoff tanks and as they are two storeys, they are sometimes known as two storey digestion tank.

Write down the components of imhoff tank with Neat sketch:

Following are the component parts of imhoff tank:

(i) sedimentation chamber

(ii) slot

(iii) Digestion chamber

(iv) Neutral zone

(v) Gas vent

(vi) sludge removal pipe

(vii) Roofs.

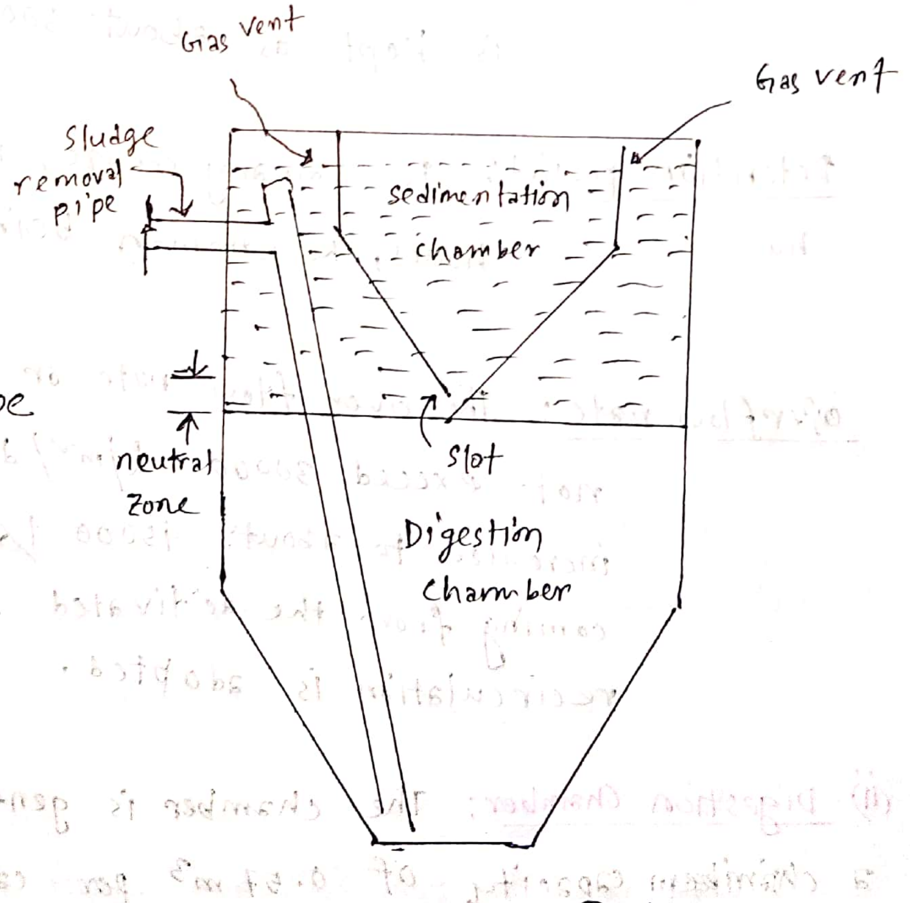

Fig. Imhoff Tank

Discuss Design aspects of Inhoff Tank:

(I) Sedimentation Chamber:

Shape: Rectangular in shape

Length: not exceeding 30m. the lengh to width ratio varies from 3 to 5.

Depth: total depth of imhoff tank varies 6 m to 11 m with depth of sedimentation chamber as about 3m.

Free board: 450 mm to 600 mm depth.

Velocity of flow: velocity of flow in sedimentation chamber is kept as about 300 mm/m

Detention period: For odinary sewage, it varies from 2 to 4 hours, the common being 2 hours.

overflow rate: The over flow rate or suface loading should not exceed 30000 l/m²/day. But it may be increased to about 45000 l/m²/day for the effluent coming from the activated sludge plant or where recirculation is adopted.

(II) Digestion Chamber: The chamber is generally designed for a minimum capacity of 0.57 m³ per capita. But for warm climate, it may be reduced to about 0.035 m³ to 0.04 m³ per capita.

The digestion chamber is generally designed to store sludge for 1 to 6 months, the common being 2 months or so.

(iii) Gas Vent: The area of scum chamber should be about 25% to 30% of total plan area of the tank with a free board of about 450 mm to 600 mm.

Write the advantages and disadvantages of imhoff tank.

Advantages: Following are the advantages of an imhoff tank:

(i). It is possible to dry easily the sludge obtained from the imhoff tank.

(ii) The process of sludge digestion in the imhoff tank is better than that of the septic tank.

(iii) The tank delivers better effluent than that recieved from the plain sedimentation tank.

(iv) The tank is quiet efficient in the removal of B.O.D and settleable solids. The B.O.D is removed to the extent of about 30 to 40% and the setteable solids are removed to the extent of about 60%.

Disadvantages:

(i) The depth of tank is more and this aspect may make its construction uneconomical in hard soils.

(ii) The tank gives out offensive odours when it is imp operly operated.

(iii) The tank has a tendency to foam or boil. This leads the scum to go up to the top of tank and it also forces the sludge particles to enter the sedimentation chamber through the slot. The foaming thus affect adversly on the quantity of effluent.

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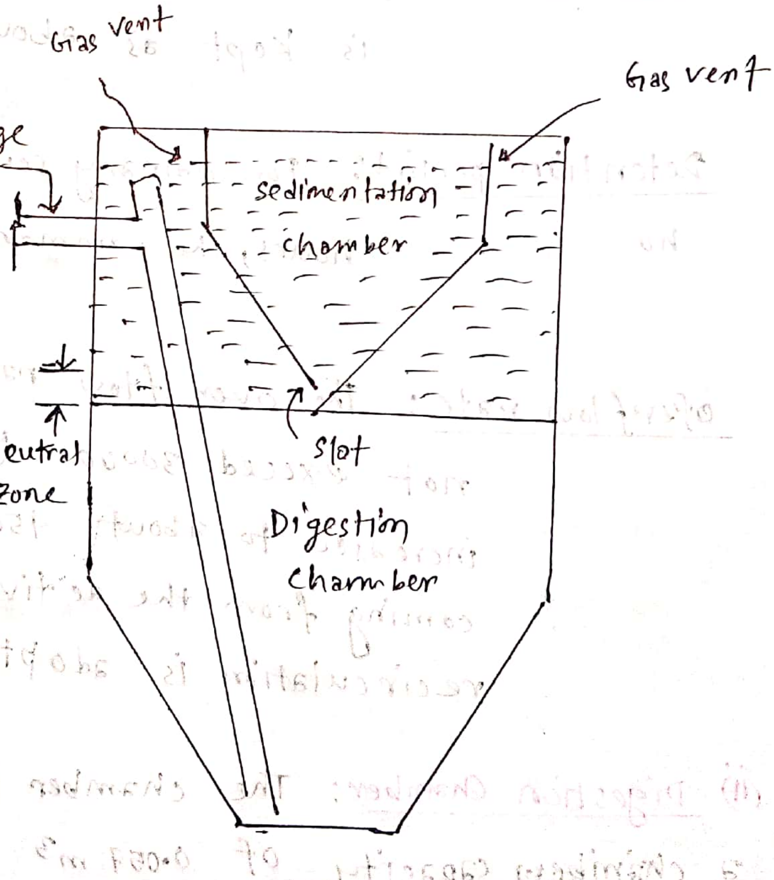

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Oxidation Pond

2017

Oxidation Pond:

An artificial pond of shallow depth formed for the retention of sewage for sufficient time is known as oxidation pond, or oxidation ditch or sewage stabilization pond or lagoon.

These ponds may be used to treat raw sewage or partially treated sewage.

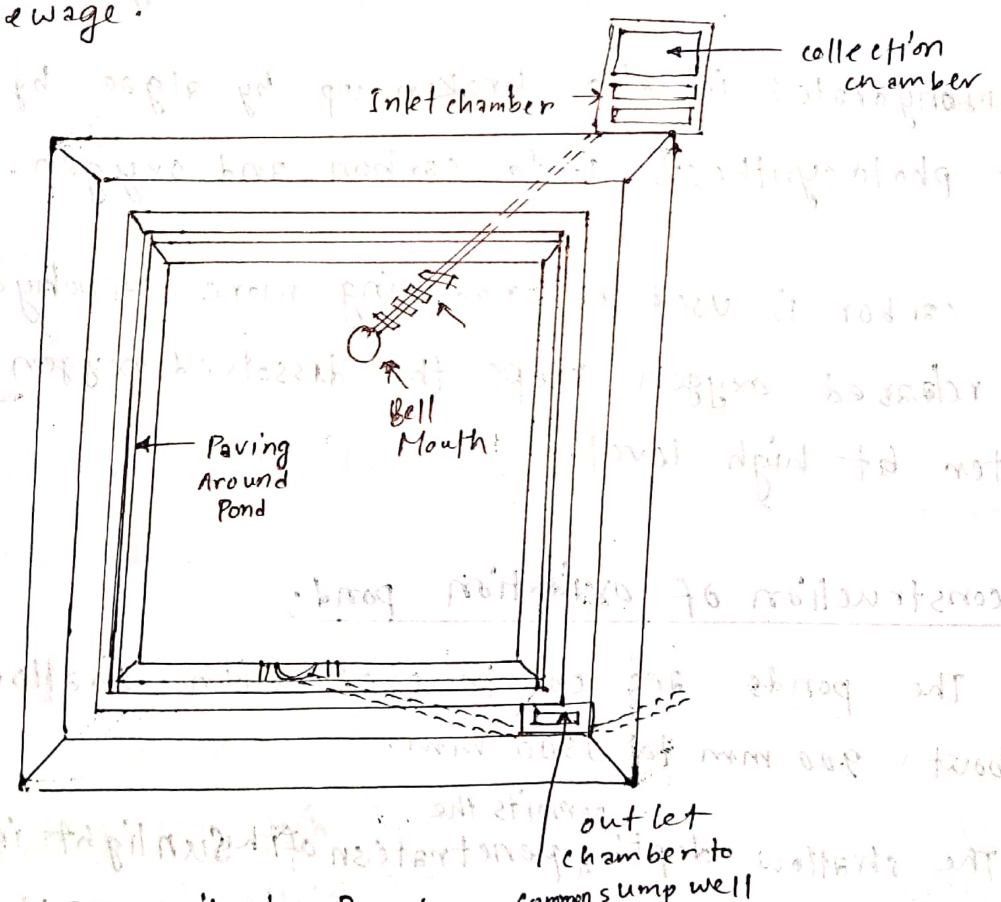


Fig: Oxidation Pond.

2017

Action in oxidation pond or, Treatment process of Oxidation Pond:

The oxidation ponds purify the sewage by dual action of aerobic bacteria and algae.

The sewage is stored under aerobic conditions which are favourable for the growth of algae, namely sunshine and warmth.

The aerobic bacteria obtain oxygen from the atmosphere and use it in the decomposition of carbo-hydrates of sewage.

carbohydrates is also broken up by algae by the process of photosynthesis. into carbon and oxygen.

The carbon is used in producing more carbohydrates and the released oxygen keeps the dissolved oxygen content of water at high level.

construction of oxidation pond:

(1) The ponds are constructed with shallow depth of about 900 mm to 1500 mm.

(2) The shallow depth permits the penetration of Sunlight into the body sewage and thus it encourages the growth of algae.

(3) It is desirable to provide a freeboard about 1 meter or so.

(4) The pond is constructed into compartments of suitable sizes and the sewage is allowed to flow in zigzag manner through these compartments.

Design Aspects of oxidation pond:

1. **Detention period:** For proper development of algae, it should be at least 7 days and preferably 2 to 6 weeks.

2. **Area:** It varies from 250 to 1000 persons per hectare.

3. **Loading:** It may be expressed in terms of B.O.D. The loading on this basis varies from 150 to 300 kg per hectare per day.

Under certain circumstances, the oxidation ponds may produce no effluent because of evaporation and seepage. But in practice, most of the oxidation ponds are usually designed as unit with continuous flow.

Classification of Stabilization ponds:

Stabilization ponds may be aerobic, anaerobic or facultative.

(i) **Aerobic Ponds:**

- **Depth:** less than 0.5 m
- **BOD Loading:** 40 – 120 kg/ha/d.
- Such ponds develop intense algal growth.

(ii) **Anaerobic Ponds:**

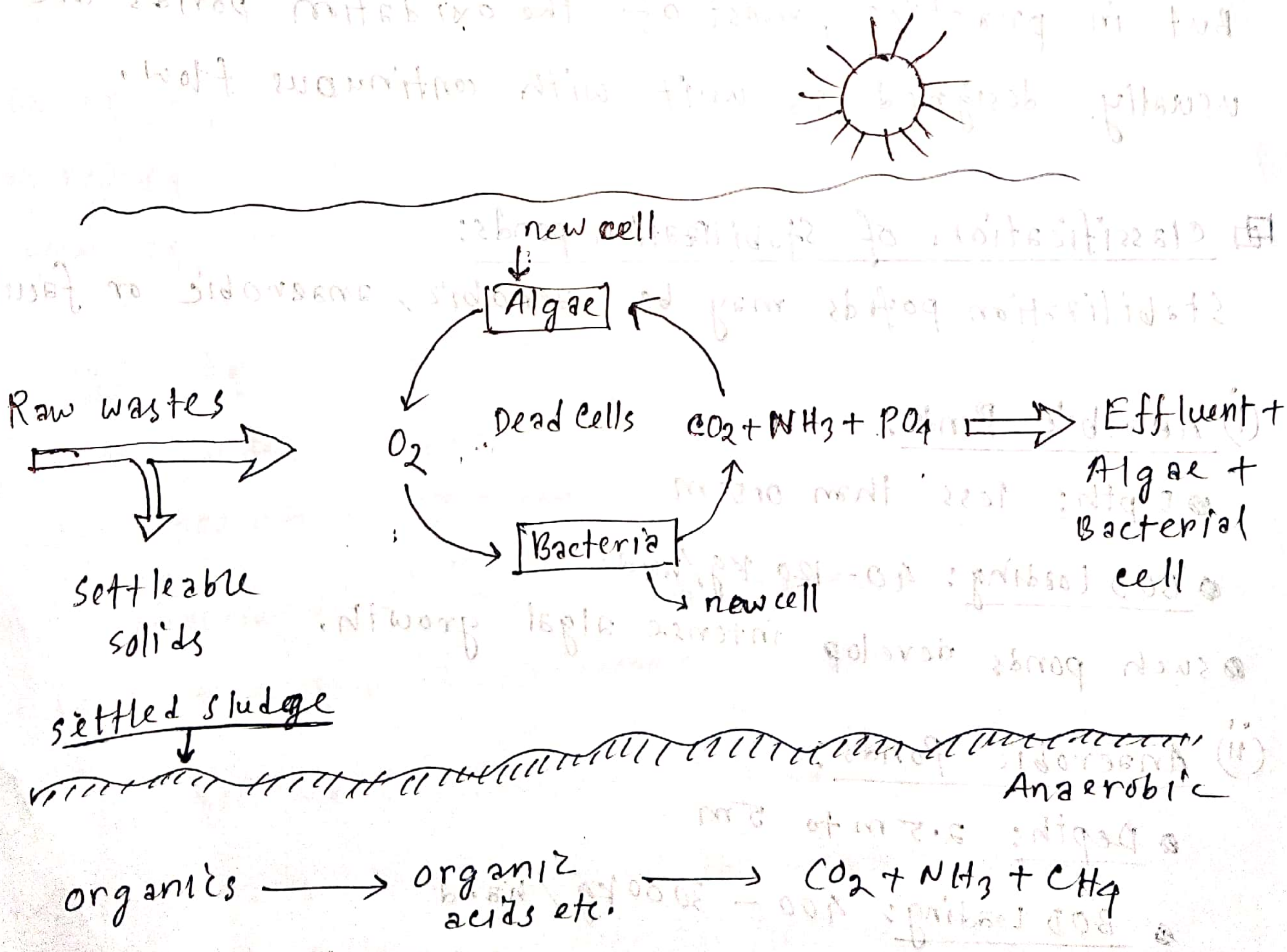
- **Depth:** 2.5 m to 5 m
- **BOD Loading:** 400 – 3000 kg/ha/d
- Such ponds are used as pretreatment of high strength wastes.

(iii) Facultative ponds:

- Depth: 1 m to 2 m.
- Such pond functions aerobically at the surface while anaerobic conditions prevail at the bottom.

Functioning of a Facultative stabilization pond:
or, Mechanism of a Facultative stabilization pond:

The functioning of a facultative stabilization pond and symbiotic relationship in the pond are shown below:



- Sewage organics are stabilized by both aerobic and anaerobic reactions.

- In the top aerobic layer, where oxygen is supplied through algal photosynthesis, the non-settleable and dissolved organic matter is oxidized to CO_2 and water.

- In addition, some of the end products of partial anaerobic decomposition such as volatile acids and alcohols, which may permeate to upper layers are also oxidized periodically.

- The settled sludge mass originating from raw waste and microbial synthesis in aerobic layer and dissolved and suspended organics in the lower layers undergo stabilization through conversion of Mithane which escapes the pond in form of bubbles.

Factors affecting Pond Reactions:

(i) waste water characterestics and fluctuations.

(ii) Environmental factors (solar radiation, light, temperature etc.)

(iii) Algal growth patterns and their diurnal and seasonal variation.

(iv) Bacterial growth patterns and decay rates.

(v) solids settlement, gasification, upward diffusion, sludge accumulation.

Advantages and Disadvantages of Oxidation Pond:

Advantages:

(i) The action involved in the operation of oxidation ponds is a natural one and it results in considerable reduction in cost as compared to the artificial sewage treatment units.

(ii) The maintenance and operation are simple and easy.

(iii) The oxidation ponds are highly efficient in the B.O.D removal and coliforms removal. The B.O.D removal is about 90% and the removal of coliforms is to extent of about 99% or so.

(iv) The oxidation ponds prove economical where land is chiefly available and suitable dry climates exists.

Disadvantages:

(i) The oxidation ponds may give out objectionable odours and cause the nuisance of mosquitoes.

(ii) The oxidation ponds may sometimes become septic due to over loading or unfavourable cloudly season.

⊞ write a short note on : Bacteria - Algae symbiosis

Algae which grows naturally in pond, where considerable quantities of both matrices and light is avaiable

The pond bacteria utilize the algal O_2 to be oxidizing the organic waste.

one of the major end products of bacteria metabolism is CO_2 which is utilized by algae.

This mutual dependence of bacteria and algae in stabilization pond is known as Bacteria- Algae Symbiosis.

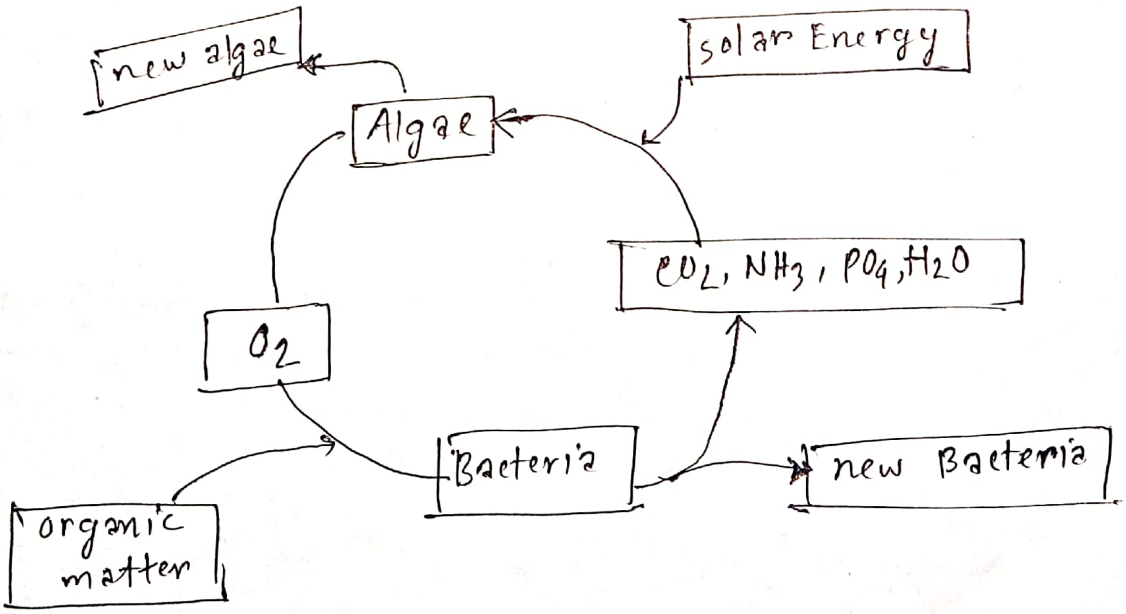


Fig. Bacteria -Algae Symbiosis

Microbiology in Waste Water Engineering

Objectives of Biological Treatment:

To coagulate and remove the non-settleable colloidal solids and to stabilize the organic matter.

① For domestic wastewater:

(i) To reduce organic content

(ii) to reduce the nutrients such as nitrogen and phosphorus.

(iii) to remove the trace organic compounds that may be toxic.

② For agricultural return waste water:

(i) To reduce the nutrients, specially nitrogen and phosphorus.

③ For industrial waste water:

(i) To remove or reduce the concentration of organic and in organic compounds.

Classification of Micro-organisms:

Based on Nucleus structure:

Class	Characterestics
① Eucaryotes	* Cells contain membrane-bound nucleus and membranous organelles.
(ii) Procaryotes	* No distinct nucleus and no membranous organelles.

Based on Kingdom:

	Kingdoms	Characterestics
Eucaryotes	Animals	Multi cellular, motile, exhibit tissue differentiation, heterotrophic
	Plants	Multicellular, Non-motile, exhibit tissue differenttiation, most phosynthetic
	Fungi	Most multicellular, non motile, heterotrophic, decomposer.
	Protista	Most unicellular, most motile, some heterotrophic some photo synthetic.
Procaryotes	Bacteria	Unicellular, some motile, some non motile, some heterotrophic, decomposers.

Based on energy and carbon: (2017)

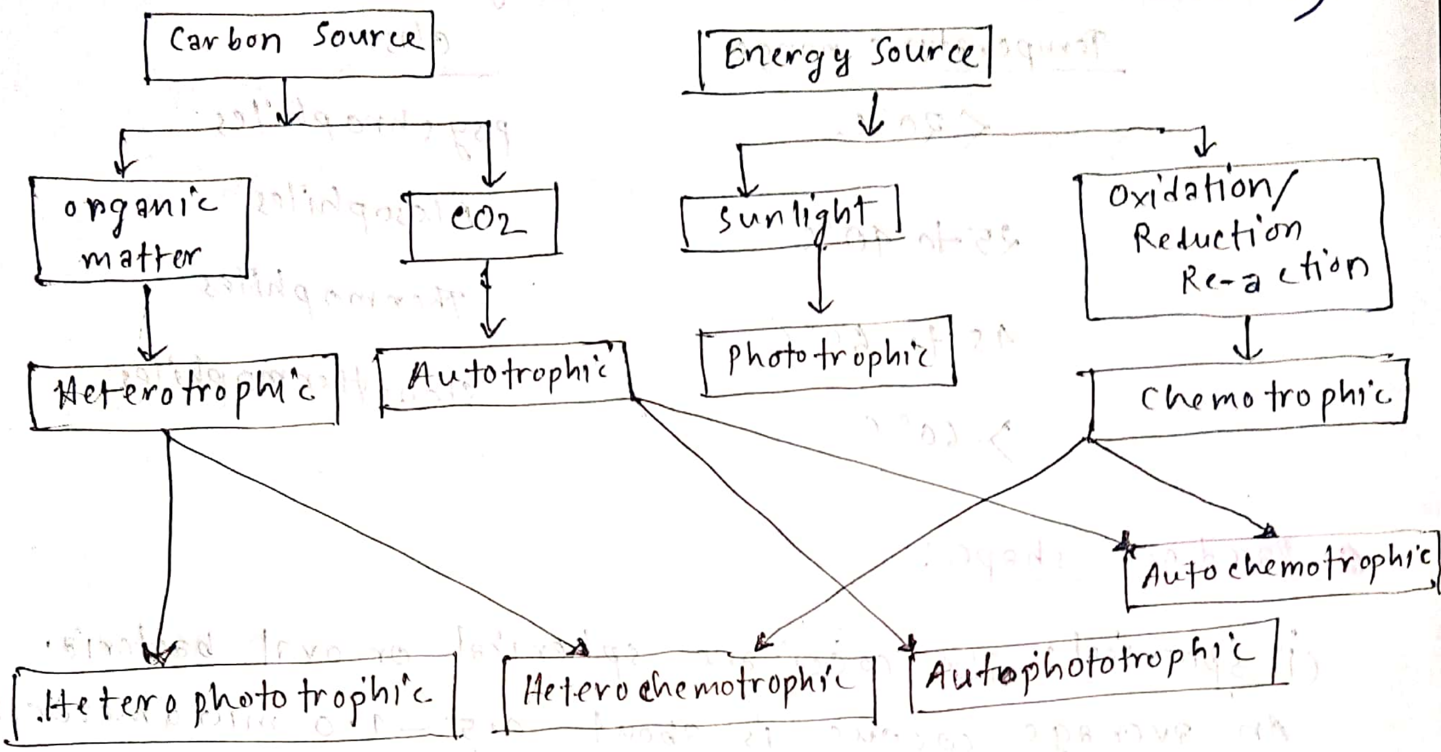
(i) Heterotrophic: If the micro-organism uses organic material as a supply of carbon, it is called heterotrophic.

(ii) Autotrophic: If the microorganisms require only CO_2 to supply their carbon needs, it is called Autotrophic.

(iii) Phototrophic: Organisms that rely on the sun for energy are called phototrophic.

(iv) Chemotrophic: If the micro-organisms extract energy from organic or inorganic oxidation/reduction reactions, it is called chemotrophic.

Classification of Micro-organisms (Based on energy and carbon)



Based on relation-ship to oxygen:

(i) Aerobes: The micro-organisms that can not survive in absence of oxygen are classified as Aerobes. They use oxygen as a terminal electron acceptor.

(ii) Anaerobes: Anaerobs are micro-organisms that can not survive in presence of oxygen. They can not use oxygen as a terminal electron acceptor.

(iii) Facultative: Facultative micro-organisms can survive both in presence and absence of oxygen.

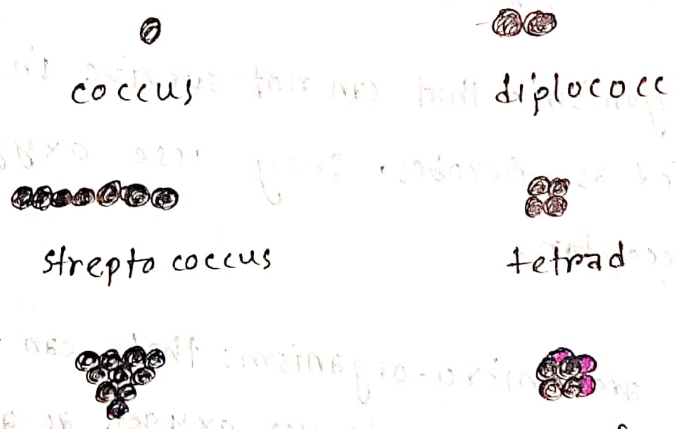
They can use oxygen as the terminal electron acceptor

Based on preferred temperature regime:

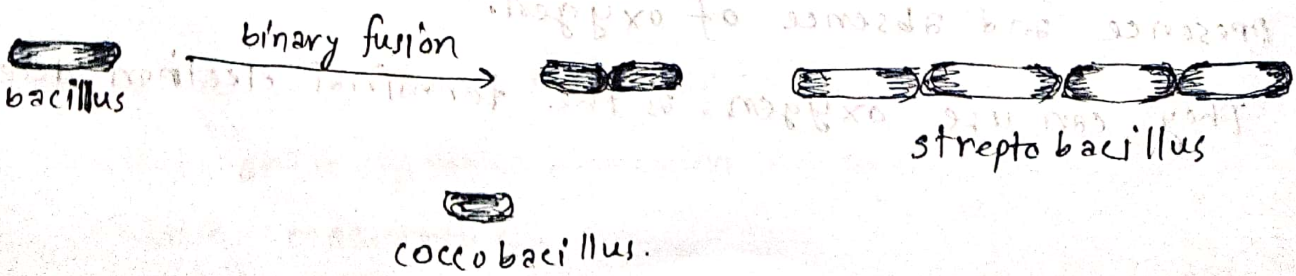
Temperature range	Class
< 20°C	psychrophiles
25 to 40°C	Mesophiles
45 to 60°C	Thermophiles
> 60°C	Stenothermophiles

Based on shape:

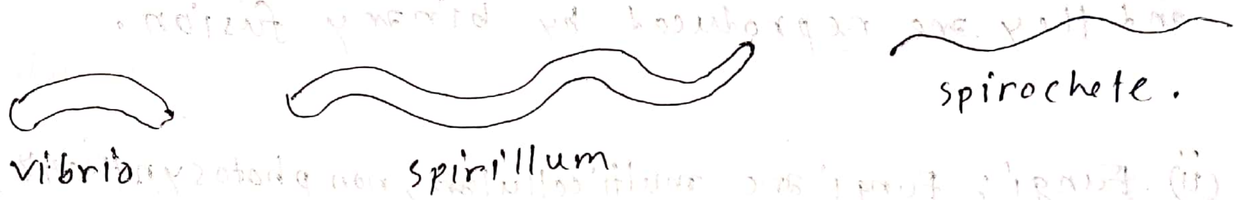
(i) Spherical: The 'cocci' are spherical or oval bacteria. An average coccus is about 0.5 – 1.0 micrometer in diameter



(ii) Rod: Bacilli are rod-shaped bacteria. An average bacillus is 0.5 – 1.0 μm wide by 1.0 – 4.0 μm long.



(iii) Spiral or Helical: Spiral come in one of three forms, a vibro, a spirillum, or a spirochete. Spirals range in size from 1 μm to over 100 μm in length.



2017

Q. Write down the role of micro-organisms in wastewater treatment.

The removal of carbonaceous B.O.D, The coagulation of non-settleable colloidal solids, and the stabilization of organic matter are accomplished biologically using a variety of micro-organisms, principally Bacteria.

The micro-organisms are used to convert the colloidal and dissolved carbonaceous organic matter into various gases and into cell tissue.

Because cell tissue has a specific gravity slightly greater than that of water, the resulting cells can be removed from treated liquid by gravity settling.

Important micro organisms Related to waste water engineering:

(i) **Bacteria:** The highest population of micro-organism in a waste water treatment will belong to the bacteria. They are single celled organisms which use soluble food. and they are reproduced by binary fusion.

(ii) **Fungi:** Fungi are multicellular, non photosynthetic, heterotropic organisms.
They are obligate aerobes that produce by fisson, budding and spore formation.

(iii) **Algae:** Algae are photoautotrophs and may be either unicellular or multicellular.
They produce oxygen through photosynthesis. But at night they use up oxygen in respiration.

(iv) **Protozoa:** Protozoa are single-celled organisms that can reproduce by binary fission.
They acts as polishers in consuming the bacteria.

(v) **Rotifiers and Crustaceans:** Both rotifers and crustaceans are animals - aerobic, multicellular chemoheterotrophs.
Rotifies consume bacteria and small particles of organic matter.
crustaceans are not found in waste water treatment system to any extent except in under loaded lagoons.

Describe briefly Microbial Metabolism:

The general term that describes all of the chemical activities performed by a cell is metabolism.

This in turn is divided into two parts:

(i) Catabolism and

(ii) Anabolism

Catabolism includes all the biochemical processes by which a substrate is degraded to end products with the release of energy.

Anabolism is the synthesis of complex molecules in living organisms from simpler ones together with the storage of energy, constructive metabolism.

Decomposition of Waste

2016

Discuss the decomposition process in waste water treatment.

2012 or, Briefly discuss the aerobic, anoxic and anaerobic decomposition of organic matter.

The type of electron acceptor avaiable for catabolism determines the type of decomposition; that is aerobic, anoxic or anaerobic, used by a mixed culture of micro-organisms.

Each type of decomposition has perticular characterestics which affect it's use in waste water treatment.

Aerobic Decomposition:

Molecular oxygen (O_2) must be present as the terminal electron acceptor for decomposition to proceed by aerobic oxidation through bacterial metabolism.

The chemical end products of this decomposition are primarily carbon-di-oxide, water and new cell material.

Anoxic Decomposition:

Some micro-organisms can use (NO_3^-) as the terminal electron acceptor in the absence of molecular oxygen. oxidation by this route is called. denitrification.

The end products from denitrification are nitrogen gas, carbon-di-oxide, water and new material.

As a consequence, the rate of production of new cells, although not as high as aerobic decomposition, is relatively high.

Anaerobic decomposition:

In order to achieve anaerobic decomposition, molecular oxygen and nitrogen must not be present as terminal electron acceptors.

Sulfate (SO_4^{2-}), carbon di-oxide and organic compounds that can be reduced, serve as terminal electron acceptors.

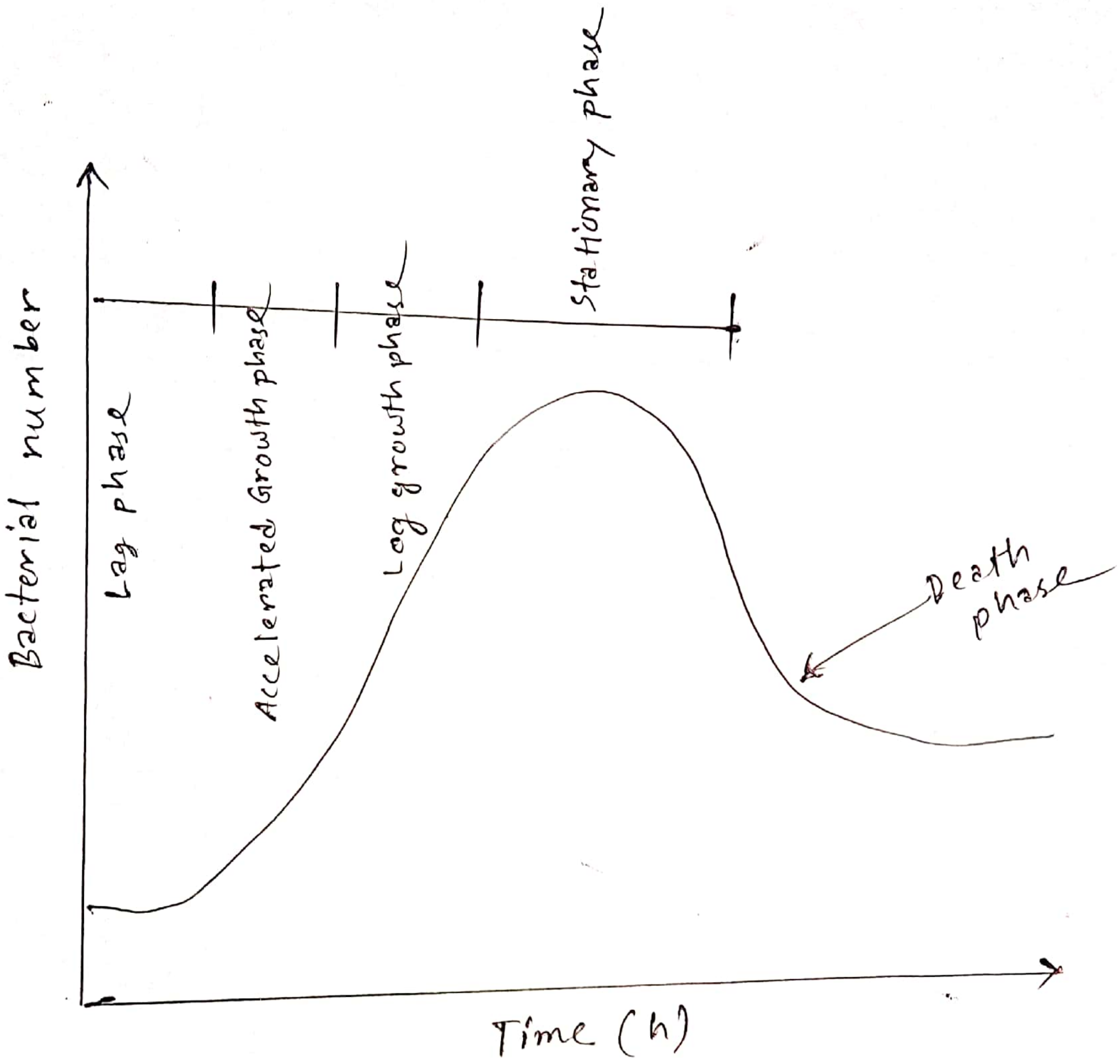
The anaerobic decomposition (fermentation) of organic matter generally is considered to be a two-step process:

(i) In the first step, complex organic compounds are fermented to low molecular-weight fatty acids.

(ii) In the second step, the organic acids are converted to methan, carbon-di-oxide serves as the electron acceptor.

Anaerobic decomposition yields carbon di-oxide, methane and water as the major end products.

Bacterial Growth in pure cultures:




Aquaculture
The farming of freshwater and
marine plants and animals.
Jackie

What is Aquaculture?

Aquaculture is the farming and husbandry of aquatic organisms under controlled or semi-controlled conditions.

These organisms may be plants, fish or shellfish — oysters, mussels, clams, shrimp, crabs, crawfish.

Aquaculture is employed for a variety of ends: fish may be raised to stock public waters for sportfishing and for commercial fishing; it may be to save an endangered species; or it may be to harvest a commercially viable crop in ponds or coastal waters.

What is Aquaculture?

In simple terms, aquaculture is agriculture: the farmer farms the water instead of the land; depending on the species, the water may be fresh or brackish or salty.

Although aquaculture is a generic term, it generally refers to the culture of plants and animals in freshwater, while culture in saltwater is commonly known as mariculture.

Why Aquaculture?

The world's oceans and rivers are fast approaching the limits of fish and shellfish production that can be harvested on a continual basis.

Farming the water is the possible solution to meet the increasing consumer demand.

In addition to the demand for seafood, there is a growing interest in sportfishing. Many public fisheries for recreational angling have had to reduce creel limits (number of fish legally allowed to be caught per day) or have imposed seasons for catching specific species of fish.

Why Aquaculture?

Aquaculture efforts can also be used to save or restore an endangered or threatened species.

These are special situations where, for various reasons, fish cannot reproduce in sufficient numbers, or the progeny do not survive well enough to maintain themselves as a population.

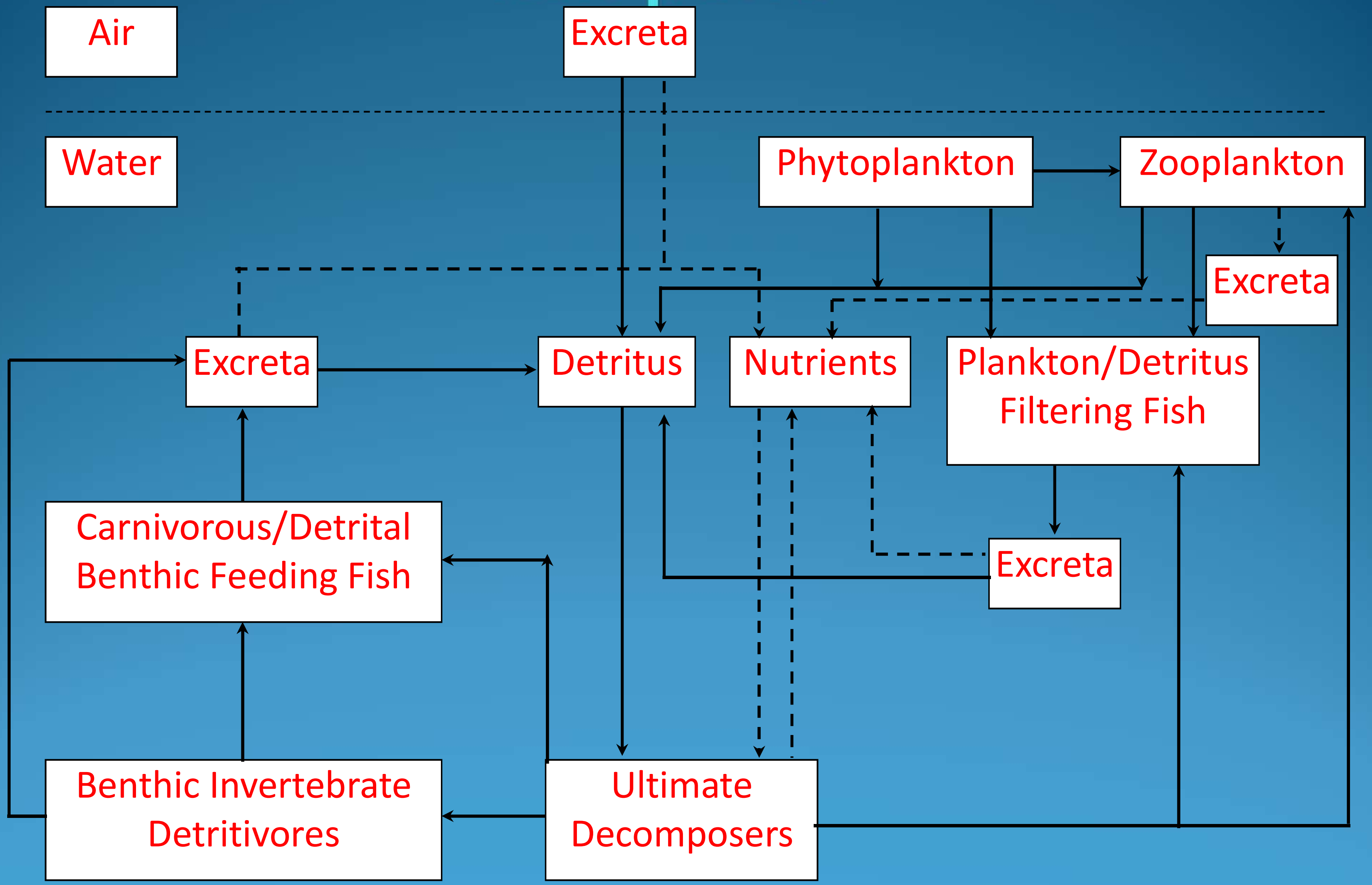
Wastewater use in aquaculture

The objective in fertilizing an aquaculture pond with excreta, nightsoil or wastewater is to produce natural food for fish.

Since several species of fish feed directly on faecal solids, use of raw sewage or fresh nightsoil as influent to fish ponds should be prohibited for health reasons.

Complex food chains in an excreta-fed fish pond as shown in Figure, involving ultimate decomposers or bacteria, phytoplankton, zooplankton and invertebrate detritivores. Inorganic nutrients released in the bacterial degradation of organic solids in sewage, nightsoil or excreta are taken up by phytoplankton.

Complex food chains in an excreta-fed fish pond



Complex food chains in an excreta-fed fish pond

Zooplankton graze phytoplankton and small detritus particles coated with bacteria, the latter also serving as food for benthic invertebrate detritivores. Plankton, particularly phytoplankaton, are the major sources of natural food in a fish pond but benthic invertebrates, mainly chironomids, also serve as fish food, although they are quantitatively less important.

Fish Species

A wide range of fish species has been cultivated in aquaculture ponds receiving human waste, including

- Common carp *(Cyprinùs carpio),*
- Indian major carps (*Catla catlax, Cirrhina mrigala and Labeo rohita),*
- Chinese silver carp *(Hypophthalmichthys molitrix),*
- Bighead carp *(Aristichthys nobilis),*
- Grass carp *(Ctenopharyngodon idella),*
- Crucian carp (*Carassius auratus),*
- Nile carp *(Osteochilus hasseltii),*

Fish Species

A wide range of fish species has been cultivated in aquaculture ponds receiving human waste, including

- Tilapia *(Oreochromis spp.),*
- Milkfish *(Chanos chanos),*
- Catfish *(Pangasius spp.),*
- Kissing gouramy *(Helostoma temmincki),*
- Giant gourami *(Osphronemus goramy),*
- *S*ilver barb *(Puntius gonionotus)* and
- Freshwater prawn *(Macrobrachium lanchesterii).*

Selection of Fish Species

The selection reflects local culture rather than fish optimally-suited to such environments. For example, Chinese carps and Indian major carps are the major species in excreta-fed systems in China and India, respectively.

In some countries, a polyculture of several fish species is used. Tilapia are generally cultured to a lesser extent than carps in excreta-fed systems although, technically, they are more suitable for this environment because they are better able to tolerate adverse environmental conditions than carp species.

Milkfish have been found to have poorer growth and survival statistics compared with Indian major carps and Chinese carps in ponds fed with stabilization pond effluent in India.

Aquatic Plants

Aquatic macrophytes grow readily in ponds fed with human waste. Some creeping aquatic macrophytes are cultivated as vegetables for human consumption in aquaculture ponds and duckweeds are also cultivated, mainly for fish feed. Among the aquatic plants grown for use as vegetables are

- Water spinach *(Ipomoea aquatica),*
- Water mimosa (*Neptunia oleracea),*
- Water cress *(Rorippa nasturtium-aquaticum)* and
- Chinese water chestnut *(Eleocharis dulcis).*

The duckweeds *Lemna, Spirodela* and *Wolffia* are cultivated in some parts of Asia in shallow ponds fertilized with excreta, mainly as feed for Chinese carps but also for chickens, ducks and edible snails

Course Code: CE 4141

Course Title: Environmental Engineering

Lecture – 16

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Cycle -10, Day-D
28-08-2019

Technical aspects of fish culture

Environmental factors

In a successful aquaculture system there must be both an organismic balance, to produce an optimal supply of natural food at all levels, and a chemical balance, to ensure sufficient oxygen supply for the growth of fish and their natural food organisms and to minimize the build-up of toxic metabolic products (Colman and Edwards, 1987).

Chemical balance is usually achieved through organismic balance in waste-fed ponds because the most important chemical transformations are biologically mediated.

It is now recognized that depletion of dissolved oxygen in fertilized fish ponds is due primarily to the high rates of respiration at night of dense concentrations of phytoplankton.

Technical aspects of fish culture

Romaire et al. (1978) introduced equation to cover the factors influencing waste-fed fish pond dissolved oxygen (DO) at dawn:

$$DO_{dn} = DO_{dk} \pm DO_{df} - DO_{m} - DO_{f} - DO_{p}$$

where:

DO_{dn} = DO concentration at dawn

DO_{dk} = DO concentration at dusk

DO_{df} = DO gain or loss due to diffusion

DO_{m} = DO consumed by mud

DO_{f} = DO consumed by fish

DO_{p} = DO consumed by plankton

Technical aspects of fish culture

Bacterial respiration is not specifically mentioned in this equation but is included in the mud consumption of DO and in the planktonic DO consumption.

In a well-managed waste-fed fish pond the DO in the morning should be only a few mg/l whereas in late afternoon the pond should be supersaturated with DO.

Mud respiration probably lowers DO by less than 1 mg/l overnight and a fish population weighing 3000 kg/ha would also lower DO by only about 1 mg/l overnight.

Technical aspects of fish culture

Phytoplankton photosynthesis is the major source of oxygen during daylight hours and, during the night, the major cause of oxygen depletion is respiration.

It has been estimated that respiration of plankton (bacterioplankton, phytoplankton and zooplankton) can lower pond DO by 8-10 mg/l overnight.

By far the greatest proportion of the DO depletion overnight is caused by the respiration of the phytoplankton that develop as a result of the nutrients contained in the waste.

Technical aspects of fish culture

Phytoplankton provide feed for the largest percentage of fish farmed in Asia (Edwards 1990).

They also exhibit a positive net primary productivity on a 24-hour basis and are net oxygen contributors to a fish pond.

The objective in a waste-fed fish pond should be to maintain an algal standing crop at an optimum level for net primary productivity by balancing the production of phytoplankton biomass, in response to waste fertilization, with the grazing of phytoplankton biomass by filter-feeding fish.

Technical aspects of fish culture

Fish mortality in a waste-fed pond can result from at least three possible causes.

- First, the depletion of oxygen due to bacterial oxygen demand caused by an increase in organic load.
- Second, the depletion of oxygen overnight due to the respiratory demand of too large a concentration of phytoplankton, having grown in response to an increase in inorganic nutrients, caused by an organismic imbalance.
- The third possible cause is high ammonia concentration in the waste feed.

All three causes of fish mortality have been reported in respect of sewage-fertilized fish ponds.

Technical aspects of fish culture

The sensitivity of fish to low levels of DO varies with species, life stage (eggs, larvae, adults) and life process (feeding, growth, reproduction).

A minimum constant DO concentration of 5 mg/l is considered satisfactory, although an absolute minimum consistent with the presence of fish is probably less than 1 mg/l (Alabaster and Lloyd, 1980).

Fish cultured in waste-fed ponds appear to be able to tolerate very low DO concentrations, for at least short periods of time, with air-breathing fish (such as walking catfish *(Clarias batrachus)* being the most tolerant, followed in decreasing order of tolerance by tilapia, carps, channel catfish and trout.

Technical aspects of fish culture

A wastewater fertilized aquaculture system might occasionally require a stand-by mechanical oxygenation system for use during periods when DO would otherwise be very low.

However, if the system is well managed to avoid overloading, this expense can be avoided.

Technical aspects of fish culture

Unionized ammonia (NH_3) is toxic to fish in the concentration range 0.2 - 2.0 mg/l (Alabaster and Lloyd, 1980).

However, the tolerance of different species of fish varies, with tilapa species being least affected by high ammonia levels.

Bartone et al. (1985) found that satisfactory growth and survival of tilapia was possible in fish ponds fed with tertiary effluent when the average total ammonia concentration is less than 2 mg N/l and the average unionized ammonia concentration was less than 0.5 mg N/l, with the latter only exceeding 2 mg N/l for short periods.

Technical aspects of fish culture

In ponds receiving large quantities of organic matter, sediments tend to accumulate and release anaerobic breakdown products, such as methane and sulphides, which can inhibit fish growth.

Bottom feeding fish, such as the common carp (*Cyprinus carpio),* are most affected by such conditions, especially if the macrozoobenthos disappear.

Technical aspects of fish culture

Fish Yields and Population Management

A wide range of yields has been reported from waste-fed aquaculture systems, for example: 2-6 tons/ha-yr in Indonesia, 2.7 - 9.3 tons/ha-yr in China and 3.5 - 7.8 tons/ha-yr in Taiwan.

Although the majority of waste-fed fish ponds stocks carps, research in Peru and Thailand has demonstrated the potential of tilapia for such systems.

Management of fish ponds can have a significant effect on fish yields but the maximum attainable yield in practice is of the order of 10 - 12 tons/ha-yr (Edwards, 1990).

Technical aspects of fish culture

Fish Yields and Population Management

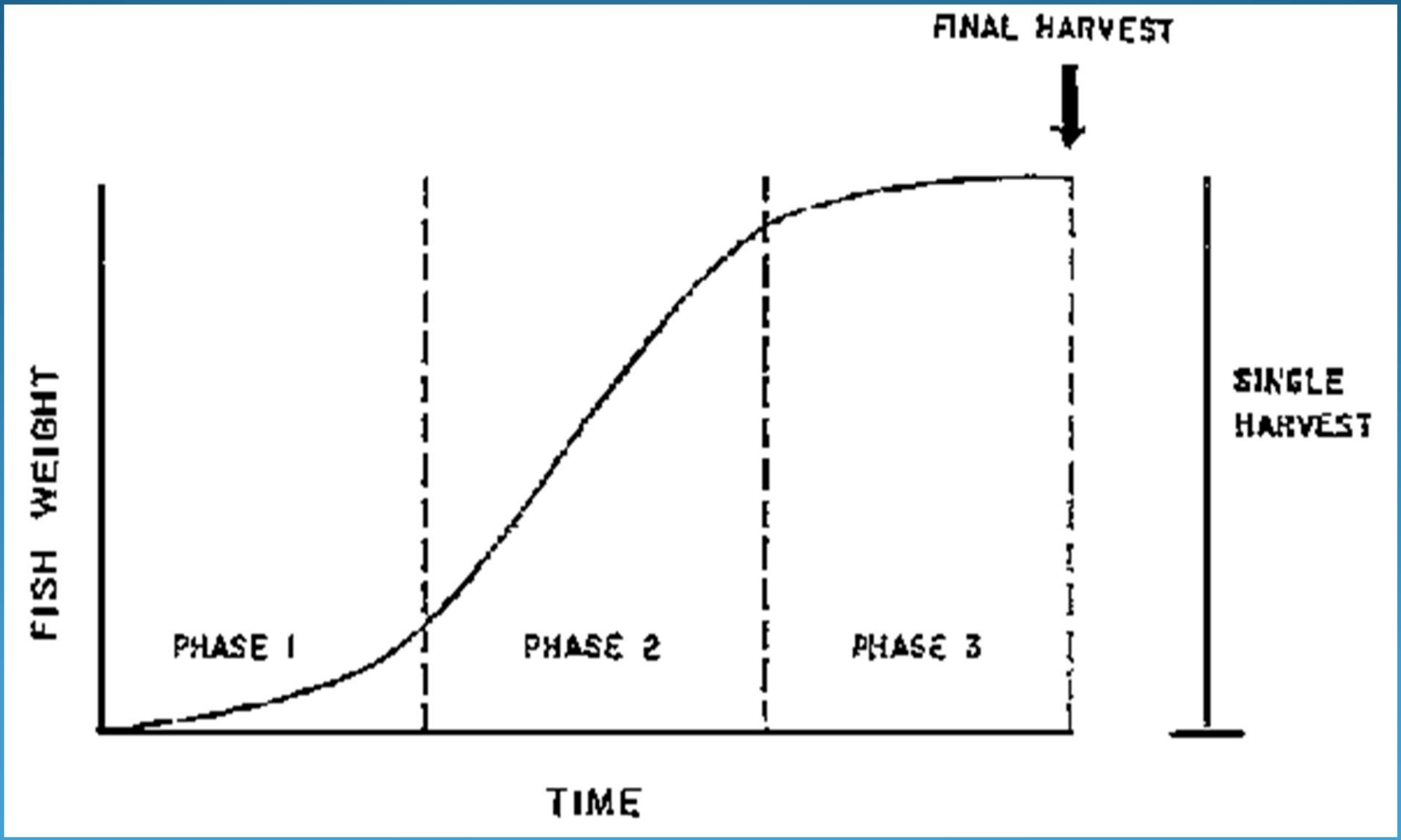
Increase in weight of small fingerlings stocked in a pond follows a sigmoidal curve. The first phase of growth (Shown in Figure) is slow, so a high stocking density can be adopted to better utilize the spatial and nutritional resources of the pond.

Alternatively, this can be achieved by stocking with larger fish having a higher initial weight, following growth in nursery ponds.

Fish yield is positively correlated with the size of the stocked fish at a given stocking density. In South China, tilapia are stocked once a year at rates of either 30 g fish and $0.15/m^2$ or 1.3 g fish at $2.3 - 3.0/m^2$ stocking density.

Technical aspects of fish culture

Fish Yields and Population Management



Technical aspects of fish culture

Fish Yields and Population Management

An increase in weight of fish in a pond leads initially to an increase in yield or production but there is subsequently a reduction in the growth rate of individual fish because of the limitation of natural food production in the system.

The third phase of slow growth in Figure is because the total weight of fish in the pond is approaching the carrying capacity.

Intermediate harvesting when the rapid growth ceases, at the end of phase 2, should lead to significant increases in total yield.

The high yields of tilapia reported in South China sewage-fed ponds are due to high stocking density and frequent harvesting.

Technical aspects of fish culture

Fish Yields and Population Management

Clearly, the key to achieving high yields in a waste-fed pond is to determine the carrying capacity of the pond, the maximum standing stock of fish.

This can be assessed by varying the waste load and determining the maximum production of natural food consistent with satisfactory water quality, sustainable through a fish culture cycle (Edwards, 1990).

Fish stocking density is related to carrying capacity according to the desired weight of individual fish at harvest.

Technical aspects of fish culture

Health Related Aspects of Fish Culture

Although it is good practice to limit the discharge of toxic materials to sewerage systems, inevitably some of these materials gain access and heavy metals and pesticides are frequently present in municipal sewage. This gives rise to concern about bioaccumulation when sewage effluent is used in aquaculture.

Algae are known to accumulate various heavy metals but, with the possible exception of mercury, fish raised in sewage-fed ponds have not been observed to accumulate high concentrations of these toxic substances.

Technical aspects of fish culture

Health Related Aspects of Fish Culture

It would appear that the concentrations of heavy metals in the pond water may be accumulated at slower rates than new tissues develop in rapidly growing fish, such as tilapia.

In the case of mercury, the position of fish in the food chain seems to be important in determining their mercury uptake, with carnivorous fish accumulating more than herbivores.

Technical aspects of fish culture

Health Related Aspects of Fish Culture

Fish, apparently, have the ability to regulate the heavy metal content of their tissues, except for mercury, and tend to accumulate metals in parts other than muscle tissue. There is little information on the uptake of toxics other than heavy metals but a high phenol content in the sewage fed to fish ponds in Wuhon, China caused the fish flesh to become unpalatable due to the odour of phenol. Weis et al. (1989) have reported on the effects of treated municipal wastewater on the early life stages of three species of fish and indicated that moderately toxic effluent (organic fractions) caused cardiovascular and skeletal defects, depression of heart rate and poor hatching, larval and juvenile growth rates.

Technical aspects of fish culture

Health Related Aspects of Fish Culture

Depuration was mentioned as a means to decontaminate fish grown in waste-fed aquaculture. It is generally believed that holding fish in clean-water ponds for several weeks at the end of the growing cycle will remove residual objectionable odours and pathogens and provide fish acceptable for market.

However, there is a lack of data on depuration practice and experimental assessment. What little evidence there is suggests that depuration of heavily contaminated fish with bacteria in muscle tissue will not be effective.

Relatively short depuration periods of one to two weeks do not appear to remove bacteria from the fish digestive tract.

Technical aspects of fish culture

Some Management Techniques

1. Transport and release of fingerlings are carried out during morning hours.
2. The stocked fishes are checked at the monthly intervals for their growth and health through sample netting.
3. Regular monitoring of physico-chemical parameters are undertaken.
4. Regular cleaning of pipes interconnecting the treatments pond and fish pond are done.

Technical aspects of fish culture

Advantages

1. The sewage fed fish culture uses the waste recycling process and maintains the good environment around the urban area.
2. Manuring and supplementary feeding is not required due to high content of nutrients in sewage.
3. Input cost is very low and production is very high.
4. This is the biological method of treating waste water before its final disposal in river.

Technical aspects of fish culture

Disadvantages

1. The sewage contain high load of organic and inorganic matters and toxic gases which may harm fish consumers.
2. As the raw sewage is used in fish ponds, there is a chance of infection and pollution to enter into human body through food chain. But this risk can be minimized if good managerial practice is followed.

Industrial Effluent Treatment & Disposal

Objectives

The principal objective of industrial wastewater treatment is generally to allow industrial effluents to be disposed of without danger to human health or unacceptable damage to the natural environment

To manage water discharged from homes, businesses, and industries to reduce the threat of water pollution.

Sources of Industrial Wastewater

Sources of Industrial Wastewater

Industries use water that obtained from the water treatment system for a variety of purposes, such as

- For manufacturing foods.
- For heating.
- For cooling.
- As carrier of raw material.
- As carrier of waste matter.
- As a solvent.

The resulting water is then classified as a wastewater.

Effects

- The indiscriminate discharge of these wastewater streams into the environment can
  - Render soils "sick ".
  - Pollute the receiving bodies of water.
  - Cause air pollution by generating obnoxious gases.
- Discharge untreated wastewater into the domestic sewer system makes the task of treating domestic sewage, a very difficult and costly exercise.
- To prevent any health hazards caused by discharging wastewater into the environment and protect domestic sewage , the wastewater must be treated before discharge.

Characteristics of Industrial Wastewater

1. Physical Characteristics

1.1 Total Solids

● Analytically the total solids content of a wastewater is defined as all the matter that remains as residue upon evaporation at 103 to 105°C.

Characteristics Of Industrial Wastewater

1.2 Odors

Industrial wastewater may contain either odorous compounds or compounds that produce odor during the process of wastewater treatment.

1.3 Temperature

The temperature of water is a very important parameter because of its effect on

- Chemical reactions and reaction rates in treatment process.

- Aquatic life.

Characteristics Of Industrial Wastewater

1.4 Color

Color of industrial wastewater varies according to the type of industry.

Most colored matter is in a dissolved state.

1.5 Turbidity

Turbidity, a measure of the light-transmitting properties of water, is another test used to indicate the quality of wastewater discharges and natural waters with respect to colloidal and residual suspended matter.

Characteristics Of Industrial Wastewater

2. Chemical Characteristics

2.1 Organic Matter

The presence of these substances has complicated industrial wastewater treatment because many of them either cannot be or are very slowly decomposed biologically.

Typical examples include:

- Fats, Oils, and Grease.
- Surfactants.
- Phenols.
- Volatile Organic Compounds (VOCs).
- Pesticides & Agricultural Chemicals.

2.2 Inorganic Matter

- Nitrogen & Phosphorus.
- Sulfur.
- Heavy Metals.

Characteristics Of Industrial Wastewater

3. Biological Characteristics

- Some industries have certain pathogenic organisms like slaughterhouses others have molds and fungi as starch and yeast factories.
- Biological information is needed to assess the degree of treatment of the wastewater before its discharge to the environment.

Important Contaminants of Concern in Wastewater Treatment

Suspended solids

Lead to the development of sludge deposits and anaerobic conditions when untreated wastewater is discharged into the aquatic environment.

Nutrients (P, N2&C)

When discharged into the aquatic environment, these nutrients can lead to the growth of undesirable aquatic life. When discharged in excessive amounts on land, they can also lead to the pollution of groundwater.

Priority pollutants

Organic and inorganic compounds selected on the basis of their known or suspected carcinogenicity, or high acute toxicity. Many of these compounds are found in wastewater.

Important Contaminants of Concern in Wastewater Treatment

Refractory organics

These organics tend to resist conventional methods of wastewater treatment. Typical examples include surfactants, phenols, and agricultural pesticides.

Heavy metals

Heavy metals are usually discharged to wastewater from commercial and industrial activities and have to be removed if the wastewater is to be reused.

Dissolved inorganics

Inorganic constituents such as calcium, sodium, and sulfate are added to the original domestic water supply as a result of water use and may have to be removed if the wastewater is to be reused.

Common Types of Wastewater Treatment Methods

1. **Physical Unit Operations**

- Treatment methods in which the application of physical forces predominates.
- Screening, mixing, flocculation, sedimentation, flotation, filtration, and gas transfer are typical unit operations.

2. **Chemical Unit Processes**

- Treatment methods in which the removal or conversion of contaminants is brought about by the addition of chemicals or by other chemical reactions.
- Precipitation, adsorption, and disinfection are the most common examples used in wastewater treatment.

Common Types of Wastewater Treatment Methods

3. **Biological Unit Processes**

- Treatment methods in which the removal of contaminants is brought about by biological activity.
- Biological treatment is used primarily to remove the biodegradable organic substances (colloidal or dissolved) and nutrients (nitrogen & phosphorus) from wastewater.
- Basically, these substances are converted into gases that can escape to the atmosphere and into biological cell tissue that can be removed by settling.

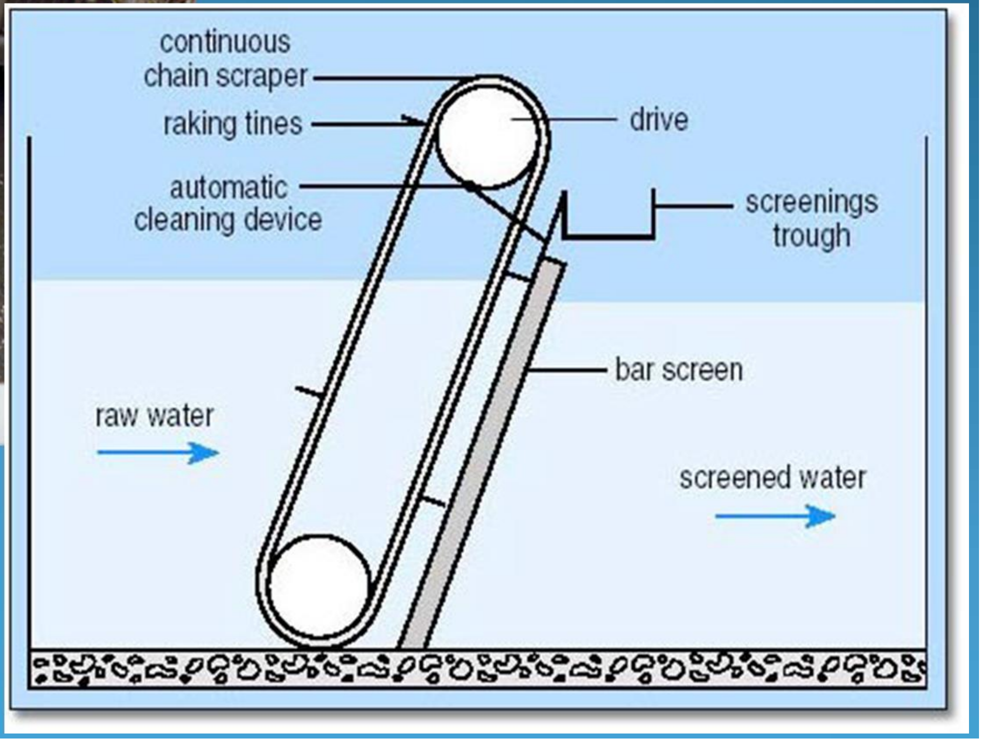
Main Treatment Technologies

1. Screening

- The first unit operation encountered in wastewater-treatment plants is screening. A screen is a device with openings, generally of uniform size that is used to retain the coarse solids found in wastewater.
- According to the method of cleaning, screens are designated as hand cleaned or mechanically cleaned.
- According to the size of openings, screens are designated as coarse or fine. Coarse screens have openings of ¼ inch or more, and fine screens have openings of less than ¼ inch.

Main Treatment Technologies

Mechanical Screen



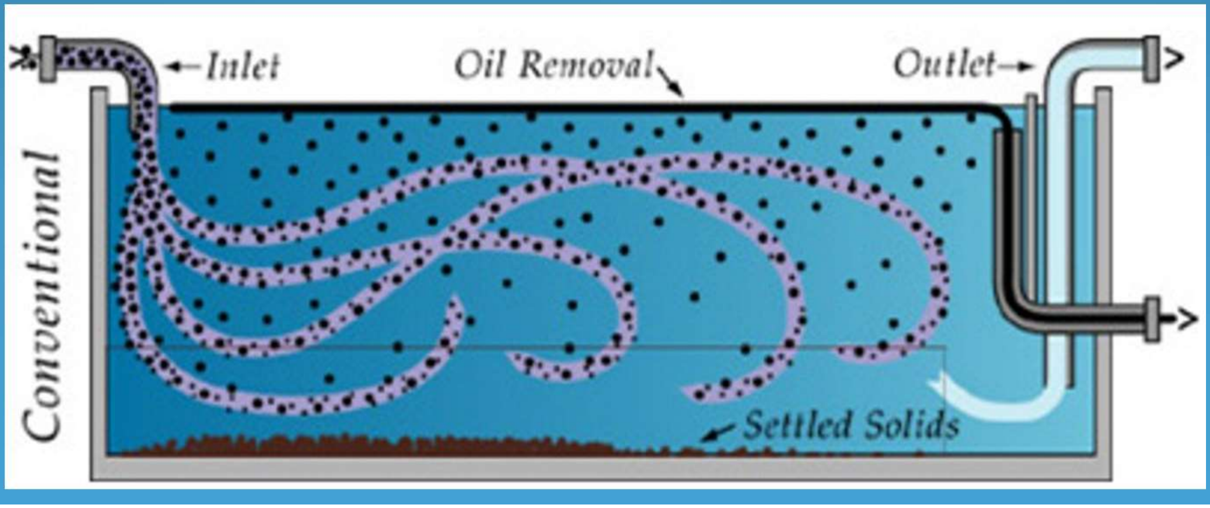
Main Treatment Technologies

2. Oil Separation

It is a process in which Floatables, namely non-emulsified oil and organics separates from wastewater.

2.1 API (American Petroleum Institute) Separators

- The design of the separator is based on the specific gravity difference between the oil and the wastewater and between the suspended solids and wastewater .
- In general, this separator can handle very large flow. However, its disadvantage is the long retention time required for efficient oil separation.

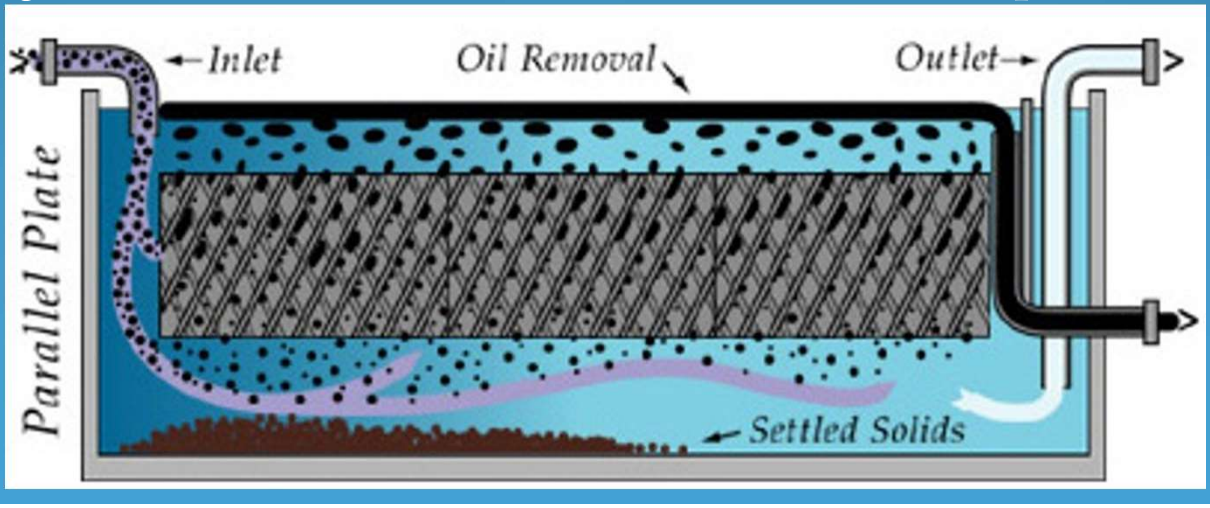


Main Treatment Technologies

2. Oil Separation

2.2 CPI (Corrugated Plate Interceptors) Units

- They consist of stacks of plates or bundles of slanted tubes, usually at 60 degrees, in a vessel or tank. It has been found that if the plates are tilted at 60 degrees, the solids will slide down the plates and be collected at the bottom.
- A CPI units can be placed in a small space but cannot take shock loads and high flows.
- They are usually more efficient than API separators and primary clarifiers in removing oil and solids, as more surface area can be provided.



Main Treatment Technologies

3 Flow Equalization

- Flow equalization is used to overcome the operational problems caused by flow variations, to improve the performance of the downstream processes, and is also used as an emergency tank to equalize wastewater effluent in case of any process failure in the treatment process.
- The design must provide for sufficient mixing to prevent solids deposition and concentration variations and also to provide aeration to prevent odor problems.
- The best location for equalization facilities to be at existing and proposed treatment plant sites. In some cases, equalization after primary treatment and before biological treatment may be appropriate.

Main Treatment Technologies

Physical Treatment

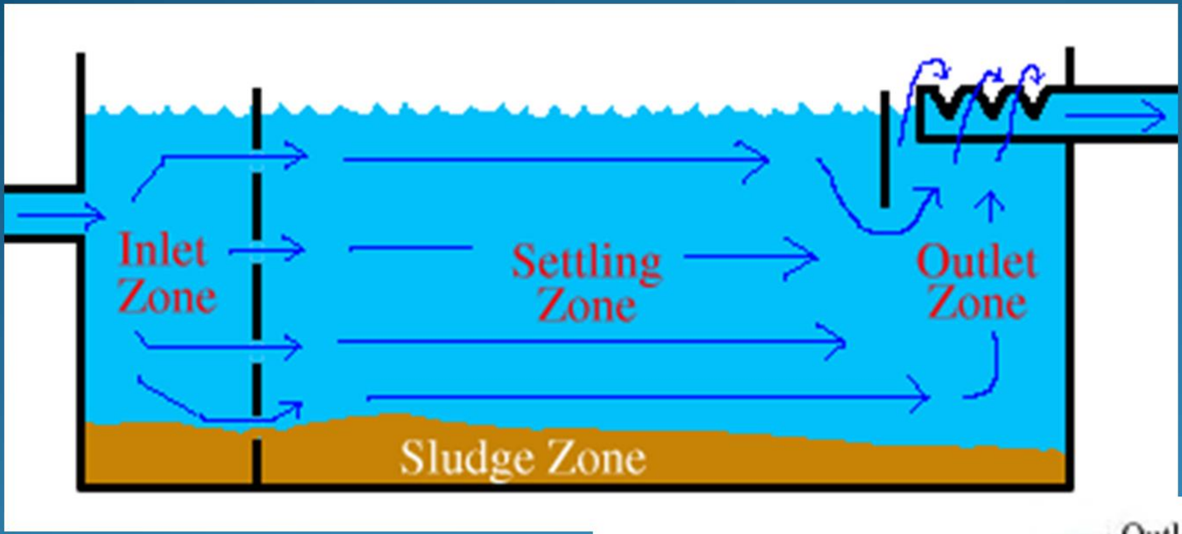
1. Sedimentation

- Sedimentation is the separation from water, by gravitational settling, of suspended particles that are heavier than water.
- Sedimentation is used for separation of grit and particulate matter in the primary settling basin, separation of biological-floc in the activated-sludge settling basin, and separation of chemical-floc when the chemical coagulation process is used. It is also used for solids concentration in sludge thickeners.
- Sedimentation basins are constructed in a variety of shapes and sizes, circular tanks or rectangular tanks.
- The basin is comprised of four zones according to function:

1-The inlet zone. 2-The settling zone.

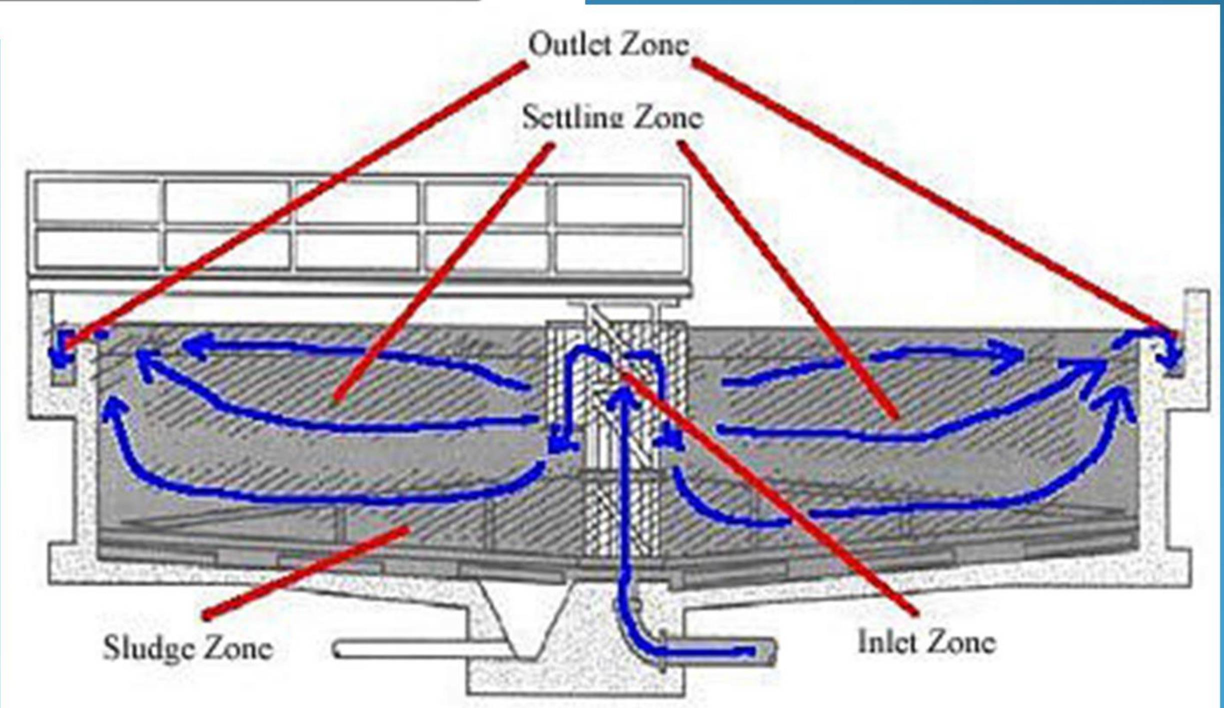
3-The sludge zone. 4-The outlet zone.

Main Treatment Technologies



Rectangular Type

Circular Type



Main Treatment Technologies

Rectangular Type

Circular Type

Main Treatment Technologies

2 Flotation

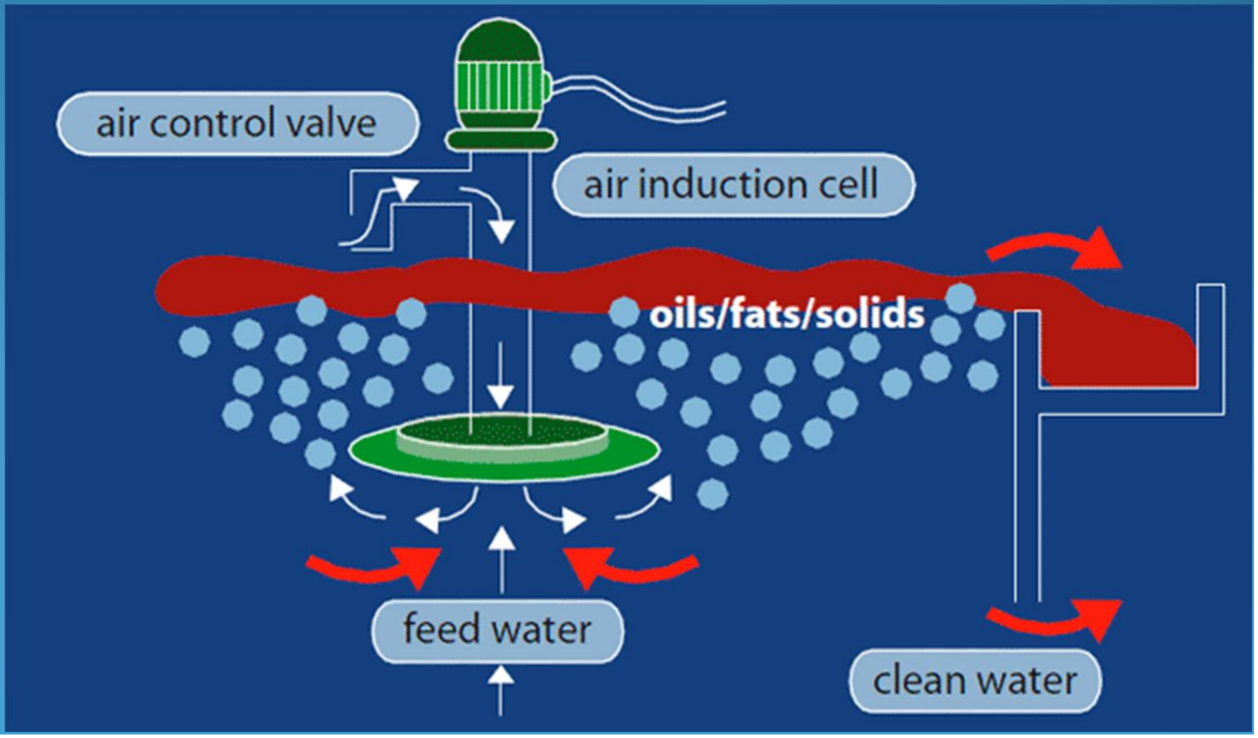
- Flotation is a unit operation used to separate solid or liquid particles from a liquid phase.
- Separation is brought by introducing fine gas (usually air bubbles) into the liquid phase. The bubbles attach to the particulate matter, and the buoyant force of the combined particle and gas bubble is great enough to cause the particle to rise to the surface to form a scum blanket, which is removed by a skimming mechanism. Grit and other heavy solids that settle to the bottom are raked to a central sludge for removal.
- Principal advantage of flotation over sedimentation is that very small or light particles that settle slowly can be removed more completely and in a shorter time.

Main Treatment Technologies

Types Of Flotation Systems

Air Flotation

In this system, air bubbles are formed by introducing the gas phase directly into the liquid phase through a revolving impeller through diffusers.

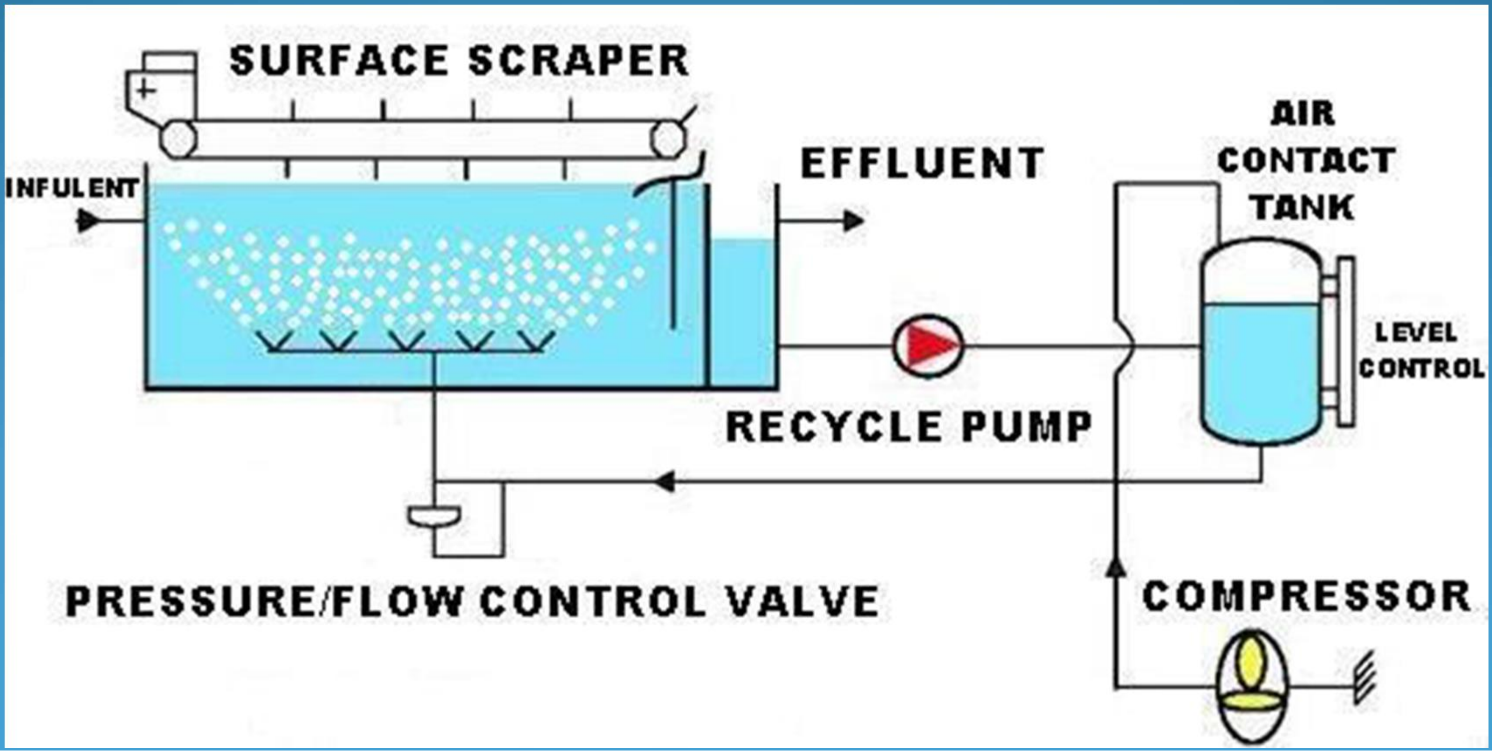


Main Treatment Technologies

Types Of Flotation Systems

Vacuum Flotation

This process consists of saturating the wastewater with air either directly in an aeration tank or by permitting air to enter on the suction side of a sewage pump.



Main Treatment Technologies

Chemical Treatment

1 Neutralization

- Industrial wastes often contain acidic or alkaline components which require neutralization before discharge or treatment.
- For wastes that are discharged to receiving waters, a pH between 6 and 9 is frequently specified by regulatory agencies. For wastes entering biological treatment processes, the pH should be maintained between 6.5 and 9 for optimum growth of the microorganisms.
- Acidic wastes are commonly neutralized with waste alkaline streams, lime, dolomite, ammonia, caustic soda, or soda ash.
- Lime is the most widely used alkaline material for neutralization acid wastes because of its low cost. Lime may be slow to react and may form insoluble precipitates.
- Alkaline wastes usually require treatment with a waste acidic stream, sulfuric acid or hydrochloric acid.

Main Treatment Technologies

2 Oxidation/Reduction

Oxidants are used in wastewater treatment as a first step in the removal of heavy metals to oxidize organics or as a last step in a treatment process, to oxidize odoriferous compounds such as hydrogen sulphide or to oxidize inorganics such as cyanide and for disinfection.

Common oxidation agents used in wastewater treatment:

-Oxygen(O_2).

-Chlorine (Cl_2).

-Sodium hypochlorite ($NaClO$).

-Calcium hypochlorite ($Ca(ClO)_2$).

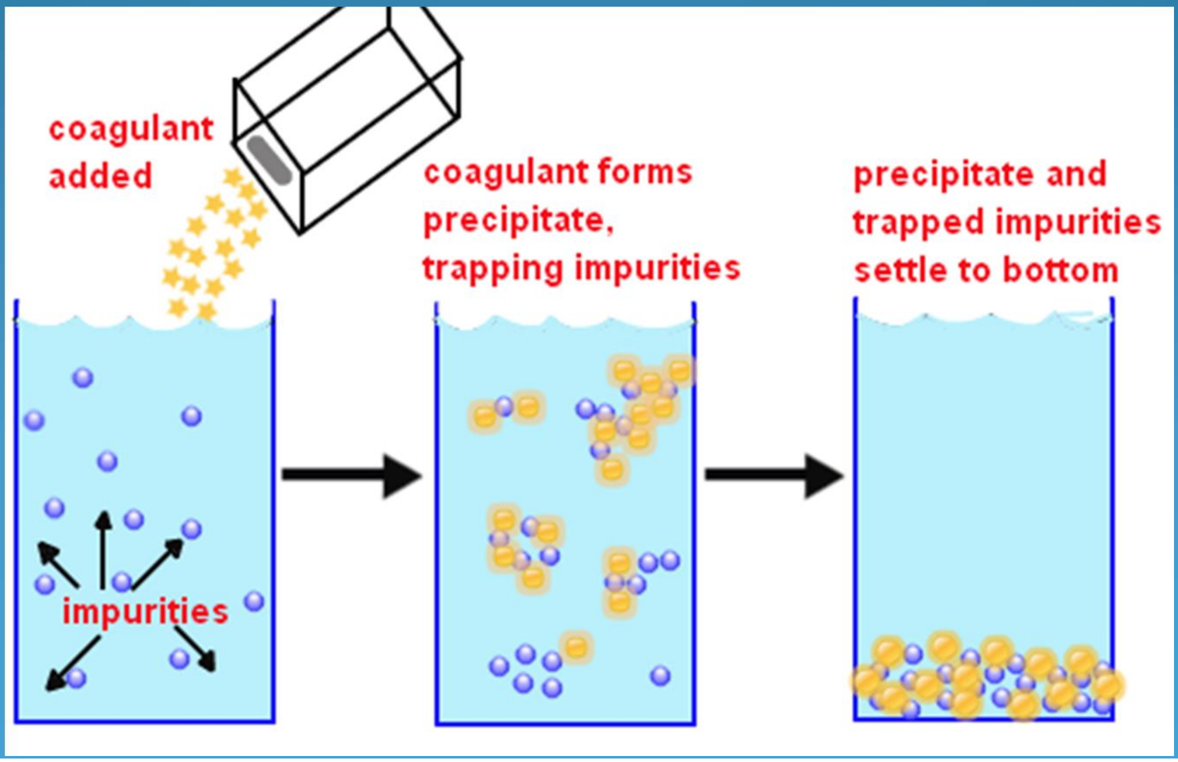
-Potassium permanganate($KMnO_4$).

-Hydrogen peroxide(H_2O_2).

Main Treatment Technologies

3 Chemical Precipitation

Chemical precipitation in wastewater treatment involves the addition of chemicals to alter the physical state of dissolved and suspended solids and facilitate their removal by sedimentation.



Main Treatment Technologies

3 Chemical Precipitation

3.1 Coagulation

- It takes place in rapid mix, or flash mix basins which are very rapid. The primary function of rapid mix basin is to disperse the coagulant so that it contacts all of the wastewater.
- Over the years a number of different substances have been used as precipitants. The most common ones

-Alum($Al_2(SO_4)_3.18H_2O$).

-Ferrous Sulfate($FeSO_4.7H_2O$).

-Lime $Ca(OH)_2$.

-Ferric Chloride ($FeCl_3$).

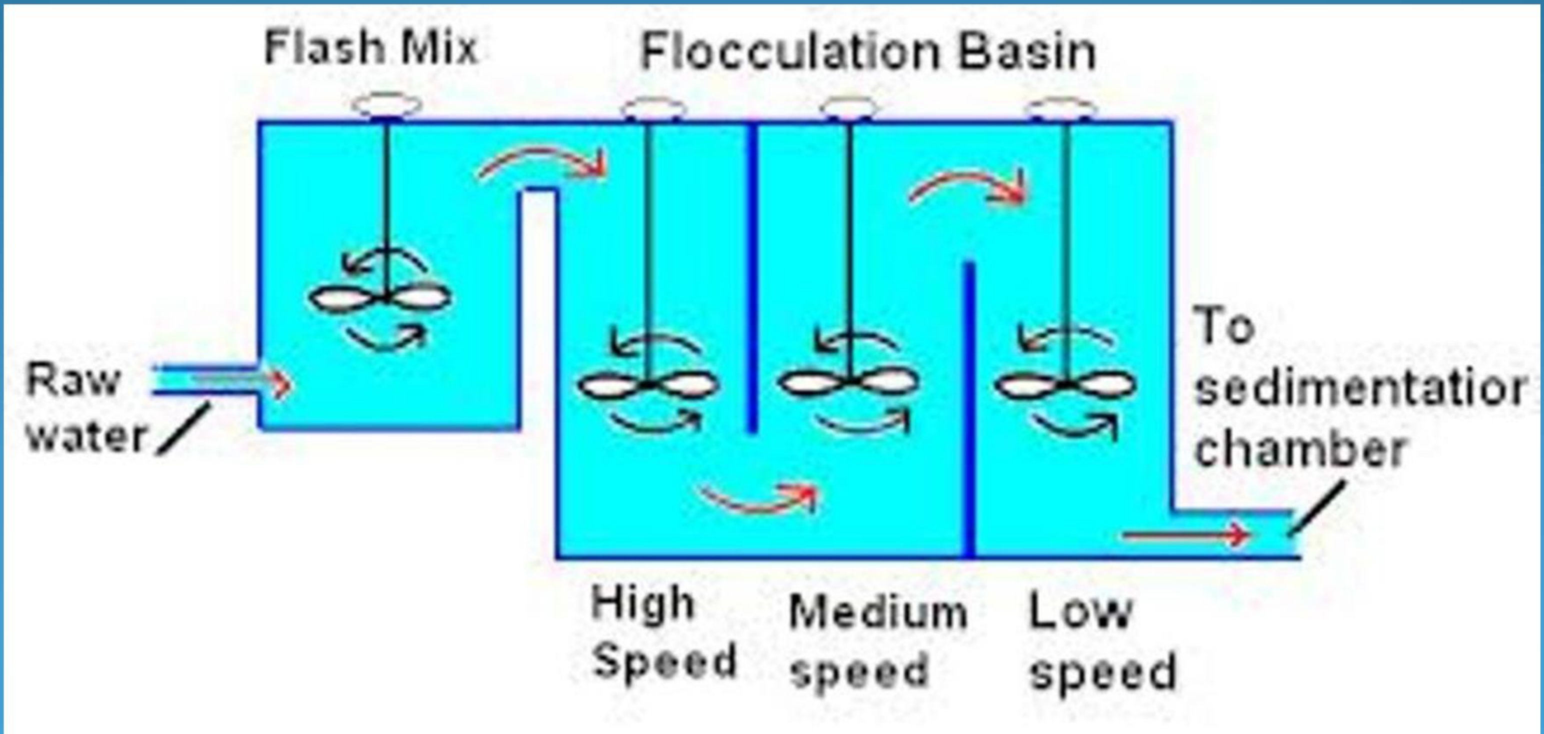
-Ferric Sulfate ($Fe_2(SO_4)_3$).

Main Treatment Technologies

3 Chemical Precipitation

3.2 Flocculation

The purpose of flocculation is to form aggregates or flocs from the finely divided matter. The flocculation of wastewater by mechanical or air agitation.



Main Treatment Technologies

3 Chemical Precipitation

**Chemical Precipitation for Improving Plant Performance

● From 80 to 90 percent of total suspended matter, 50 to 80% of BOD_5 and 80 to 90% of bacteria can be removed by chemical precipitation. In comparison, when plain sedimentation is used, only 50 to 70 percent of total suspended matter, 25 to 40% of BOD_5 and 25 to 75 percent of bacteria can be removed.

Main Treatment Technologies

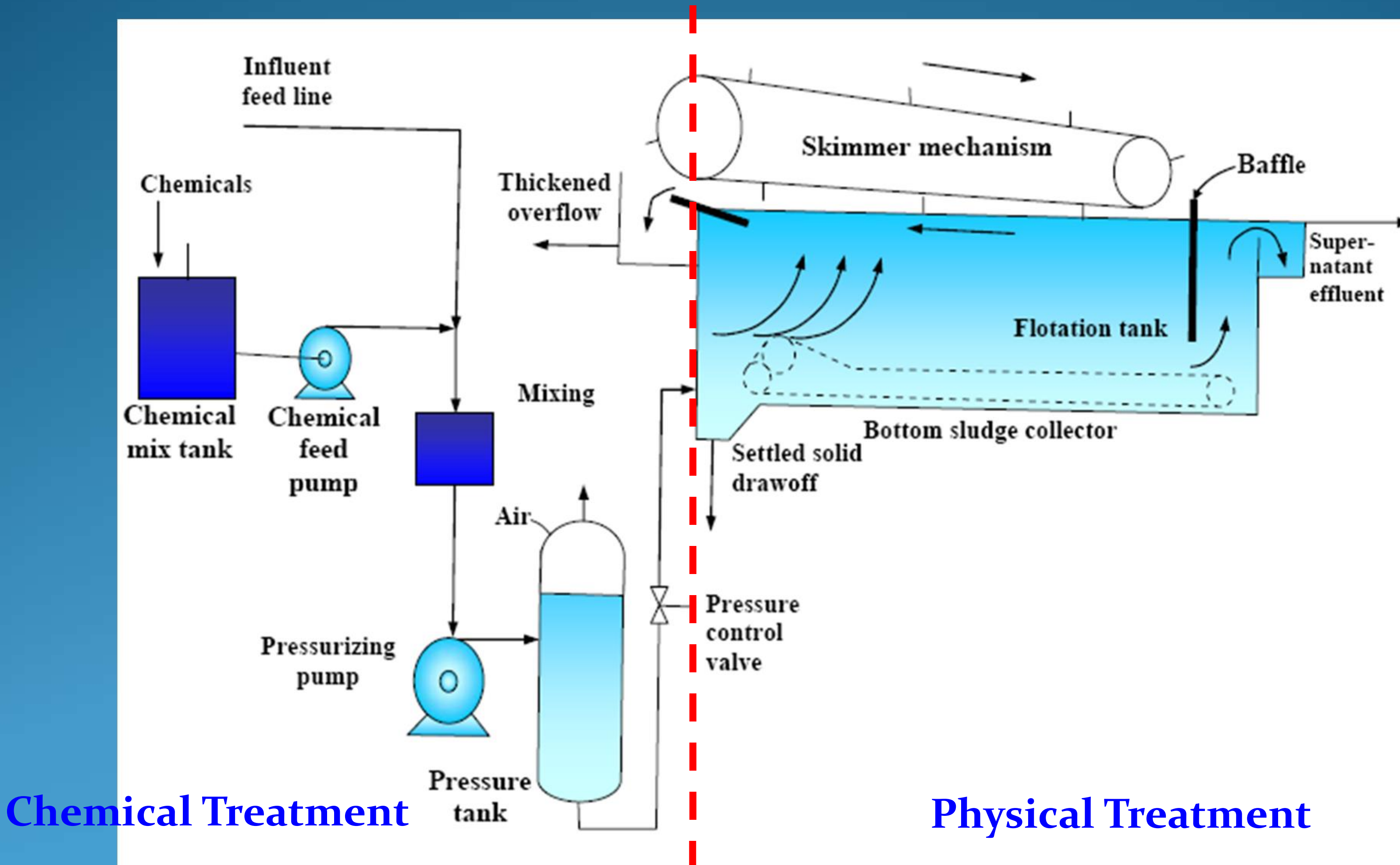
Physio-Chemical Treatment

Dissolved Air Flotation (DAF) System

- In dissolved air flotation (DAF), air is intimately contacted with an aqueous stream at high pressure, dissolving the air. The pressure on the liquid is reduced through a back pressure valve, thereby releasing micron-sized bubbles that sweep suspended solids and oil from the polluted stream to the surface of the air-flotation unit.
- Solids having a specific gravity greater than water tend to settle to the bottom and are removed by a rotating scraper arm. Attached to the same shaft is a rotating skimmer blade that removes the floating matter from the surface of the vessel into a skimming hopper.
- Clean water passes underneath a skirt and then must leave the vessel through a launder, which is located in the peripheral region.

Main Treatment Technologies

Physio-Chemical Treatment

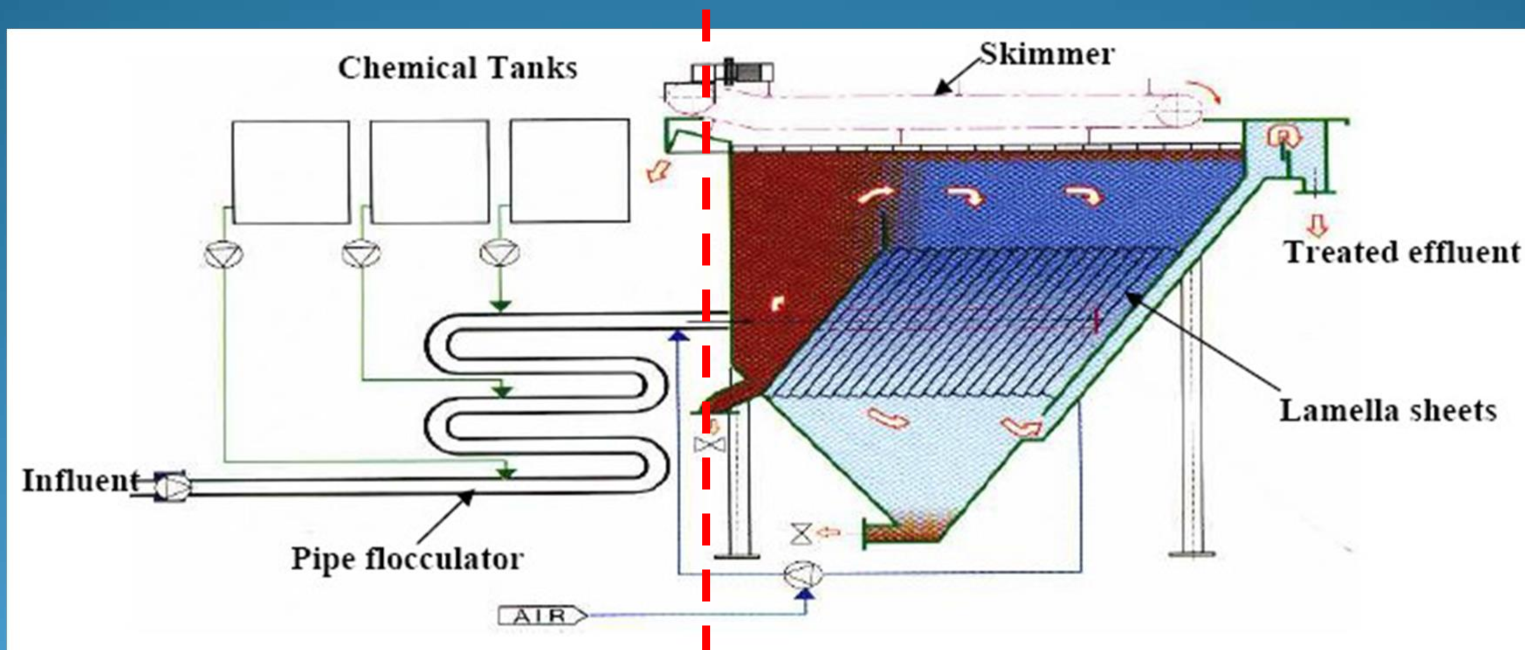


DAF system without recycling

Main Treatment Technologies

Physio-Chemical Treatment

A portion of the effluent water is recycled for pressurization. Compressed air is introduced into the discharge of the recycle pump, and intimate contact with the water is achieved in the aeration tank.



Chemical Treatment

Physical Treatment

DAF system with lamella, type flocculate & recycling

Main Treatment Technologies

Biological Treatment

1 Aerobic Biological Treatment

1.1 Activated-Sludge Process

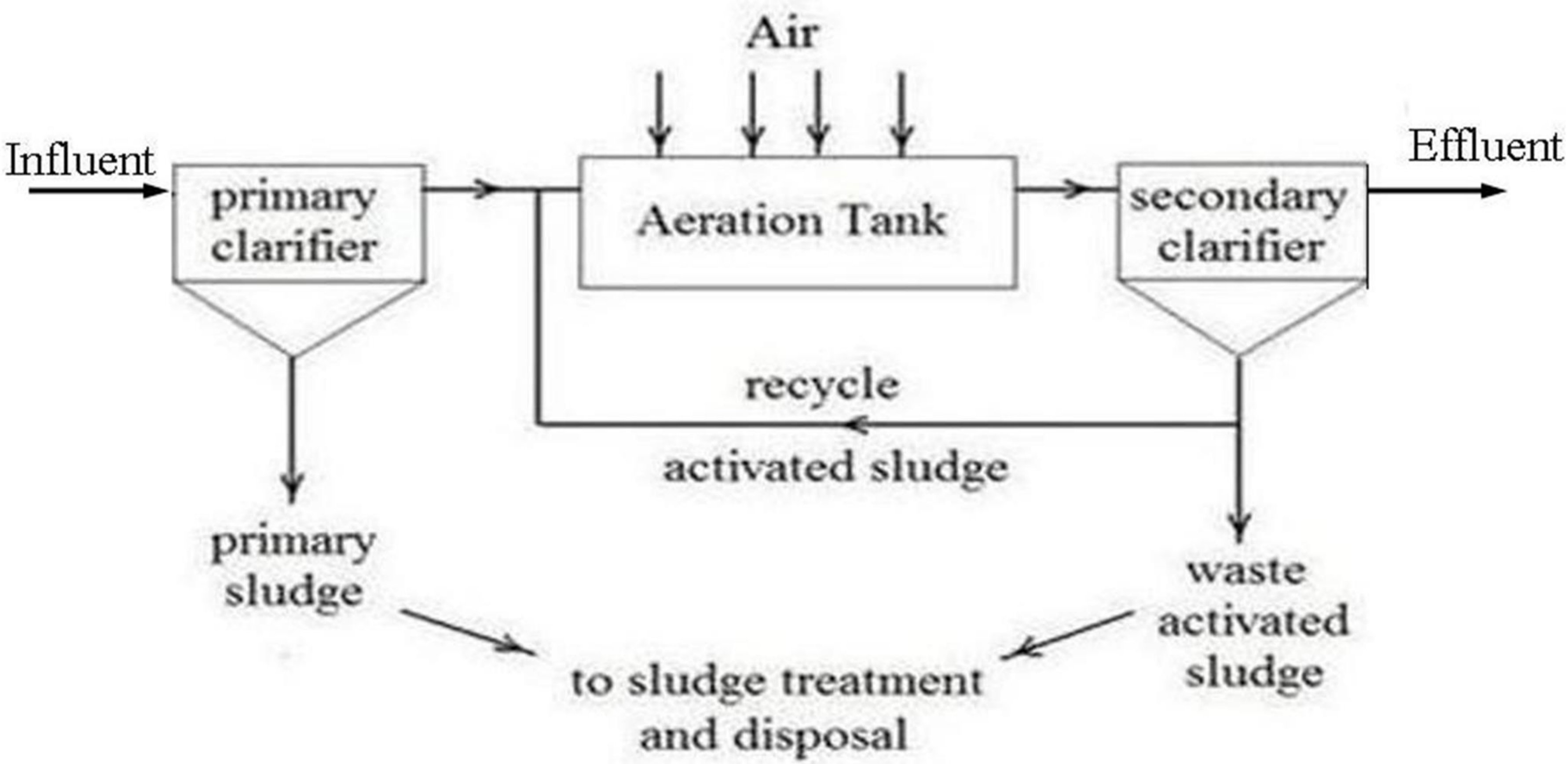
1.1.1 Conventional Activated Sludge

● The conventional activated sludge system contains a tank for wastewater aeration followed by a settler and a solids recycle line.

● The wastewater flows through under constant aeration in the presence of activated sludge and exits at the end of the tank after 4-8 hours of residence time. The oxygen concentration in the reactor should be 0.5-2 mg/l throughout, where values over 2 mg/l are considered lost energy.

Main Treatment Technologies

Biological Treatment



Main Treatment Technologies

Biological Treatment

1.1.2 Extended Aeration

● This is the modified form of a conventional activated sludge process in which the production of excess sludge is minimized by oxidation and an increase in residence time, i.e. through the larger size of the aeration tank.

● The retention time is extended to 1-2 days, which results in a very low net yield of sludge due to its consumption of endogenous respiration.

● The main advantage of the extended aeration system is in having the minimum of sludge handling facilities as compared with other conventional activated sludge processes.

● The sludge in extended aeration effluents is very light, of nondegradable nature, and settles with difficulty. Therefore, settling tanks are provided with a longer retention time of approximately 4 hours versus 2 hours for the conventional treatment process.

Main Treatment Technologies

Biological Treatment

1.2 Sequential Batch Reactor "SBR"

• The unit processes involved in the SBR and conventional activated sludge systems are identical. Aeration and sedimentation/clarification are carried out in both systems. However, there is one important difference. In conventional plants, the processes are carried out simultaneously in separate tanks, whereas in SBR operation the processes are carried out sequentially in the same tank.

● As currently used, all SBR systems have five steps are commonly carried out in sequence as follows:

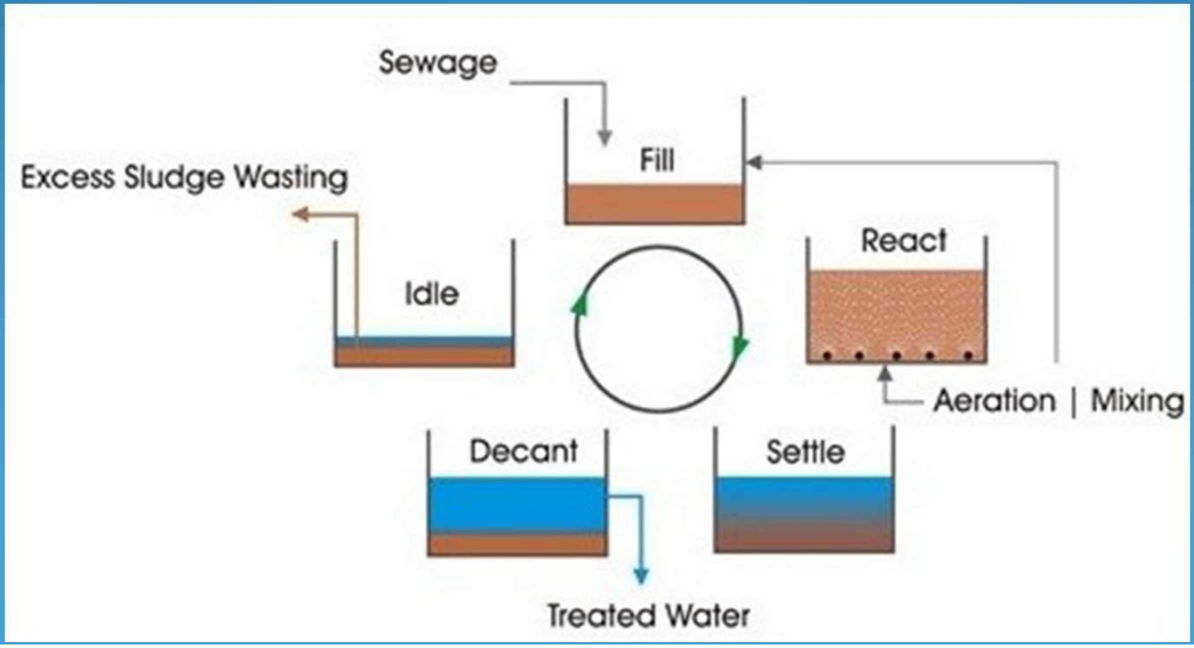
1- fill. 2- react (aeration). 3- settle (sedimentation/clarification). 4-draw (decant).
5- idle.

Main Treatment Technologies

Biological Treatment

1.2 Sequential Batch Reactor "SBR"

A unique feature of the SBR system is that there is no need for a return activated-sludge (RAS) system. Because both aeration and settling occur in the same chamber, no sludge is lost in the react step, and none has to be returned from the clarifier to maintain the sludge content in the aeration chamber.



Main Treatment Technologies

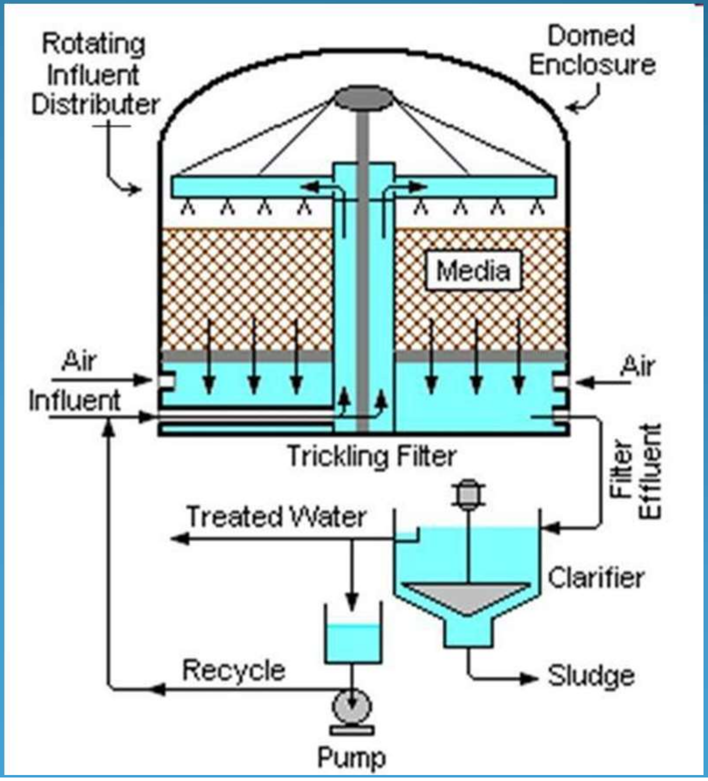
1.3 Trickling Filter " Biological Air Filters"

- The trickling filter consists of a bed of a highly permeable medium to which microorganisms are attached and through which wastewater is percolated or trickled.
- The filter media usually consist of either rock (slag is also used) or a variety of plastic packing materials.
- Rock filter beds are usually circular and the liquid wastewater is distributed over the top of the bed by a rotary distributor, and the wastewater was allowed to contact the media for a short time.
- The collected liquid is passed to a settling tank where the solids are separated from the treated wastewater. In practice, portion of the liquid collected in the under-drain system or the settled effluent is recycled, usually to dilute the strength of the incoming wastewater and to maintain the biological slime layer in a moist condition.

Main Treatment Technologies

1.3 Trickling Filter " Biological Air Filters"

The limitations of the trickling filter included a relatively high incidence of clogging, the long rest period required, and the relatively low loading that could be used.



Main Treatment Technologies

Anaerobic Biological Treatment

● The anaerobic process has been developed for the treatment of sludge and high strength organic load.

● The disadvantage of the anaerobic treatment as compared to aerobic treatment is that the slow growth rates require a relatively long detention time in the digester for adequate waste stabilization to occur.

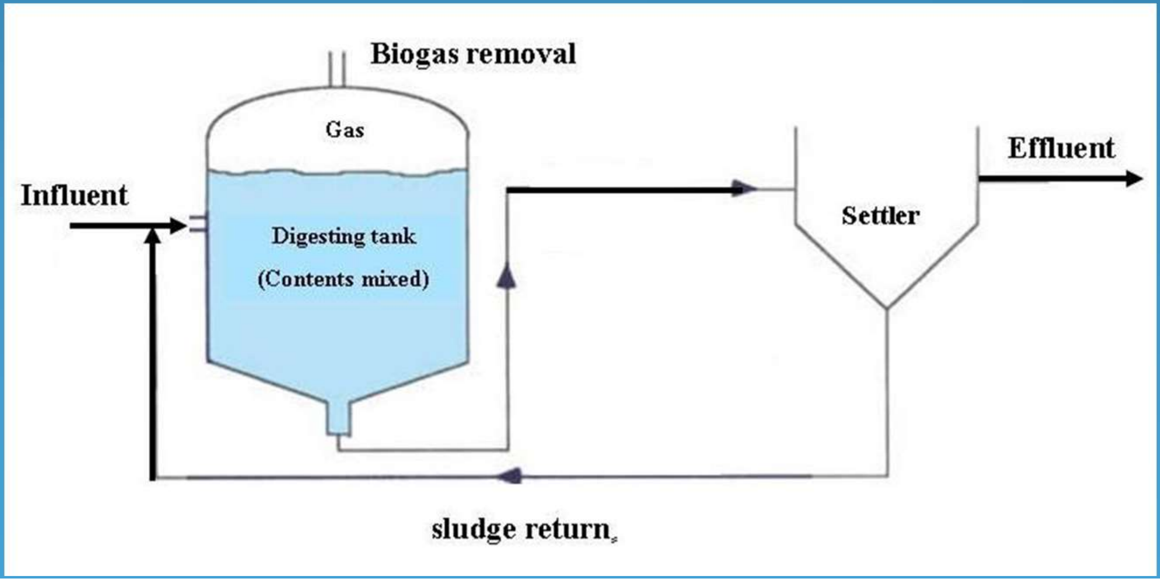
On the other hand, most of the organic waste is converted to methane gas, which is combustible and therefore a useful end product.

The high temperature necessary to achieve adequate treatment are often listed as disadvantages of the anaerobic treatment process; however, high temperatures are necessary only when sufficiently long mean cell-residence time cannot be obtained at nominal temperatures.

Main Treatment Technologies

Anaerobic Biological Treatment

- In the anaerobic process, untreated wastes are mixed with recycled sludge and then digested in a reactor sealed off from the entry of air.
- After digestion, the mixture is separated in a clarifier or vacuum flotation unit, and the supernatant is discharged as effluent, usually for further treatment.
- Settled anaerobic sludge is then recycled to seed the incoming wastewater.



Auxiliary Operations

1 Disinfection

- Disinfection refers to the selective destruction of disease-causing organisms. All the organisms are not destroyed during the process.

  This differentiates disinfection from sterilization, which is the destruction of all organisms.

- Disinfection is most commonly accomplished by the use of the following agents:

1- Chemical Agents.

2- Physical Agents.

3- Radiation.

Auxiliary Operations

2 Reuse of Treated Effluent

- Reuse of treated wastewater in various industries is becoming very popular being a cheaper source of water supply where the industrial plant can reuse its own wastewater through recycling or after treatment or it can be used for irrigation.
- There are many possibilities that some of hazardous and toxic chemicals may pass to the treated effluents. In order to eliminate health hazards several advanced methods of tertiary treatment for industrial effluents with disinfection are available world wide to meet the standards for effluent reuse for several purposes.

Auxiliary Operations

2.1 Advanced Treatment Techniques "Tertiary Treatment"

2.1.1 Filtration

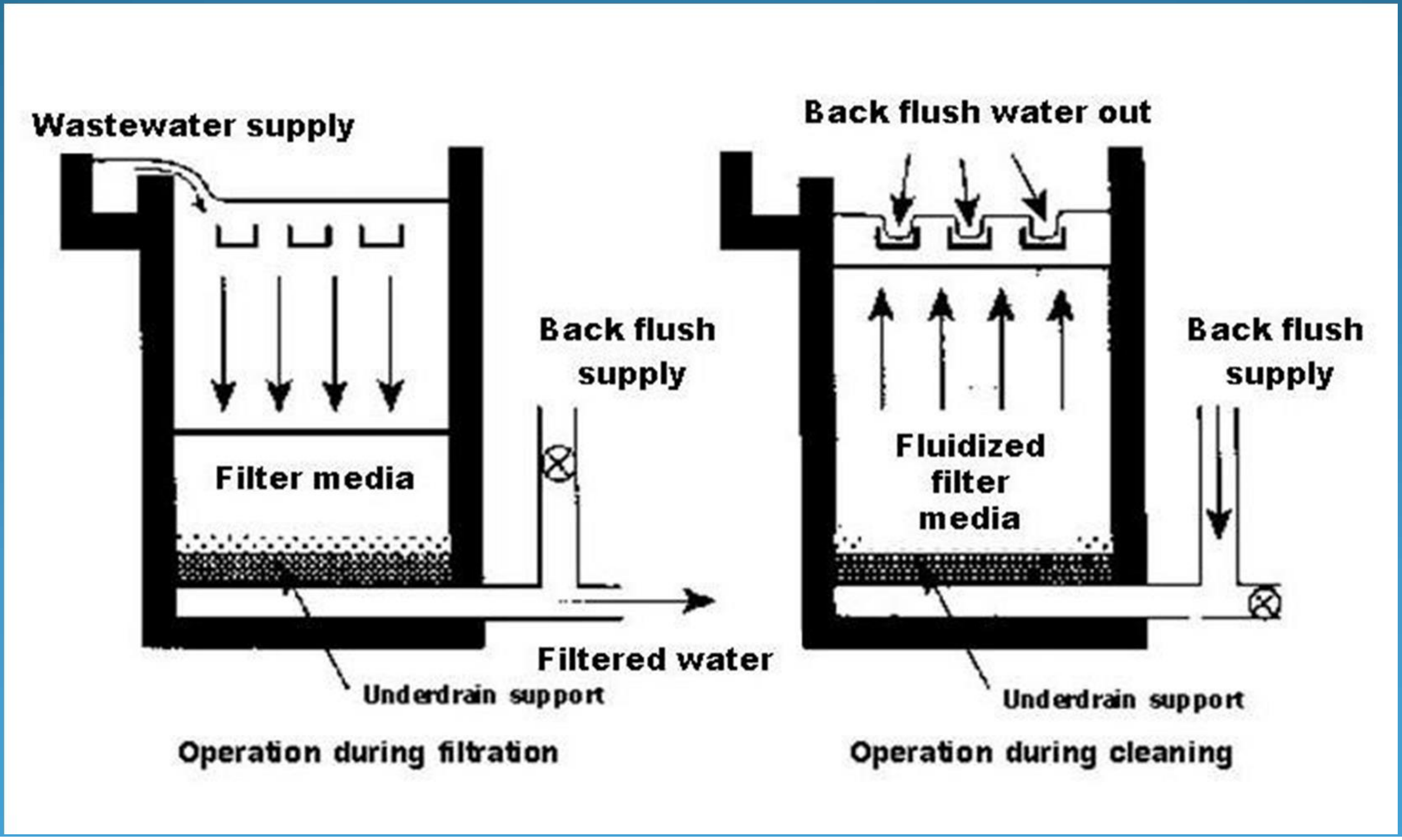
2.1.1.1 Granular Media Filters

- Granular media filters are widely used in wastewater treatment for the removal of both organic and inorganic suspended solids.
- Granular media filters can operate either by gravity flow (gravity filters) or by pressure (pressure filters).
- The most common types of filters are two and three media filters. A common design for a two media filter would have a bed of 0.5 mm sand layer below a 0.9 mm anthracite layer. A common design for a three media filter would have a 30 to 40 mesh garnet layer below the sand layer. Specialty filters could use different media with different effective sizes.

Auxiliary Operations

2.1.1.1 Granular Media Filters

Solids are captured by the bed and eventually have to be removed by scouring and backwashing.



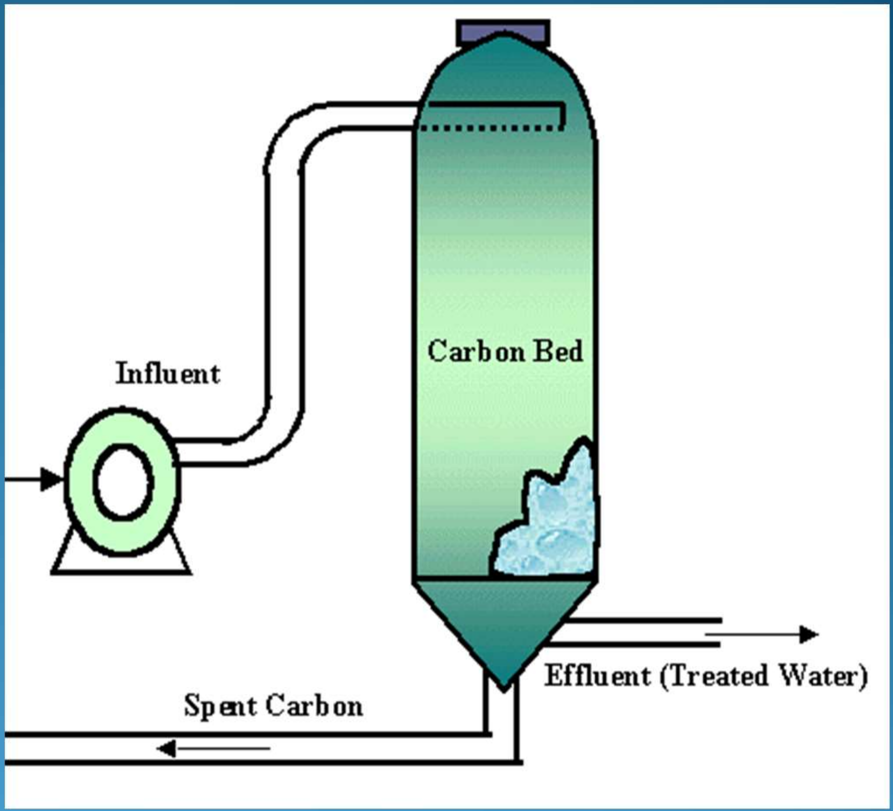
Auxiliary Operations

2.1.1.2 Carbon Adsorption

Carbon adsorption is used to remove certain types of organic contaminants that are resistant to primary and secondary treatment when such removal is required.

There are some cases where an organic stream contains contaminants that are valuable enough to recover with carbon adsorption.

Another use of carbon columns is to remove Volatile Organic Compounds (VOCs) from wastewater. All VOCs can be adsorbed onto activated carbon to a greater or lesser extent.



Auxiliary Operations

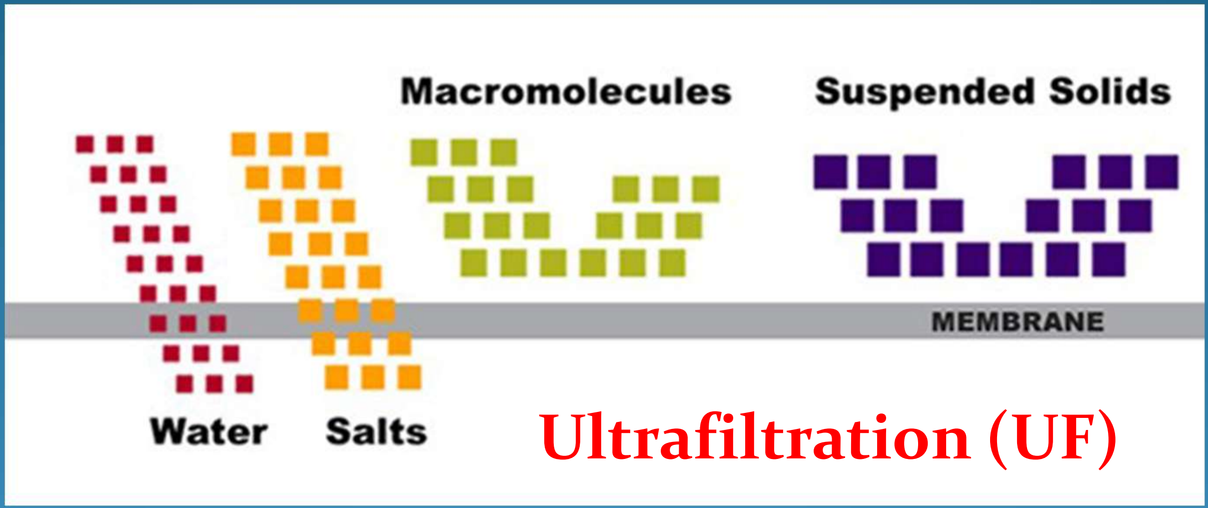
2.1.2 Membrane Separation

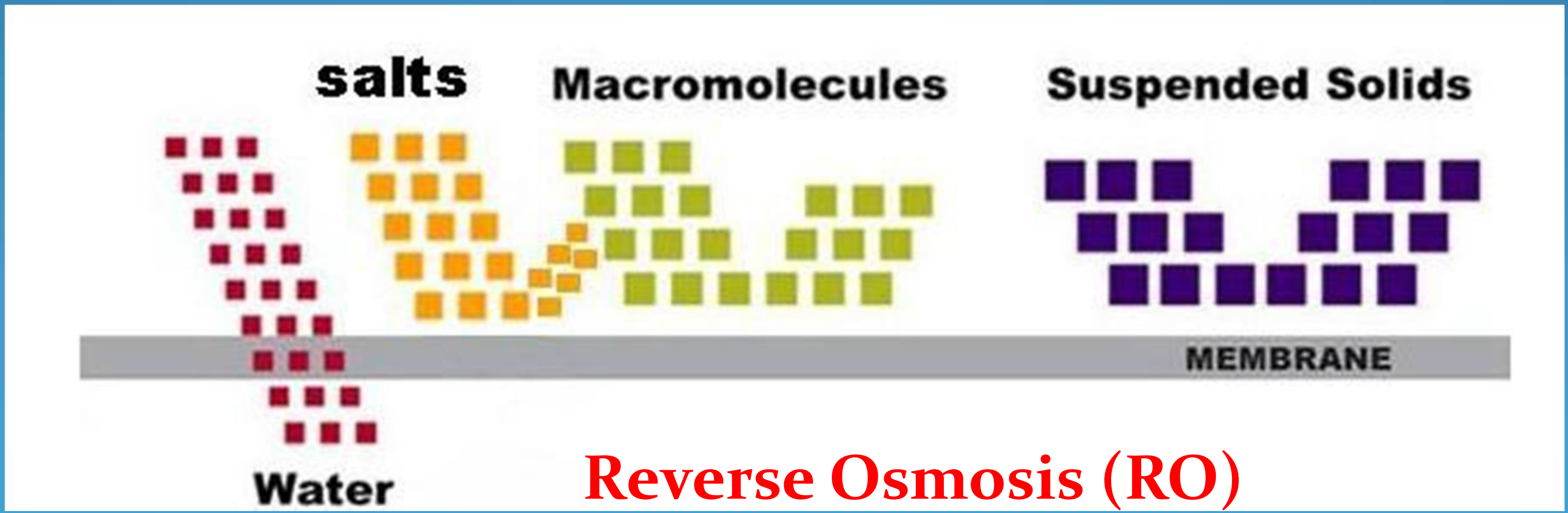
Membrane separation techniques are used to remove very fine particles from water, to desalinate water, and recently, membranes have been developed to remove organics from water, such as oil and other organics that have clogged and degraded membranes in the past

- Membranes are made of various materials but all have a consistent pore size that will permit particles or molecules of a given size to pass through the membrane and will prevent molecules or particles of a size larger then the pore size from passing through.
- Membrane Separation include ultrafiltration (UF) and reverse osmosis (RO).

Auxiliary Operations

2.1.2 Membrane Separation





Course Code: CE 4141

Course Title: Environmental Engineering

Lecture – 18

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Professor
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Cycle -12, Day-D

15-09-2019

Sludge treatment and disposal

Sludge Treatment & Disposal

- The sludge resulting from wastewater treatment operations and processes is usually in the form of a liquid or semisolid liquid that typically contains from 0.25 to 12 percent solids by weight, depending on the operations and processes used.
- Sludge is by farther largest in volume, and its processing and disposal is perhaps the most complex problem facing the engineer in the filed of wastewater treatment.
- The problems of dealing with sludge are complex because it is composed largely of the substances responsible for the offensive character of untreated wastewater. The portion of sludge produced from biological treatment requiring disposal is composed of the organic matter contained in the wastewater but in another form which can also decompose and become offensive; and only a small part of the sludge is solid matter.

Preliminary Operations

Preliminary Operations are used to provide a relatively constant, homogenous feed to sludge-processing facilities.

1 Sludge Grinding

Sludge grinding is a process in which large and string material contained in sludge is cut or sheared into small particles to prevent the clogging of or wrapping around rotating equipment.

2 Sludge De-gritting

In some plants where separate grit removal facilities are not used ahead of the primary sedimentation tanks or where the grit removal facilities are not adequate to handle peak flows and peak grit loads, it maybe necessary to remove the grit before further processing of the sludge.

Preliminary Operations

3 Sludge Blending

- Sludge from primary, secondary, and advanced processes are blended to produce a uniform mixture to enhance plant operability and performance.
- Blending tanks are usually equipped with mechanical mixers and baffles to ensure good mixing.

4 Sludge Storage

- Sludge storage is particularly important in providing a uniform feed rate ahead of the following processes: lime stabilization, heat treatment, mechanical dewatering, drying, and thermal reduction.
- If sludge is stored longer than two or three days, it will deteriorate and will be more difficult to dewater.

Sludge Thickening

Thickening is a procedure used to increase the solids content of sludge by removing a portion of the liquid fraction.

Gravity Thickening

Gravity thickening is accomplished in a tank similar in design to conventional sedimentation tank. Normally, a circular tank is used.

The supernatant flow that results is returned to the primary settling tank or to the head works of the treatment plant.

The thickened sludge that collected on the bottom of the tank is pumped to the digesters or dewatering equipment as required.

Sludge Stabilization

- Sludge is stabilized to

(1) reduce pathogens
(2) eliminate offensive odors
(3) inhibit, reduce, or eliminate the potential for putrefaction.

- The technologies for sludge stabilization are

(1) lime stabilization.
(2) heat treatment.
(3) anaerobic digestion.
(4) aerobic digestion.

Sludge Stabilization

lime stabilization

- In the lime stabilization process, lime is added to untreated sludge in sufficient quantity to raise the pH to 12 or higher.
- Two methods for lime stabilization used are addition of lime to sludge prior to dewatering, termed "lime pre-treatment" and the addition of lime to sludge after dewatering, or "lime post-treatment".
- Either hydrated lime, $Ca(OH)_2$, or quicklime, CaO, may be used for lime stabilization.

Sludge Dewatering

Dewatering is a physical (mechanical) unit operation used to reduce the moisture content of sludge.

1 Chemical Conditioning

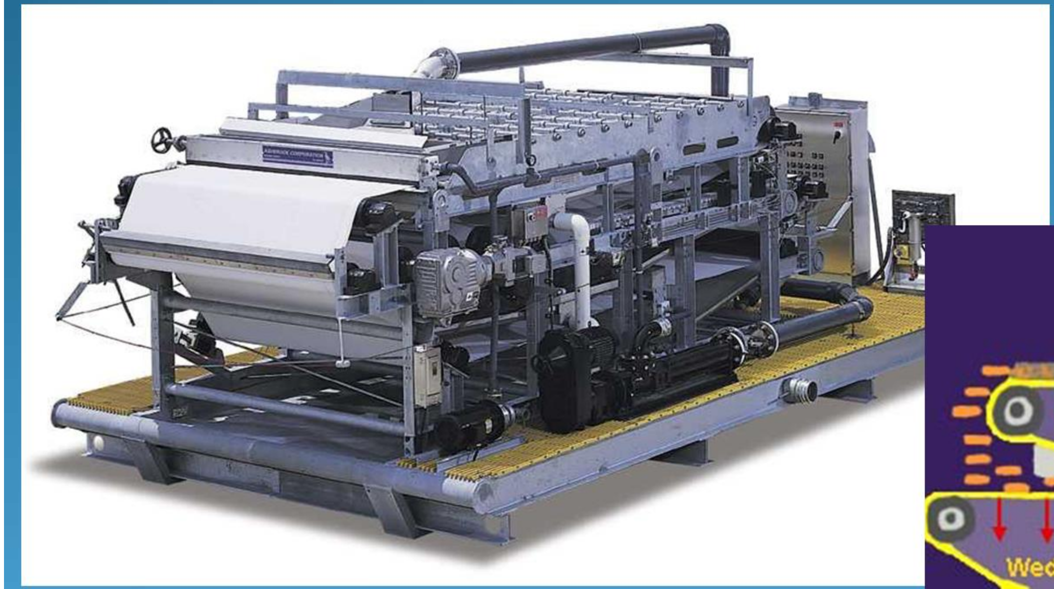
- The use of chemicals to condition sludge for dewatering is economical because of the increased yields and greater flexibility obtained. Chemical conditioning can reduce the 90 to 99 percent incoming sludge moisture content to 65 to 85 percent, depending on the nature of the solids to be treated.
- Chemicals used include ferric chloride, lime, alum, and organic polymers.

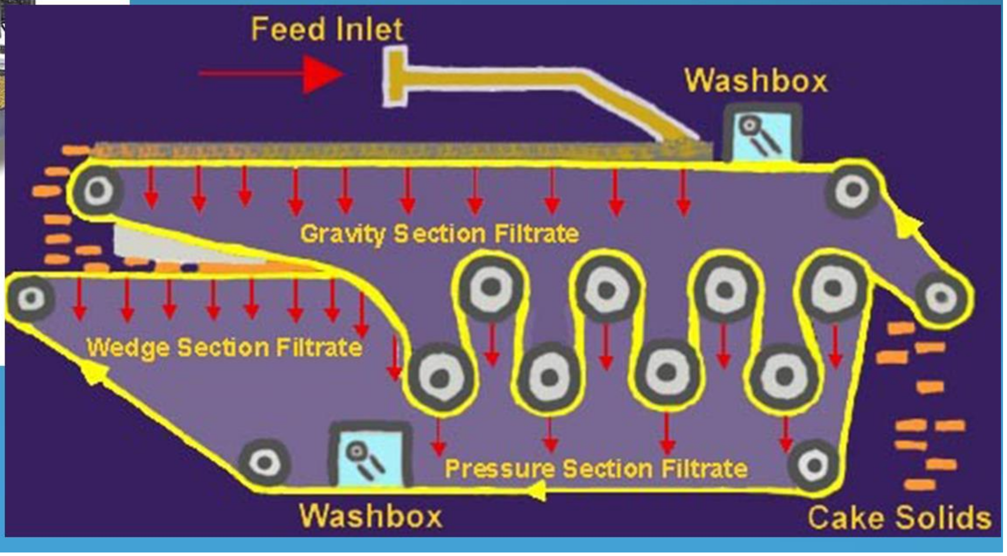
Sludge Dewatering

2 Mechanical Dewatering

2.1 Belt Press

● Belt filter presses are continuous-feed sludge-dewatering devices that involve the application of chemical conditioning, gravity.





Sludge Dewatering

2 Mechanical Dewatering

2.2 Filter Press

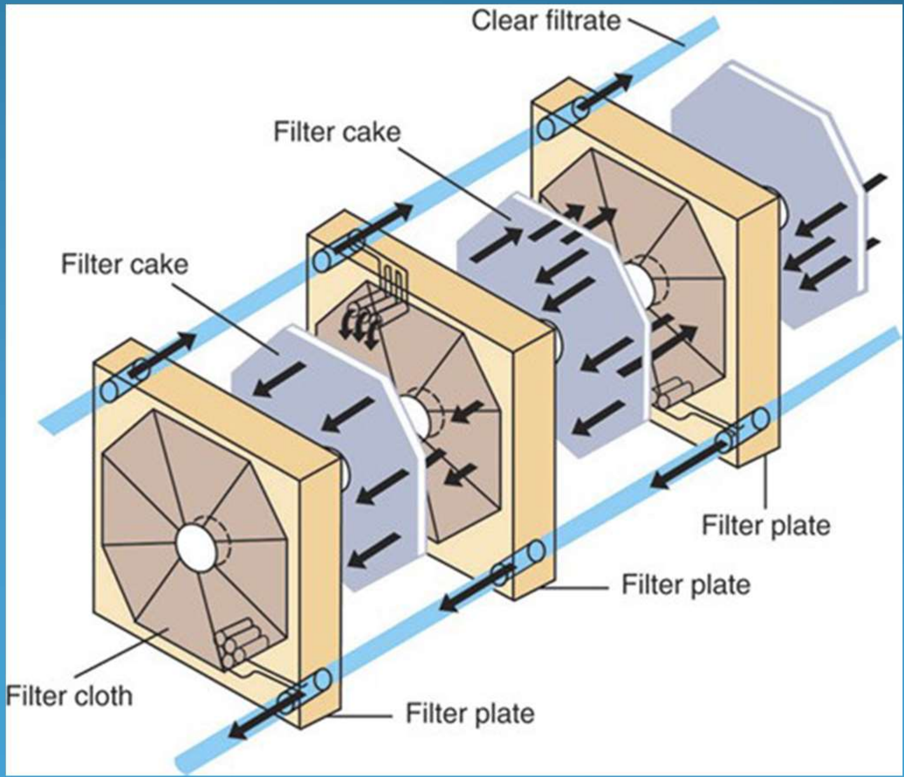
- In a filter press, dewatering is achieved by forcing the water from the sludge under high pressure.
- Filter press consists of a series of rectangular plates, recessed on both sides, that are supported face to face in a vertical position on a frame with a fixed and movable head. A filter cloth is hung or fitted over each plate.
- In operation, chemically conditioned sludge is pumped into the space between the plates, and pressure of 100 to 225 lb/in^2 (690 to 150kN/m^2) is applied and maintained for 1 to 3 hrs, forcing the liquid through the filter cloth and plate outlet ports.

Sludge Dewatering

2 Mechanical Dewatering

2.2 Filter Press

The plates are then separated and the sludge is removed. The filtrate is normally returned to the head works of the treatment plant.



Sludge Treatment & Disposal

3 Sludge Drying Beds

3.1 Conventional sand Drying Beds

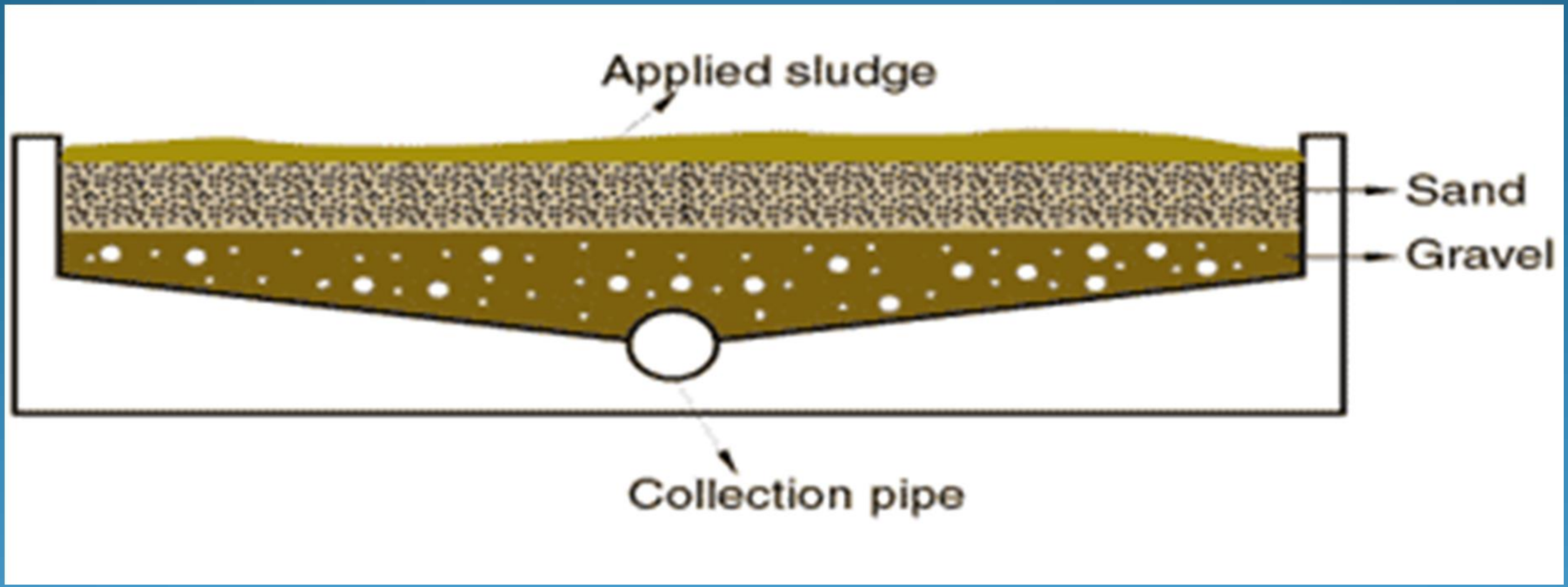
In a typical sand drying bed, sludge is placed on the bed in a 8 to 12 in (200 to 300 mm) layer and allowed to dry. Sludge is dewatered by drainage through the sludge mass and supporting sand and by evaporation from the surface exposed to the air. Most of the water leaves the sludge by drainage.

The moisture content is approximately 60 percent after 10 to 15 days under favorable conditions. Sludge removal is accomplished by manual shoveling into wheelbarrows or trucks or by a scraper or front-end loader.

Sludge Treatment & Disposal

3 Sludge Drying Beds

3.1 Conventional sand Drying Beds



Sludge Disposal and Utilization

1 Beneficial Uses of Sludge

The fertilizer value of biological sludge, which should be evaluated where the sludge is to be used as a soil conditioner, is based primary on the content of nitrogen, phosphorus, and potassium.

2 Sludge Disposal

2.1 Landfilling

- There are two types of landfills for industrial sludge: those which accept non-hazardous wastes and those that accept hazardous wastes.
- Landfills are designed to prevent the contamination of ground water and to prevent the migration of the wastes from the landfill.

Sludge Disposal and Utilization

2.1 Landfilling

- For this reason, landfills usually have thick, 3 to 10 feet covers of clean impermeable clay or dirt on top.
- Landfill bottom and sides are also made of impermeable clays or dirt. The sump collects leachate from the landfill and is pumped to a wastewater treatment plant.
- Hazardous landfills must meet very stringent requirements. The bottoms and sides must be double contained, which is usually accomplished by installing two liquid barriers, usually plastic.
- The top of a hazardous waste landfill must be impermeable, which is usually accomplished by installing a plastic water barrier in the dirt cover.
- Liquid is collected from the space between the barriers in a leachate collection system and is properly disposed of.


Model For Industrial Wastewater Treatment Plant
Thank you All

Environment Sanitation

2018, 2017, 2015, 2014, 2012

What is sanitation?

Sanitation is defined as the science and practice of effecting heathful and hygenic conditions, and involves the study and use of hygenic measures such as:

(i) safe, reliable water supply.

(ii) proper drainage of waste water.

(iii) proper disposal of all human waste.

(iv) prompt removal of all refuse.

2014, 2018

Describe the objectives of sanitation.

The pricipal objectives of providing sanitation facilities:

(i) To have improved public health.

(ii) To minimize the environmental pollution.

2018, 2015, 2012

Explain the role of water, sanitation and health education in improvement of public health.

It is important to understand that the improvement of health is not possible without sanitary disposal of human exreta. However, neither sanitation nor water supply alone is good enough for health improvement. Health education or hygiene promotion must accompany sufficient quantities of safe water and sanitary disposal of excreta to ensure the control of water and sanitation-related diseases.

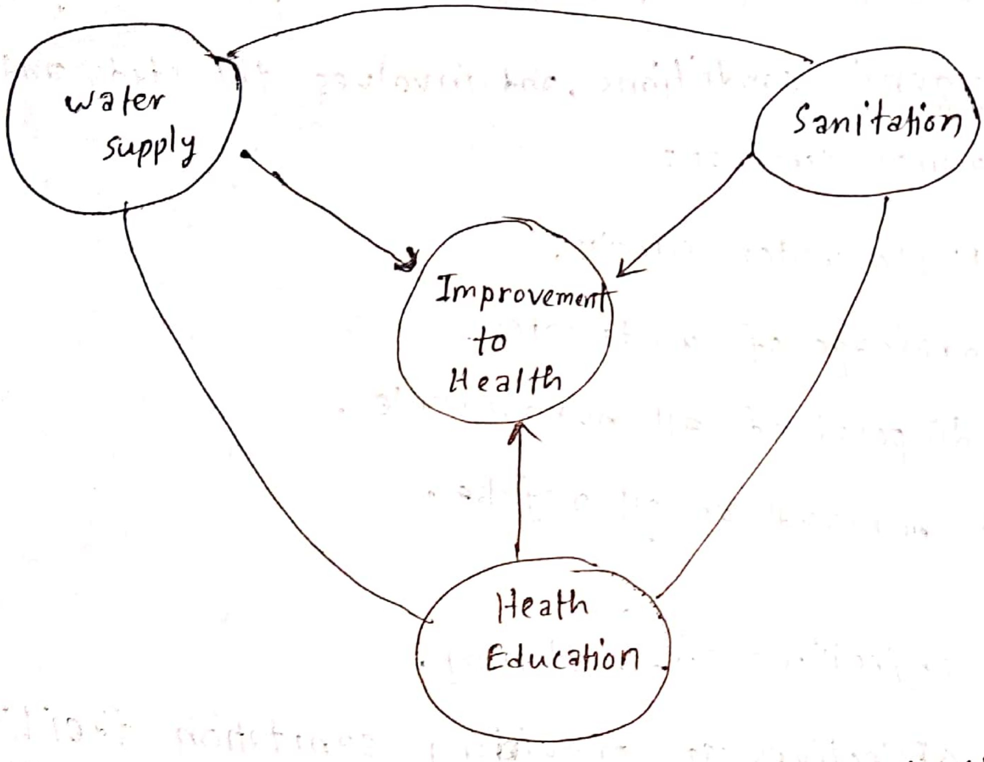


Fig. Inter-relationship between, sanitation and health education

IDWSS (1981-1990): (Then)

* 122 deaths for every 1000 live births in 1981.
* infant mortality rate was 110 in 1990.
* Low sanitation coverage (6% of rural population) and absence of health education.

Bangladesh Demographics Profile - 2018 (Now)

* population — 157,826,578 (July 2017 est.)
* Death rate — 5.4 death / 1000 population (2017 est.)
* Drinking water source - (improved) urban — 86.5% of population
  Rural — 87% of population
  Total — 86.9 % of population.

2018

Explain role of sanitation in controlling the transmission of excreta-related diseases.

sanitation can contribute greatly to preventing the spread of infectious diseases through transmission of diseases causing agents, as in the case when pathogenic organisms are transmitted from the excreta of an infected person to healthy person.

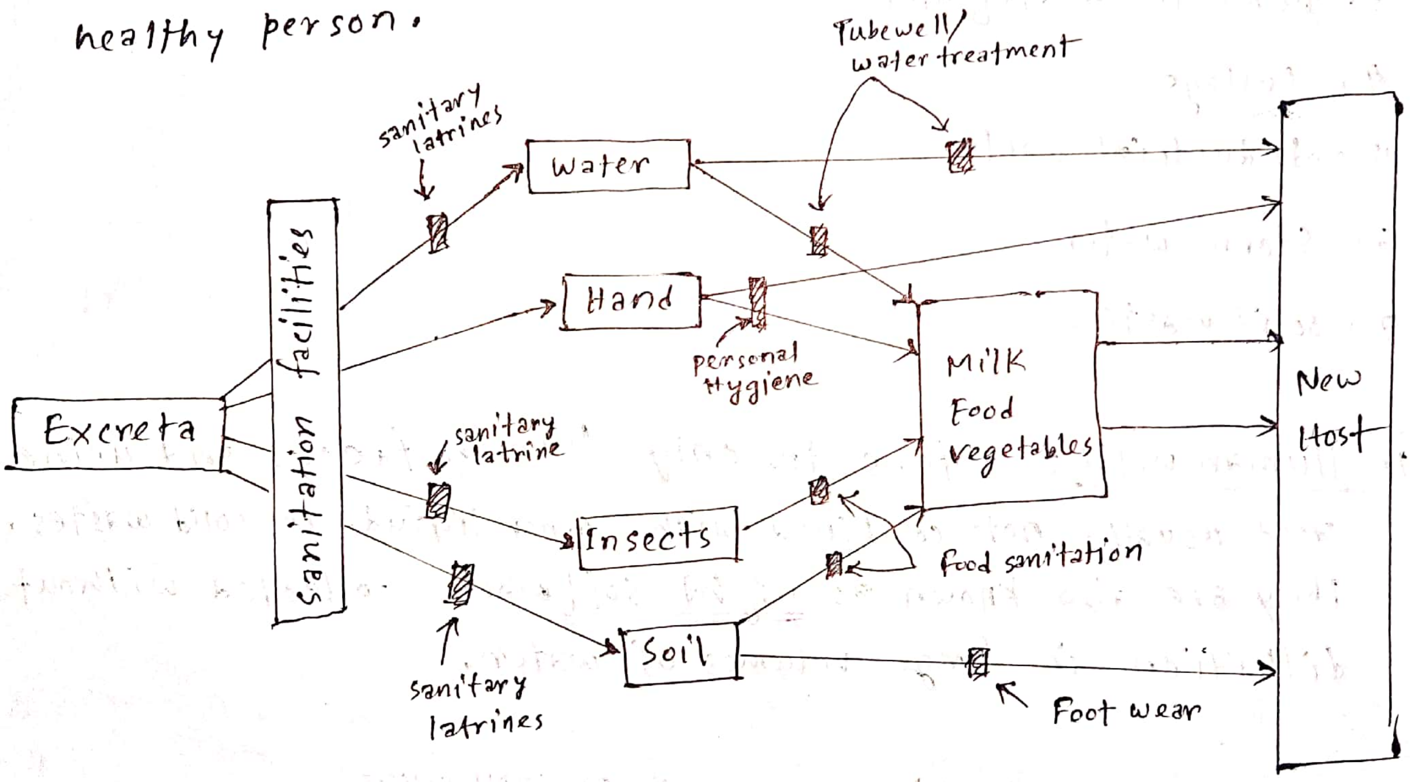


Fig. Disease Transmission and Sanitation

As indicated in the figure,
sanitation facilities can prevent transmission by breaking the chain of transmission at the source of the infection process.

Short Note

Classification of Waste : In general, waste can be classified as follows:

1. Human waste
2. Municipal sewage / waste water
3. Domestic Sewage
4. Sullage
5. Industrial waste
6. Storm water
7. Solid waste.

1. Human waste: refers to only human faeces and urine and usually not combined with other liquid or solid wastes. They are also known as night soil when collected without dilution in large volumes of water.

(2 – 6) ⟶ Bari Sir এর part -এ লেখা আছে

7. Solid wastes: Include all materials which are normally solid and are discarded as unless or unwanted during human activities.

Domestic solid waste is a composition of organic food wastes, paper and paper products, wood, plastics, leather and rubber materials, glass, metals and stones etc.

Sanitation Systems

What is sanitation system?

A sanitation system involves all arrangements necessary to store, collect, process and deliver human wastes or other forms of wastes back to nature in a safe manner.

What are the functions of sanitation system?

1. Excretion and Storage.
2. Collection and Transportation.
3. Process / Treatment.
4. Disposal / Recycle.

Types of sanitation System:

What is on-site system? Describe the suitability of it.

On site system: When the waste are collected, treated and disposed of at the point of generation, it is called on-site system.

Example: Pit latrine, Septic Tank system.

Suitability of on-site system:

(i) Rural areas with low population density:

(ii) Low water consumption.

(iii) Low infiltration rate.

(iv) Low ground water table areas.

what is off site system? Describe the suitability of it.

Off site system: when the wastes are collected and transported to some where else for treatment and disposal, it is called off site system.

Example: Bucket Latrine systems, conventional sewerage system.

suitability of off-site system:

(i) Rural / Urban area with high population density.

(ii) High water consumption.

(iii) High infiltration rate of soil.

(iv) High ground water table.

Dry system:

In dry system, No water is used for dillution of waste.

Example: Pit latrine (on-site), Bucket latrin (off-site)

Suitability: where pipe water supply is not avaiable.

Wet system:

In wet system, the waste is dilluted with flushes of water.

Example: septic tank system (on-site), conventional sewerage system (off-site)

Suitability: Where pipe water supply is avaiable.

Describe the appropriateness of sanitation system:

suitability of sanitation systems is very sensitive to the level of water supply and population density. The following figure provides a guide to the suitability of sanitation system.

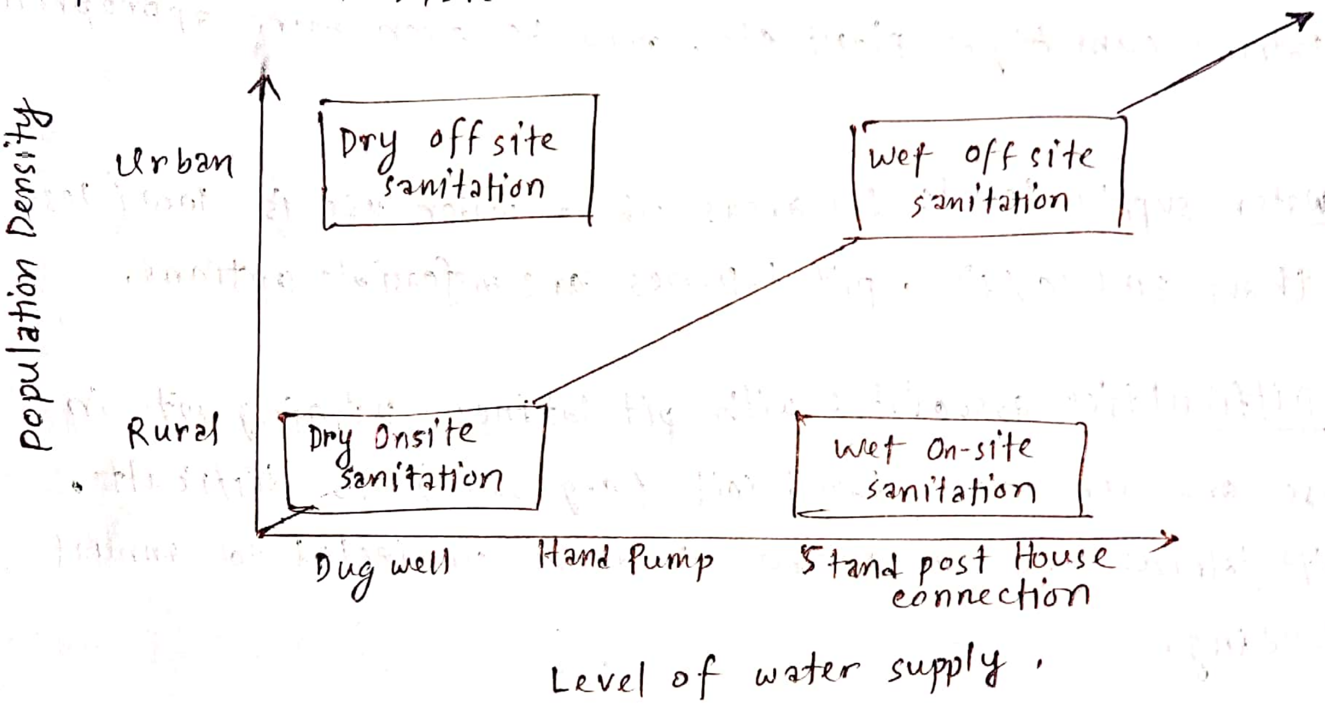


Fig. Sanitation systems based on population density and water consumption.

It is rather difficult to evaluate different sanitation systems in general terms. No sanitation system can be considered superior to others in every respect. Any system can be best system, depending on the characterestics of the design area and of the users of the system.

2016

What are the important factors/various problems for sanitation in Bangladesh

(i) Housing Density: simple single pit latrines are suitable for in rural areas and low density urban areas (300 people/ha.) At higher densities Alternating double pit latrines may be feasible. But other options such as SBS system, community latrine cum biogas plant etc. may be even more appropriate.

(ii) Water supply level: In areas where water use is low (less than 30 l/c/d), pit latrines are feasible options.

(iii) Difficulties associated with pit latrine: Digging pit in loose and un consolidated soil (e.g. sand) is difficult. Pit latrine are vurnerable in areas subjected to annual flooding.

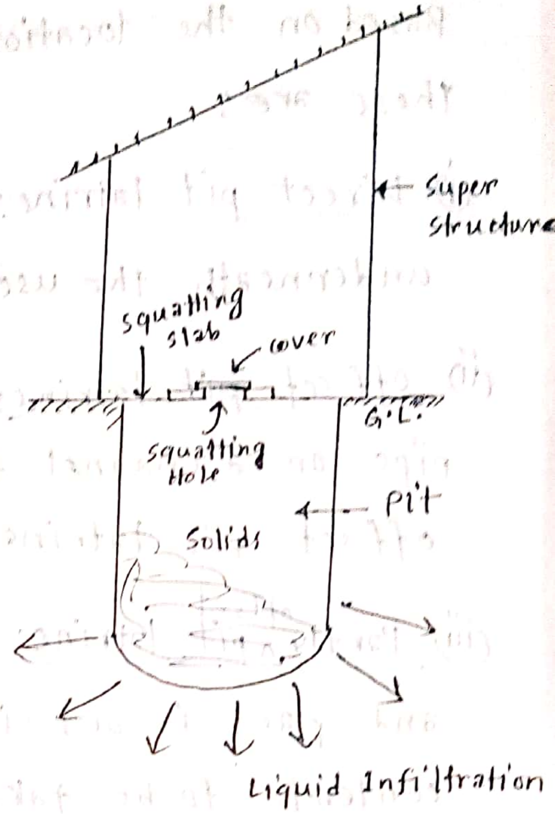
(iv) Operations and maintenance: In all latrines cleanliness is of utmost importance. Fouled latrines become a focus of disease transmission and may create health hazard.

(v) Soil permeability: soils with permeability below 2.5 mm/hour (e.g. expansive soils) are unsuitable for pit latrines.

(vi) Ground water pollution: The deposition of excreta in pits may pollute water sources. It should be at least 2 m of soil depth between bottom of the pit and the water table surface. Pits should be located at least 10 m away from any water sources.

Low Cost Sanitation Technologies

Simple Pit Latrine



Basic Components:

1. a manually dug or bored hole in to the ground : Pit
2. an appropriate seat or squatting slab
3. a superstructure.

Basic Principle:

1. Urine and other liquids soak into the ground.
2. Solid materials are decomposed in the pit.

Suitability of Pit Latrines:

(i) Most common and simplest form of excreta disposal in many developing countries.

(ii) widely used in low income urban communities.

(iii) Most approprite for individual householders.

Types of pit Latrine:

Based on the location of pit, pit latrine are three types. These are:

(i) Direct pit latrine: When excreta fall directly in to the pit underneath the user, it is called direct pit latrine.

(ii) Off set pit latrine: When excreta pass through a short pipe or a channel to a pit a few meters away, it is called off set pit latrine.

(iii) Partly offset pit latrine: When part of pit is under the shelter and part is out side, where a removal cover allows the contents to be taken out, it is called partly offset pit latrine.

Design consideration for pit latrines:

1. Pit size: not more than 1.5 m wide.

2. Soil permeability: low permeability below 2.5 mm/h are un suitable.

3. Lining: Pits in unsuitable soils must be fully lined. Lining materials are concrete rings, bricks, cement-stabilized soil blocks, masonry, perforated oil drums etc.

4. Safe distance: safe distance between the pit latrines and source of drinking water should be at least 10 m.

Pit latrine Design:

Effective pit volume: It can be calculated as:

$$V = C \times P \times N$$

where,

V = Effective Volume (m^3)

C = solids accumulation rate ($m^3/p/yr$)

P = No. of persons

N = Design life (yrs)

Kalbermatten et. al (1980) suggested the following equation for a pit latrine of depth not exceeding 4 m.

$$V = 1.33 \times C \times P \times N$$

Values of solid accumulation rates:

Wet Pit

- Anal cleansing (water) = 0.04
- Anal cleansing (solids) = 0.06

Dry Pit

- Anal cleansing (water) = 0.06
- Anal cleansing (solids) = 0.09

Advantages and Disadvantages of simple pit Latrine:

Advantages:

(i) Least costly.

(ii) Easily constructed and maintained

(iii) Prevents hookworm transmission

(iv) offer better solution than open defecation and unhygenic hanging latrines.

(v) Structurally safe.

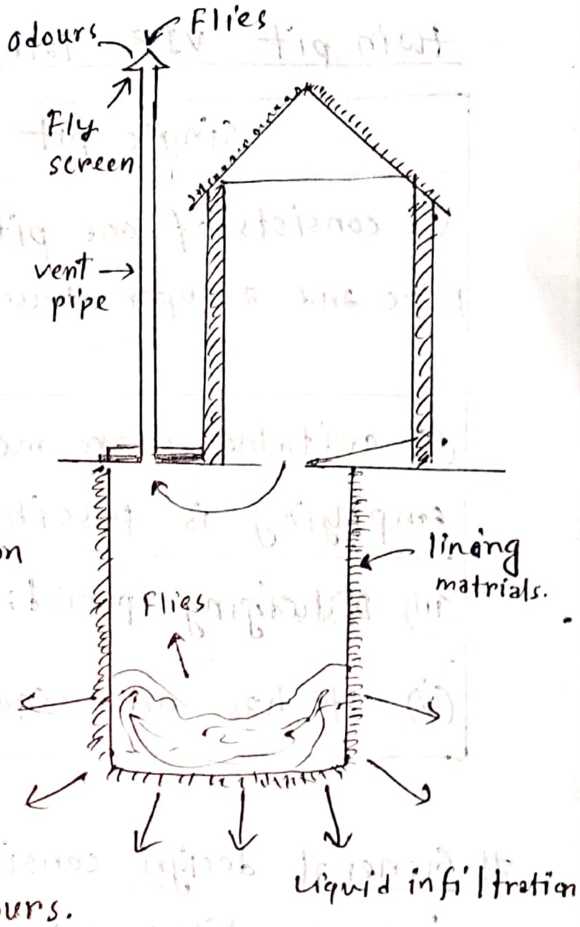
Disadvantages:

(i) odour nuisance

(ii) flies lay their egg in faeces with in poorly built latrines.

(iii) Improper lining of pits may lead to collapes of the super structure.

Ventilated Improved Pit (VIP) Latrine



Basic components:

1. A pit – single pit or alternating twin-pit.

2. A cover slab – usually made of concrete contain two holes: one squat hole and other for vent pipe.

3. A super structure – privacy and protection from rain and sun.

4. Vent pipe and fly screen – Keep the latrine free from flies, mosquitoes and unpleasant odours.

Basic principle:

1. The disadvantages of simple pit latrine are minimized by using vent pipe and fly screen

2. Urine and other liquids infiltrates in to the sorrounding soil.

3. Solid materials are anaerobically decomposed.

Difference between single pit VIP latrine and Alternating twin pit VIP latrine:

Single pit VIP	Alternating twin pit VIP
(i) consists of one pit, a vent-pipe and a super structure.	(i) consists of two seperate pit, two vent pipe and a super structure located centrally.
(ii) suitable where mechanical emptying is possible	(ii) suitable where sufficient area is present.
(iii) Design period: 10 years.	(iii) Design period: 1-3 years.
(iv) It has one squat hole	(iv) It has two squat hole.

General design considerations; 2014, 2013, 2010

(i) Design life: • For single pit VIP latrines: 10 years.
• For twin pit VIP latrines: 1-3 years.

(ii) Dimensions: • pit cross sectional area $\leq 2\,m^2$
• pit diameter or width = 1 – 1.5 m

(iii) Vent pipe: • polyvinyl chloride (pvc), unplasticized pvc (upvc), bricks etc
• length:
- for flat roofs – 500mm and
- for sloping roofs – 500 mm above the highest point

(iv) Diameter of vent pipe: • PVC – 150 mm dia

• Brick – 230 mm squar

• others – 230 mm

(v) Fly Screen: • Mesh aperture ≤ 1.2m × 1.5m

• corrosion resistant materials – stainless steel screens.

Advantages and Disadvantages of VIP latrine:

Advantages:

(i) low cost

(ii) Easy construction and maintenance.

(iii) Minimal health risk

(iv) controls odour and nuisance

(v) Minimal water requirement

(vi) twin pit VIP offers a long term solution.

Disadvantages:

(i) potential for ground water pollution

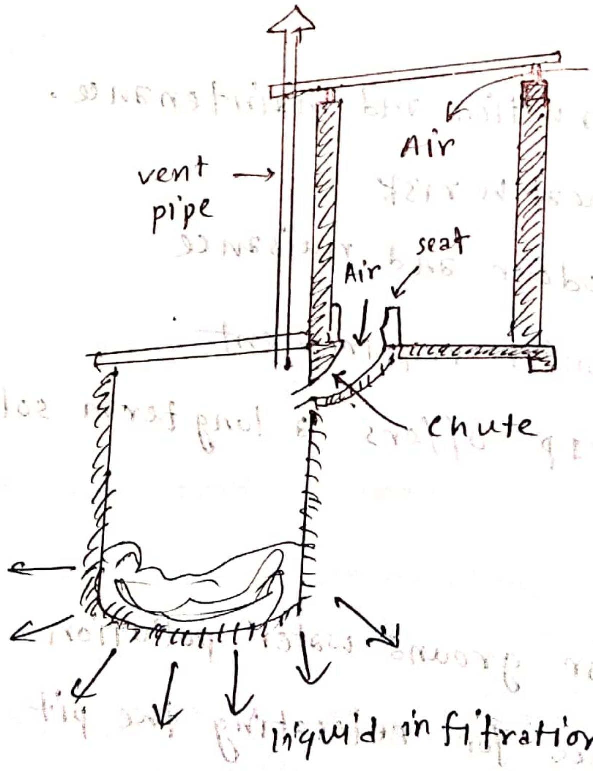
(ii) Lack of space for relocating the pit in densely populated areas.

(iii) Difficulty of construction in rocky and high water table areas.

Reed Odourless Earth Closet (ROEC)

Basic components:

1. A pit – fully offset pit
2. A cover slab – usually made of concrete
3. A super structure – privacy and protection from rain and sun
4. Vent pipe and fly screen – Keep the latrine free from flies, mosquitoes and unpleasant odour.
5. A curve chute.



Basic Principle:

1. The disadvantages of VIP latrine are minimized by providing fully offset pit, curve chute.
2. Urine and other liquids infiltrates into the surrounding soil
3. Solid materials are anaerobically digested.

Advantages and Disadvantages of ROEC: 2011/07/06

Advantages:

(i) Pit can be made larger as the super structure is fully offset and thus have longer life than VIP Latrin.

(ii) Pit can be empitied without disturbing the super structure and it can be a permanent facility.

(iii) There is no danger of users, particularly for children falling into it.

(iv) More acceptable to the users because the excreta can not be seen.

Disadvantages:

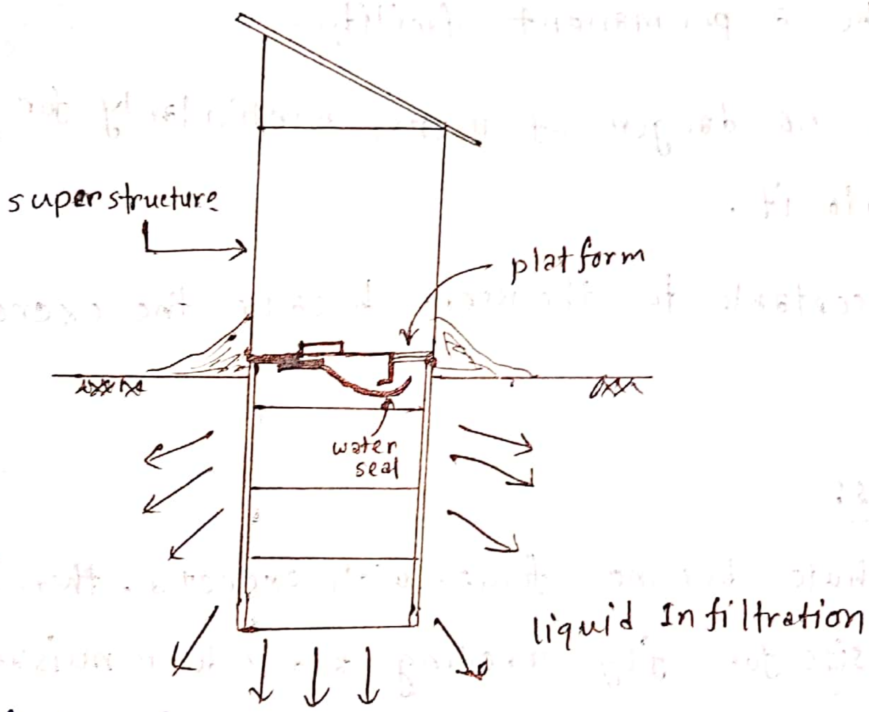
(i) ROEC chute becomes fouled with excreta, thereby providing a possible site for fly breeding and odour nuisance.

(ii) Regular cleaning of chute is required with a long-handled brush or small amount of water.

Pour Flush Sanitation Latrine

Basic components:

1. Single or Alternating twin leach pits.
2. A super structures – privacy and protection from sun and rain.
3. Latrine pan with integral water seal.



Functions of Pour flush Latrine:

(i) After each use, the latrine is manually pour flushed through the pan and trap with about 2-3 litres of water. Some of the clean flush water remains in the trap and maintains water seal thus providing the barrier against odours and insects.

(ii) Around 5-10 lpcd ~~water~~ of waste water enter in to the pit. The pit should have sufficient volume to store these amount of water and soil must have sufficient long term infiltration capacity.

Types of Pour flush latrine :

There are two types of pour flush latrines.

(i) Direct pit pour-flush latrine.

(ii) Off set pit pour-flush latrine.

Offset pit pour-flush latrines are two types:

(i) Single off set pour flush

(ii) Alternating twin off set pour flush

Suitability of Pour flush latrine : 2012, 2010

(i) may be used in both rural and urban areas.

(ii) where water supply is adequate for flushing and maintaining water seal.

(iii) Single pits may be suitable in urban areas only if they can be desludged mechanically.

(iv) Twin pits are recommended if the pits are to be desludged manually.

2012, 2010

Advantages and Disadvantages of pour flush technology

Advantages:

(i) Less expensive compared to conventional latrines.

(ii) offer appropriate and hygenic solution for exereta disposal.

(iii) can be upgraded to connect to a sewer system or septic tank system.

(iv) Eliminate odours, insects and fly breeding.

(v) can be located, if desired, inside the house.

(vi) Easy construction and maintenance of single pit pour-flush latrine.

Disadvantages:

(i) Avaiable water (5 lit/p/day) is required through out the year.

(ii) Water seal may be clogged easily if garbage is thrown into it.

(iii) Construction is difficult in high water table areas and low permeable soil.

(iv) Require separate sullage disposal facilities.

General Design Considerations: 2007

(i) Shape of pit: Can be circular, square, rectangular or even triangular depending on the size and shape of site.

(ii) Minimum water requirement: 2-3 litres.

(iii) Pit Depth: should not exceeding 1.8 m to protect ground water pollution.

(iv) Lining materials: Burnt clay, concrete, brick masonry, bamboo etc.

(v) Inlet position: Should be at least 0.5 m above the highest ground water table.

(vi) Free space over inlet: usually 0.5 m above the inlet.

(vii) Elevated pit: In flood prone-areas, the pits must be constructed on elevated earthen mounds with at least 1.5 m earth covering all around the pits.

(viii) Safe Distance: safe distance between pits and tubewells or any other water bodies should be at least 10.0 meters.

(ix) Infiltration capacity:
- sandy or silty soil would be good
- if soil are compacted clay of low permeability then a sandenvelop of at least 0.3 m should be provided around the pit.

(x) Distance between 2 Pits:
- Should be at least equal to effective depth of the pit
- Effective depth is measured from the inlet pipe to bottom of pit.

Design of pour flush Latrine:

1. side wall area required for infiltration,

* varies generally 5-20 lpcd

$$A_i = \frac{Q}{I}$$

where, Q = waste water flow (l/day)

I = Infiltration rate (l/m²day)

A_i in m^2

2. The pit volume corresponding to side wall area, (for circular pit)

$$V_i = \pi D^2 h / 4$$

where, h = height of side wall Area $= \frac{A_i}{\pi D}$

$$\Rightarrow V_i = \frac{\pi D^2}{4} \times \frac{A_i}{\pi D} = \frac{A_i D}{4}$$

$$\therefore V_i = \frac{QD}{4I}$$

- For alternating twin pits, $V_s = C \times P \times N$

which ever is greater V_i and V_s, is the effective volume of each pit.

- For single pit pour flush latrine, the effective volume,

$$V = V_s + V_i$$

Infiltration Rate: (Mara, 1996)

Soil Type	value of I (l/m²/day)
Sand	50
Sandy loam	30
porous silty loam, porous silt clay loam	20
Compact silty loam, clay	10

Aqua Privies

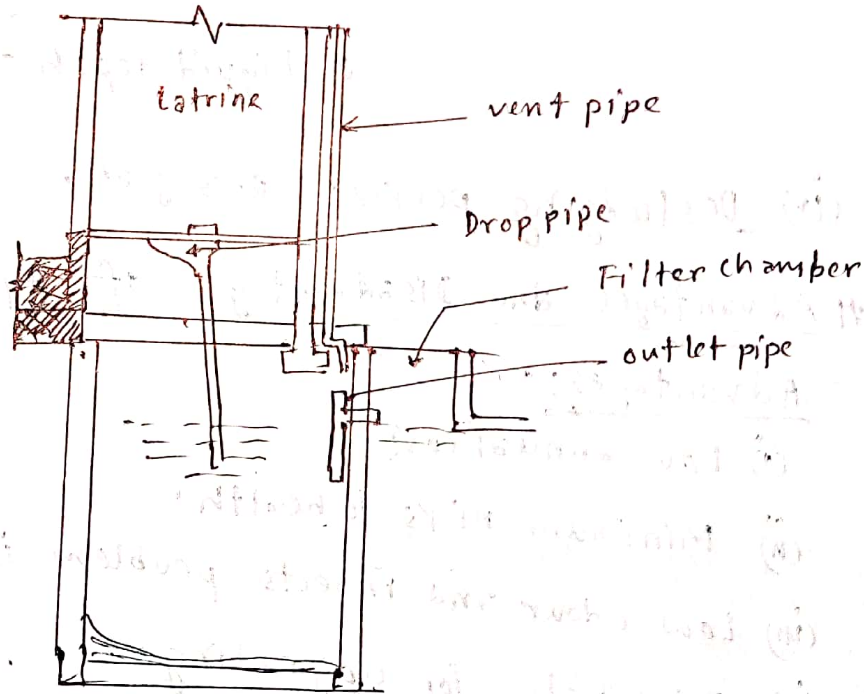
Basic Components:

(i) Squatting plate with integral submerged drop pipe — to act as water seal.

(ii) A super structure — privacy and protection from rain and sun

(iii) A small septic tank — discharges effluent to an adjacent drainage field or soak pit.

(iv) A soak pit



Basic Principles:

(i) Excreta directly enter in to the tank without flushing, where they settle and are decomposed anero bically.

(ii) Liquid discharges through outlet pipe to an adjacent drainage field or a soak pit.

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General Design consideration:

(i) Tank volume: 1.5 litres/p/day solids + 4.5 litres/p/day wastewater to maintain water seal.

(ii) Soak pit design: • Effluent flow = 6 litres/p/day

• Infiltration rate = 10 litres/m^2/day

(iii) Septic tank design: • Sludge accumulation rate = 0.03 - 0.04 m^3/p/year

• Tank will fill up to $\frac{2}{3}$ of its volume.

• Liquid depth = 1 - 1.5 m

(iv) Desludging period: 2-3 years.

Advantages and Disadvantages of Aqua privies

Advantages:

(i) Low annual cost.

(ii) Minimum risks to health.

(iii) Low odour and insects problem if water seal is maintained.

(iv) Potentials for upgrading.

(v) Sullage disposal potential.

Disadvantages:

(i) Difficult to maintain water level inside the tank. Hence failure can occur.

(ii) Higher investment cost compared to pour flush or VIP latrine.

(iii) Desludging is required on a regular basis by local municipal authorities.

(iv) can not be installed within the house.

(v) Additional water is required for maintaining water seal.

*** Improvement from pit latrine to Aqua privies:

① Simple pit Latrine: (i) A pit
(ii) A squatting seat
(iii) A super structure

Advantages: (i) prevent hookwork transmission
(ii) offer better solution than open defecation.

Disadvantages: (i) odour-nuisance and fly breeding.

② VIP Latrine:

improvement: * vent pipe and fly screen

Advantages: (i) controls odour-nuisance and fly breeding

Disadvantages: (i) short service life
(ii) excreta can be seen which is unpleasant to users.

③ ROEC Latrine:

improvement: (i) fully offset pit
(ii) A curve chute

Advantages: (i) longer service life
(ii) excreta can not be seen

Disadvantages: (i) Odour nuisance and fly breeding

④ Pour-flush latrine:

improvement: (i) water seal

(ii) Alternating twin off set pit

Advantages: (i) Eliminate odour and nuisance

(ii) can be located into house

Disadvatages: (i) Require seperate sullage disposal facilities

⑤ septic tank:

improvement: (i) septic tank

(ii) soak pit

Advantages: (i) ~~potential~~ sullage disposal potential

Disadvantages: (i) can not be installed with in the house.

Compost Latrine

Basic principle:

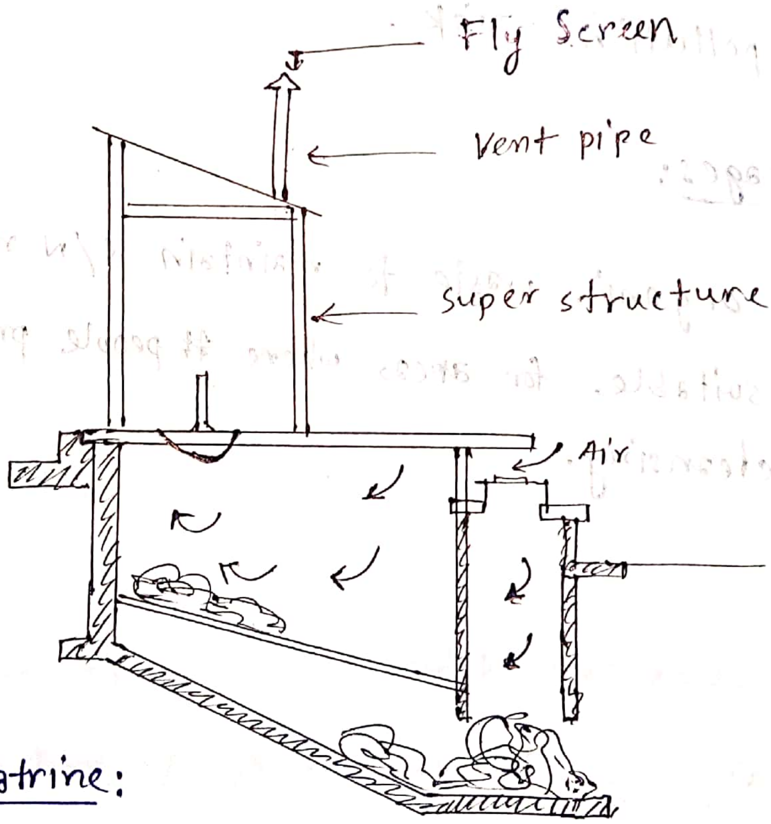
(i) Aerobic decomposition of faeces generates sufficient heat to destroy the pathogens and forms a good soil conditioner / fertilizer for subsequent use.

(ii) Necessary conditions:

(a) an appropriate carbon to nitrogen ratio (C/N) ratio

(b) a low moisture content

(c) access to air to ensure aerobic condition.



Types of compost Latrine:

(i) continuous compost latrine

(ii) Batch compost latrine.

Advantages and Disadvantages of Compost Latrine

Advantages:

(i) Appropriate for use in areas where there is a tradition of using excreta on the land.

(ii) Can be useful in areas where there is a need for soil conditioner.

(iii) Need no water for flushing because composting is most efficient if materials is moist.

(iv) Low pollution risk.

Disadvantages:

(i) Need organic waste to maintain C/N ratio

(ii) Not suitable for areas where # people prefer water for anal cleansing.

Septic tank

septic tank:

A septic tank is a buried, water tight receptacle designed and constructed to receive waste water from a home, to seperate the solids from liquid, to provide limited digestion of organic matter, to store solids and to allow the clarified liquid to discharge for further treatment and disposal.

process in a septic tank: 2012, 2011, 07, 06

The most important processes that take place in septic tank include:

(i) seperation of suspended solids.

(ii) Digestion of sludge and scum.

(iii) stabilization of the liquid.

(iv) Growth of micro organism.

seperation of suspended solid is a mechanical process which result in the formation of three distinct layer in the septic tank:

(i) a layer of sludge at the bottom

(ii) a floating layer of scum on the top

(iii) a relatively clear layer of liquid in the middle.

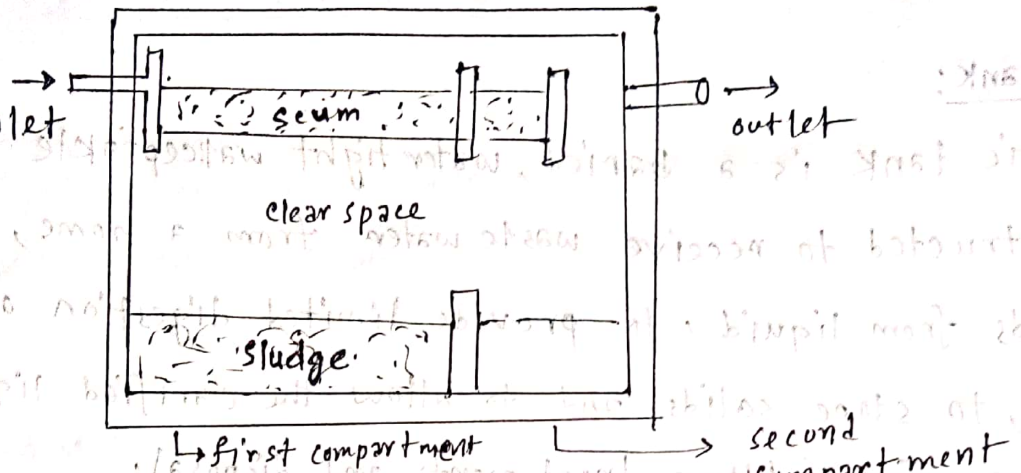


Fig. components of a septic tank system.

Anaerobic bacteria degrade the organic matter in the sludge as well as in scum. As a result of this bacterial action, volatile acids are formed at the first instance and eventually are converted mostly to H_2O, CO_2 and CH_4.

A large variety of micro-organisms grow, reproduce and die during bio degradation process that take place in the septic tank. Most of them attached to the organic matter and seperated out with the solids.

Design procedure: 2012, 2011; 07, 06

(i) scum storage zone: scum accumulates at approximately 30 – 40% of the sludge accumulation rate.

$$V_{sc} = 0.4\, V_{sl}$$

(ii) sedimentation zone: $t_h = 1.5 - 0.3 \log (Pq)$

but not less than 0.2 days.

Here,

t_h = minimum mean hydraulic retention time (days)

P = population

q = waste water flow per person (l/day)

$$V_h = 10^{-3}\, Pq\, t_h$$

(iii) sludge digestion zone: $t_d = 30 \times (1.035)^{35-T}$

$$V_d = 0.5 \times 10^{-3} P t_d$$

Here,

t_d = time required for anaerobic digestion

P = population

T = temperature (°C)

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(iv) Digestion sludge storage zone:

$$V_{sl} = C \times P \times N$$

Here, C = sludge accumulation rate

P = population

N = desludging period

C = 0.06 $m^3/p/yr$ when N < 5 years

C = 0.04 $m^3/p/yr$ when N > 5 years

Anupom Sir – [C = 0.05 $m^3/p/yr$ when N = 5 years]

Overall design capacity,

$$V = V_{sc} + V_h + V_d + V_{sl} = V_h + V_d + 1.4\, V_{sl}$$

Clear space depth: The clear space depth, which is the minimum acceptable depth of the sedimentation zone just prior to deslydging, comprises the submerged scum clear depth and the sludge clear depth.

Submerged clear depth: It is the distance between the under side of scum layer and bottom of the outlet tee' and should be at least 0.075 m.

Sludge clear depth: It is the distance between the top of the sludge layer and bottom of the out let 'tee'.

$$d_{sc} = 0.82 - 0.26A$$

Should not be less than 0.3 m

Total clear space depth = $(0.075 + d_{sc})$

Sedimentation depth = $\frac{V_h}{A}$

The greater depth is the desired depth.

Site selection for disposal of septic tank effluent:

(i) Soil permeability:

- Should be moderate to rapid.
- percolation rate should be 24 min/cm or less.

(ii) Ground water table:

- At least 1.22 m (4 ft) below the bottom of the sub-surface absorption field or soak pit during wet season.

(iii) Impervious layers:

- Should be more than 1.22 m below the seepage bed or the pit bottom

(iv) Safe distances

- Should not be with in 15.24 m of a stream or other water-body.

(v) Flood area:

- Should not be installed in frequent flooding area.

Sub Surface Absorption System

There are three types of sub surface absorption system:

(i) Absorption Trenches.

(ii) Absorption beds or Seepage beds.

(iii) Soakage pit.

Absorption Trenches:

The effluent flows by gravity from septic tank through a closed pipe and a distribution box in to perforated pipes in trenches.

Usually the pipes consists of open-jointed drainage tiles of 10 cm diameter laid on a 1m depth of crushed rocks or gravel and soil.

Design of an absorption field:

$$L = \frac{NQ}{2DI}$$

where, L = trench length (m)

N = Number of users

Q = waste water flow (lpcd)

D = effective depth of trench (m)

I = design infiltration rate ($l/m^2/day$)

* Design infiltration rate for the septic tank is usually taken as 10 $l/m^2/day$.

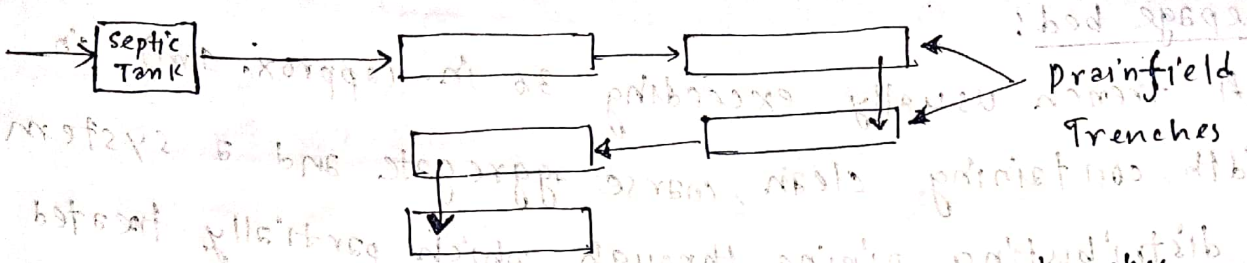

Fig. Subsurface soil absorption trenches

Soakaways:

- These are deep excavations used for subsurface disposal of septic tank effluent.
- Absorption pits or soakaways or soak pit are recommended as an alternative fields / trenches are not practicable and where top soil is under laid with porous soil or fine gravel.
- Soakaways can be typically 2 to 2.5 m in diameter and 3 to 6 m deep depending on the amount of waste water flow and infiltration capacity of soil.

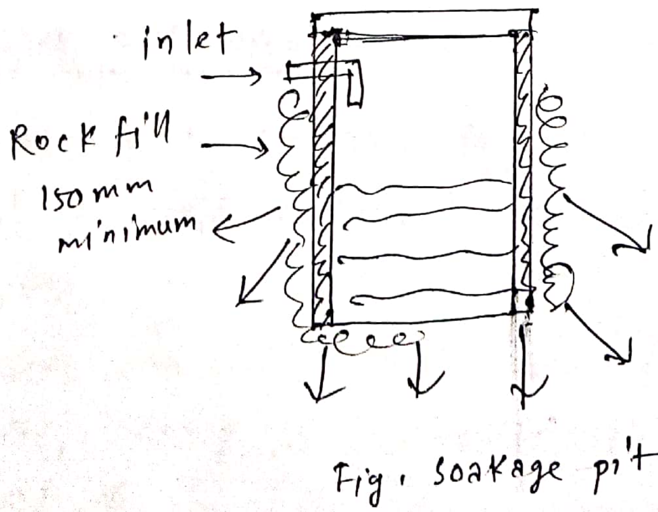

Fig. Soakage pit

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seepage bed:

A trench usually exceeding 36 in. (approxi. 1m) in width containing clean, coarse aggregate and a system of distributing piping through which partially treated sewage may seep in to the sorrounding soil.

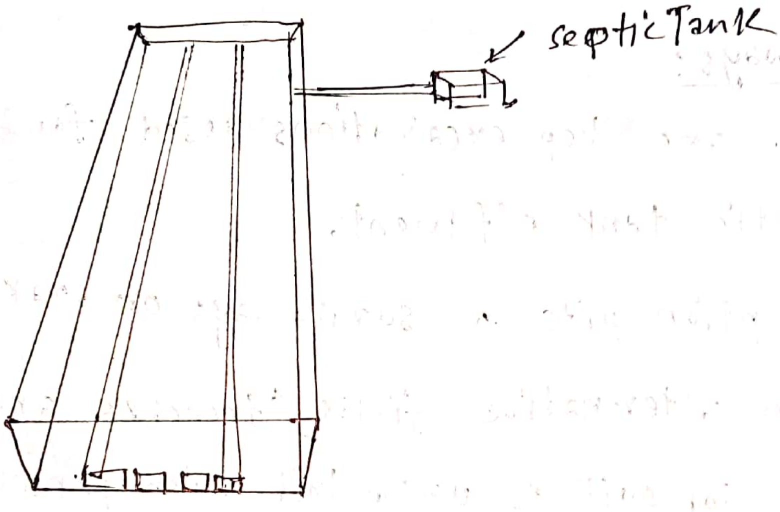
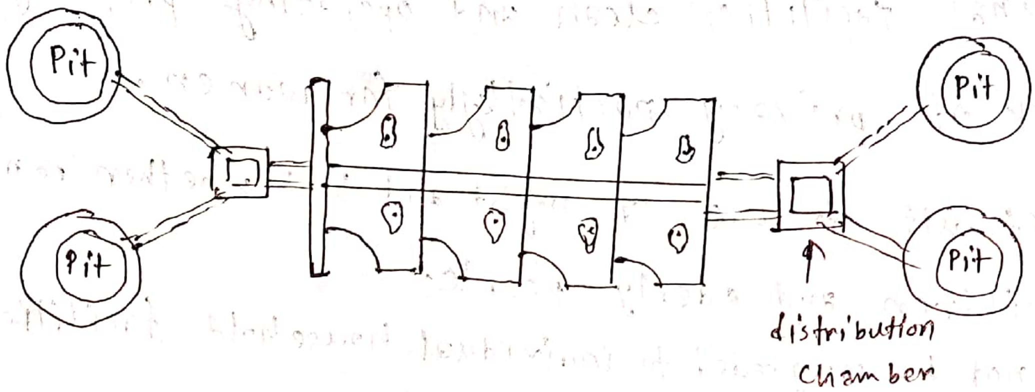


Fig. seepage bed.

Communal Sanitation System

Communal sanitation system:

A communal sanitation system consists of a number of squatting facilities with a common disposal system.



Suitability of communal sanitation system: where -

(i) Sewerage system are not feasible both technically and economically.

(ii) On-site individual sanitation systems are not possible due to housing density or ground condition.

Advantages and Disadvantages of such system:

(i) The option is suitable for densly populated slum areas where individual on-site system is technically and economically unfeasible.

(ii) The users can share total costs of communal sanitation facilities, leading low per capita cost compared to high technical standard of the facility.

(iii) communal sanitation facilities if connected to a biogash plant, may provide significant amount of energy required for cooking and lighting.

Disadvantages:

(i) Lack of commitment by individual users to keep the communal facilities clean and operating properly.

(ii) lack of privacy particularly for women.

(iii) Difficult to use at night and bed whether condition for children and ederly people.

(iv) can not be upgraded to individual household facilities.

What is the primary reason for failure of communal and public toilet facilities. 2014, 12, 11, 07

⇒ The primary reason is Their operation and maintenance. All over the world the main problem is keeping these facilities clean. As users are not motivated to do this when this is not part of their housing.

Fouling of latrines and urinals is common and once a latrine is fouled, subsequent users find no other alternative but to foul it more.

The major problem is who is to keep the facility clean.

How these systems can be sustainable? 2014, 12, 11, 07

(i) The way to avoid the unhygenic conditions in communal sanitation facilities is to employ a full time attendant for operation and maintenance.

(ii) Appropriate fees may be charged for use of these facilities and the money thus collected may be used to pay for the salary of the attendant and the rest spent for maintenance.

Difference between communal sanitation and public toilets facilities. 2014, 12, 11, 07

Communal Sanitation	Public Toilets
Communal sanitation facilities are built outside household plots in communities and used by people for their daily needs when at home.	Public toilet facilities are built in or near market places, commercial areas, city centres. and other public places and are intended for people who are away from their homes.

Air Pollution

#What is Air Pollution: 2018, 2013

Air pollution can defined as the presence of one or more contaminants in air like dust, mist, smoke, odour etc in excess quantities that causes injurious to human beings, plants, animals and properties.

composition of Air:

constituent	Percentage by volume
Nitrogen	78.10
Oxygen	20.90
Carbon-di-oxide	0.04
Water vapour, ozone, argon, krypton, carbon-mono oxide etc.	0.96

Describe the sources of air pollution: 2018, 2016

The main sources of air pollution can be—

(i) Natural sources

(ii) Artificial sources

(i) Natural sources: Following are the natural sources contributing to air pollution:

(a) Atmospheric Reaction: In the lower atmosphere, the natural chemical reactions lead to the conversion of gases and vapours in to solids and liquid products by oxidation, condensation or polymerisation.

(b) Dust and aerosols: The dust and aerosols of natural origin which are present in the atmosphere consists of salt particles from sea water, air-borne particles from soil and vegetation.

(c) Micro-organism: This consists of viable particles in the form of algae, fungi, bacteria etc.

(d) Pollens: They enter the atmosphere from trees, grasses and weeds. They are transported from one place to another by wind currents.

(e) Radeo-active minerals: The radio-activity of the atmosphere is influenced by the radio-active minernals, the action of cosmic rays etc.

(ii) Artificial sources: Following are the artificial sources of air pollution:

(a) combusion of fuels: The burning of fuels like oil, coal etc leads to the formation of undesirable gases.

(b) Industries: some of the industrial activities like non-ferrous metal smelting and refining, iron manufacturing, oil refining etc.

(c) Thermal power houses: Thermal power plants are main contributor of SO_2 emissions.

(d) Vehicle pollutions: The exhaust from the automobiles contains a dangerous gas namely cabon mo-oxide.

Describe briefly the effects of Air Pollution. 2017, 2013

Followings are the effects of air pollution:

(i) Effect on certain materials: Air pollution affect the certain materials in following ways–

(a) abrasion

(b) corrosion

(c) Deposition & Removal

(d) Direct chemical attack

(e) Indirect chemical attack

(ii) Effect on human health: The inhalation of undesirable gases from the atmosphere has marked effect on human health.

(iii) Effect on physical features of the atmosphere:

(a) it has considerable impact on urban areas.

(b) visibility of eye is reduced due to smoke, fog, dust etc.

(c) weather condition is changed

(d) solar radiation is reduced to the extent of about 30% or so.

(e) composition of normal air is disturbed.

(iv) Effect on vegetation: Low concentration of O_3, NO_2, SO_2 gas may severely damage the sensitive vegetation.

What is the importance of air?

Importance of air lies in the fact that it is the sources of life on earth.

There is no life in our solar system without air, as seen on other planets.

- For physiological requirements of an adult man is –
  - (i) 14 kg of air
  - (ii) 1·5 kg of food
  - (iii) 2 kg of water daily.

- People can survive without – food for 5 weeks
  - – water for 5 days
  - – air for few minutes only.

- The uses of air and its applications include –
  - (i) provides living energy.
  - (ii) supports water cycle.
  - (iii) supports carbon cycle.
  - (iv) Balances the temperature on earth.
  - (v) conducts sound and helps in transmission.
  - (vi) Air transport etc.

Short Notes:

(i) Aerosols: An aerosol is a particle of solid or liquid matter of such minute size that it can remain suspended in the atmosphere for a long period of time.

- Liquid particles: spherical in shape.
- Solid particles: spheres, filaments and various irregular shape.

(ii) Smoke: The vaporous matter, with suspended particles of carbon arising from something burning, is known as smoke.

- particle size: less than 1.0 μ
- Tobacco smoke: 0.25 μ

(iii) Fog: The visible moisture in the atmosphere is known as Fog. Mass of smoke, dust etc.

(iv) Haze: A thin vapour of fog, smoke, dust etc. in the air is known as Haze.

(v) Mist: A cloud of dust, gas etc. or large mass of water vapour like a light fog is known as the Mist.

Green House Effect

What is green house?

The term green house is used to mean a building made mainly of glass with heat and humidity regulated for growing plants.

What are the greenhouse gases?

1. Carbon-dioxide (CO_2): Most abundant Gas.

2. Nitrous oxide (N_2O): Biogenic gas emitted by— fertilizers and deforestation, biomass burning, nitrogenous fossil fuel combustion.

3. Methan (CH_4): Anaerobic decomposition in biological system, biomass burning, land fills and wet lands.

4. Other gases (O_3, NO, SO_2): fossil fuel burning and manufacturing process of chemicals.

Describe the effect of green house gases.

1. Ocean gets warmed up by the rise in temperature, sea level would rise flooding low-lying regions.

2. In temperature regions, winter will be shorter and warmer and the summer will be longer and hotter.

3. Plants and animals will be affected and ecosystem will be unbalanced.

4. Increase in rainfall to the extent of about 10%.

5. Tropic may become wetter and the sub-tropics may become more drier.

6. Plants will grow with the increase in carbon di-oxide in the air.

What are the solutions to minimize green house effect?

1. Reduction of fossil fuel combustion

2. Rely on renewable source of energy like bio-gass, nuclear, solar and wind.

3. Dispose the green house gases elsewhere than in the atmosphere.

4. learn to adopt and accept the changing climate.

Ozone layer

Ozone layer: An ozone layer is present in the atmosphere upto a distance of about 60 Km with concentration of the order of 1 in 10000 upto 20 to 25Km.

It acts as umbrella against the harmful ultra violet radiation reaching the earth.

Entire quantity of ozone would form a layer of 3mm.

Effects of Ozone on Human Health:

Ozone level (ppm)		observed effects.
0.20	—	No ill effects.
0.30	—	Nose and throat irritation.
1 to 3	—	Extreme fatigue after two hours.
9	—	severe trouble with lungs.

Adverse effect of Ultra violet Radiation:

1. Damage of immune system.
2. Disturbance in eco system.
3. Effect on crop yield espicially that of timber
4. Increase of skin cancer and eye ailments.
5. shorter life of paints and plastics.

Acid Rain

What is acid rain? 2017

The pH of natural rainfall is around 7. But when it travels through polluted enironment, its pH value lowers, and when the value of pH falls to 5 or below, the rain is specially termed as Acid Rain.

Every source of energy has mainly two elements, namely sulphur and nitrogen.
when they burn in the presence of oxygen, converted into their respective oxides.
During the rain, these oxides react with large quantities of water vapour of the atmosphere to form acids like sulphuric acid, sulphurous acid, nitric acid and nitrous acid.

Describe the harmful effect of acid rain: 2017

1. It can acidify the fresh water of rivers, lakes, springs, well etc.
2. It may cause the neurological diseases of Human being.
3. It has the potential to convert the forests into waste lands.
4. It is a versatile destroyer with planetery or universal implications.
5. It is dangerous to living organism as it can damage life.

6. It may have damaging effects like corrosion of metals.

7. It serves as a poison to the wild life.

Noise Pollution

What is Noise Pollution?

When the sound waves are non-periodic, irregular and of short duration, they produce a displeasing effect and such a sound is known as the noise pollution.

Describe the effects of Noise pollution:

1. It creats uncomfortable living conditions.
2. It leads to fatigue and work deficiency of person.
3. It leads to nervous irritability, strain and some psychological reactions.
4. It may result shorten memory.
5. It can interfere with speech communication.
6. It has an influence on blood pressure, in muscular strain and even on sleep.
7. It also hinders the development.

Effects of Noise on human beings:

(i) Temporary threshold shift (TTS): It means any loss of hearing which the ear recovers. It has been due to the metabolic changes in the air and failure to return to the normal biochemical state before further exposer takes place.

(ii) Permanent threshold shift (PTS): It is produced by the noise which produces TTS and is exposed for a long time. Thus workers exposed to high levels of noise have TTS at the end of their work of day from which they usually recover by the next morning or after a week.

Acceptable noise levels:

The maximum level of noise which will neither annoy the occupants nor damage the acoustics of the building is termed as the acceptable noise level inside the building.

It depends on the following factors:

(i) Nature of the noise.
(ii) Type and use of building.
(iii) time of fluctuations of the noise.
(iv) Background noise.

controls of noise pollution:

1. Ear protection aids
2. Design of doors and windows
3. Enclosures.
4. Improvement in working method
5. Legislative measures
6. planting of trees
7. Town planning
8. Treatment of walls, floors and ceilings.
9. Use of silencers or filters.
10. Vibration damping.

Difference Between Air pollution and Noise pollution:

Item	Air Pollution	Noise Pollution
1. Duration	The sources polluting air persist for some period of time.	The sources can be controlled immediately.
2. Effect on Human health	It adversely affects human health.	It may not by itself affect human health.
3. Nature of phenomena	It is an international phenomena	It is a local phenomena
4. Nature of substances	It may contain toxic substances.	It does not contain harmful substances.
5. Treatment	It is most essential and shall be strictly enforced as per legal requirements.	It does not prove fatal even if not treated properly.
6. Importance	It has gained high importance due to its serious harmful effects.	Its importance is related to better environment conditions.

Water pollution

What is water pollution?

Any physical, biological or chemical change in water quality that adversely affects living organisms or makes water unsuitable for certain use is referred to as Water Pollution.

Describe the sources of water pollution.

Two chief sources of water pollution is —

(i) point source pollution.

(ii) Non-point source pollution.

(i) point source pollution: Point source pollution is defined as any single identifiable source of pollution from which pollutants are discharged.

Example: Industrial waste, municiple sewage etc.

Point source pollution sources are discrete and identifiable. Hence it is easy to monitor and regulate.

(ii) Non-point source pollution: When a source of pollution can not be readily identified i.e sources are scattered or diffuse are called Non-point source of pollution.

Example: Runoff from farmlands, construction sites, animal waste etc.

Another sources of water pollution:

1. water and sewage company works.
2. Petroleum industry.
3. Acid rain.
4. Radio-active materials.
5. Aquatic plants (e.g. water hyacinth)
6. Industrial waste
7. Solid waste.

Describe the causes of water pollution.

1. Biochemical Oxygen Demand (BOD): B.O.D is often indication of the presence of sewage and other organic waste. High levels of B.O.D can deplete the oxygen in water.

2. Nutrients: Nutrient acquires more suspicious face at high concentration. Synthetic fertilizers are composed of nutrients. Nutrients are also discharged as organic matter.

3. Suspended solids / sediments: Suspended solids are physical pollutants. This can stunt the growth of the aquatic plants.

4. <u>Oil and grease:</u> Oil spills are a major problem in near coastal waters and can kill or adversely affect fish, other aquatic organisms and Birds and mammals.

5. <u>Bacteria, viruses and protozoa:</u> These micro-organisms are naturally found in water and elsewhere in the environment and can cause infection.

Discuss the effect of water pollution.

1. <u>Effects on Human Being:</u> On consuming polluted water following effects are observed on human beings:

(i) Skin cancer
(ii) Choleria
(iii) Typhoid fever
(iv) Damages of nervous system
(v) Birth defects.
(vi) Hepatisis
(vii) Malaria etc.

2. <u>Effects on plants and animals:</u>

(i) Lower crop yields.
(ii) Harmful to aquatic life and wild life.
(iii) Excess growth of algae can kill aquatic life.
(iv) Reduce photosynthesis.
(v) Disrupts food chain and food web.

Discuss control measures for preventing water pollution.

1. Setting up effluent treatment plans to treat waste.

2. Recycling of waters

3. Treatment of industrial waste before discharge.

4. Developing economical method of water treatment.

5. Strict enforcement of water pollution control act.

6. River, stream, lakes and other reservoirs must be well-protected from being polluted.

7. Public awareness.

Sewerage System

2013, 2010

Problem - 5.3 (Rangawala)

Calculate the velocity, discharge and chezy's co-efficient for a stoneware sewer running full. The diameter of sewer is 150 mm and it is laid at a gradient of 1 in 60. Assume, N = 0.013 in Manning's formula.

Solution: According to manning's formula.

$$V = \frac{1}{n} R^{\frac{2}{3}} . S^{\frac{1}{2}}$$

Here, $n = 0.013$

$R = \frac{d}{4}$ (for running full)

$= \frac{0.15}{4} = 0.0375$ m

$S = \frac{1}{60}$

$$= \frac{1}{0.013} \times (0.0375)^{\frac{2}{3}} \times \left(\frac{1}{60}\right)^{\frac{1}{2}}$$

$= 1.1126$ m/sec.

Then, $Q = AV$

$$\Rightarrow Q = \frac{\pi}{4} \times (0.15)^2 \times 1.1126 = 0.02 \text{ m}^3/\text{sec}.$$

According to chezy's formula,

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

$$\Rightarrow 1.1126 = C \times \sqrt{0.0375 \times \frac{1}{60}}$$

$$\Rightarrow C = 44.504$$

(Ans.)

2014, 2011

Problem - 5.5:

A combined sewer of circular section is to be laid to serve a particular area. Calculate its size from the following data:

Area to be served = 100 ha.

population = 90000

Maximum velocity of flow = 3 m per second.

Time of entry = 3 minutes.

Time of flow = 17 minutes.

Rate of water supply = 240 l per head per day.

Impermeability factor = 0.50

Solution:

D.W.F: Average discharge = $\frac{90000 \times 240}{24 \times 60 \times 60} = 250$ l/sec.

Assuming a multiplying factor of 2,

Maximum discharge, $Q_{max} = 2 \times Q_{avg}$.

$= (2 \times 250)$ l/sec.

$= 500$ l/sec.

Storm water:

Time of concentration = $(3 + 17) = 20$ min.

a = 30
b = 10

Rain fall intensity, $R = \frac{25.4\,a}{t + b} = \frac{25.4 \times 30}{20 + 10}$ (a, b: constant; t: min.)

$\therefore R = 25.4$ mm/hour

$\therefore$ discharge, $Q = \frac{AIR}{360} = \frac{100 \times 0.50 \times 25.4}{360}$

$= 3.528 \ m^3/sec.$

$= 3528$ litre/sec.

$\therefore$ combined discharge,

$Q = (500 + 3528) = 4028$ l/sec.

$= 4.028 \ m^3/sec.$

$A = \frac{Q}{V} = \frac{4.028}{3.00}$.

2014

Problem: 3.3

$\Rightarrow \frac{\pi}{4} d^2 = 1.343 \Rightarrow d = 1.3075 m (\simeq 1.4 m)$ (Ans).

Work out the ratio of D.W.F and W.W.F of a city having the following particulars:

Area = 30000 hectares

Water supply rate = 200 litres per capita per day

population $= 18 \times 10^5$

Intensity of rainfall = 15 mm per hour

Average permeability = 0.50

Assume that 60% of water supplied reaches the sewer.

Comment on your result.

Solution: (1) D.W.F $= (18 \times 10^5 \times 200 \times 0.60) = 2.16 \times 10^8$ l/day

$= \frac{2.16 \times 10^8}{24 \times 60 \times 60}$ l/sec.

$= 2500$ l/sec.

$= 2.5 \ m^3/sec.$

(2) $W.W.F = Q = \frac{AIR}{360} = \frac{30000 \times 0.50 \times 15}{360} = 625\ m^3/sec.$

$\therefore \frac{D.W.F}{W.W.F} = \frac{2.50}{625} = \frac{1}{250}$

As the ratio is very low, it will not be desirable to adopt combined system of sewerage. Hence seperate sewerage system should be recomended in this case.

2011

Problem - 3.4:

A town having a population of 20000 has a sewage of D.W.F. 25 litres per second having average B.O.D of 325 mg/l. The sewage contains industrial waste to the extent of 2.5 litres per second. having a total B.O.D of 202 kg per day. Find out the per capita B.O.D load in kg per day.

Solution:

Total B.O.D load $= (25 \times 325) = 8125$ mg/sec.

$= \frac{8125 \times 24 \times 60 \times 60}{10^6}$ kg/day

$= 702$ kg/day.

Total B.O.D load of industrial waste $= 202$ kg/day.

$\therefore$ The net B.O.D load $= (702 - 202)$ kg/day $= 500$ kg/day

$\therefore$ B.O.D load per capita $= \frac{500}{20000} = 0.025$ kg/day.

(Ans.)

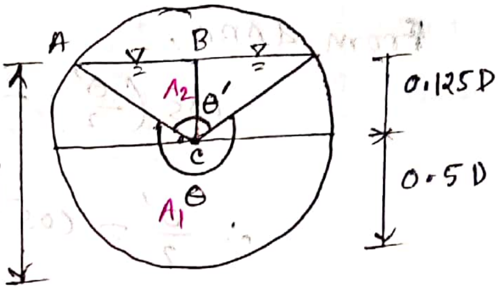
2015

Design a sewer line when $\left(\frac{5}{8}\right)^{th}$ full. $P = 150000$, $q = 160$ lpcd and $v = 1.5\ ms^{-1}$

Solution:

Discharge, $Q = \dfrac{150000 \times 160}{24 \times 60 \times 60 \times 1000} = 0.278\ m^3/sec.$

Let, Diameter of sewer = D



From, △ABC

$$\cos\left(\frac{\theta'}{2}\right) = \frac{CB}{AC} = \frac{0.125D}{0.5D}$$

$$\therefore \frac{\theta'}{2} = \cos^{-1}\left(\frac{0.125}{0.5}\right) = 75.52^\circ$$

$$\therefore \theta' = (2 \times 75.52) = 151.04^\circ$$

Hence $\theta = (360 - 151.04) = 208.96^\circ$

$$\therefore \text{Area of the flow} = \underbrace{\frac{\pi D^2}{4} \times \frac{\theta}{360}}_{A_1} + \underbrace{2 \times \frac{1}{2} \times \overbrace{0.125D \tan\left(\frac{\theta'}{2}\right)}^{AB} \times \overbrace{0.125D}^{BC}}_{A_2\ (\triangle ABC)}$$

$$= \frac{\pi}{4} \times D^2 \times \frac{208.96}{360} + (0.125)^2 D^2 \times \tan\left(\frac{151.04}{2}\right)$$

$$= 0.456D^2 + 0.0605D^2$$

$$= 0.5165D^2$$

Then, $Q = Av$

$\Rightarrow 0.278 = 0.5165D^2 \times 1.5$

$\Rightarrow D = 0.60\ m = 600\ mm$

(Ans.)

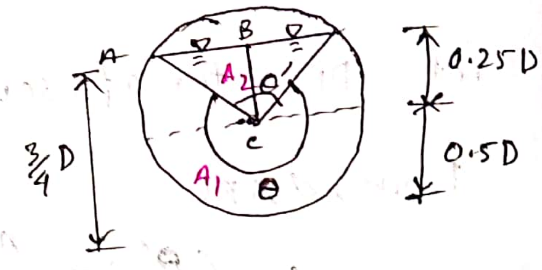
2012

Design a sewer line when running at $(\frac{3}{4})^{th}$ full.

Given $Q = 6$ cfs, $n = 0.013$, $S = 0.020$.

Solution:

Assume, the diameter of sewer line $= D$



From $\angle ABC$,

$$\cos\left(\frac{\theta'}{2}\right) = \frac{CB}{AC} = \frac{0.25\,D}{0.5D}$$

$$\therefore \frac{\theta'}{2} = \cos^{-1}\left(\frac{0.25}{0.5}\right) = 60^\circ$$

$$\therefore \theta' = (2 \times 60) = 120^\circ$$

$$\therefore \theta = (360 - 120) = 240^\circ$$

$$\text{Area, } A_1 = \frac{\pi}{4} D^2 \times \frac{\theta}{360} = \frac{\pi}{4} \times D^2 \times \frac{240}{360} = 0.5236\,D^2$$

$$\text{Area, } A_2 = 2 \times \frac{1}{2} \times 0.25D \tan\left(\frac{120}{2}\right) \times 0.25D = 0.1083\,D^2$$

$$\therefore \text{Total Area, } A = (0.5236 + 0.1083)\,D^2 = 0.6319\,D^2$$

$$\text{wetted perimeter, } P = \pi D \times \frac{\theta}{360} = \pi D \times \frac{240}{360} = 2.0944\,D$$

$$\therefore R = \frac{A}{P} = \frac{0.6319\,D^2}{2.0944\,D} = 0.3017\,D$$

cfs unit ← (1.49)

$$\text{velocity, } v = \frac{1.49}{n} \times R^{\frac{2}{3}} \times S^{\frac{1}{2}} = \frac{1.49}{0.013} \times (.3017D)^{\frac{2}{3}} \times (.020)^{\frac{1}{2}}$$

$$= 7.2914\,D^{\frac{2}{3}}$$

$$\therefore \text{Discharge, } Q = AV$$

$$\Rightarrow 6 = 0.6319\,D^2 \times 7.2914\,D^{\frac{2}{3}} \Rightarrow D = 1.1041 \text{ ft.}$$

(Ans.)

Scanned by CamScanner

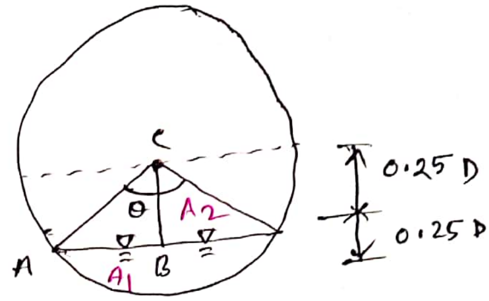
2011

Design a sewer line when running at $\left(\frac{1}{4}\right)^{th}$ full.

Given, $Q = 6$ cfs, $n = 0.013$, $S = 0.020$

Solution:

Assume, Dia. of sewer = D



From ΔABC,

$$\cos\left(\frac{\theta}{2}\right) = \frac{CB}{AC} = \frac{0.25D}{0.5D}$$

$$\therefore \frac{\theta}{2} = \cos^{-1}\left(\frac{0.25}{0.5}\right) = 60^\circ$$

$$\therefore \theta = 120^\circ$$

$$\therefore A_1 = \frac{\pi}{4}D^2 \times \frac{120}{360} = 0.2618\,D^2$$

$$A_2 = \frac{1}{2} \times 0.25D \tan\left(\frac{120}{2}\right) \times 0.25D \times 2 = 0.1083\,D^2$$

$$\therefore \text{Area} = A_1 - A_2 = \left(0.2618D^2 - 0.1083D^2\right) = 0.1535\,D^2$$

$$\text{perimeter, } P = \pi D \times \frac{120}{360} = 1.0472\,D$$

$$\therefore R = \frac{A}{P} = \frac{0.1535D^2}{1.0472D} = 0.1466\,D$$

$$\text{velocity, } V = \frac{1.49}{n} R^{\frac{2}{3}} S^{\frac{1}{2}} = \frac{1.49}{0.013} \times (0.1466D)^{\frac{2}{3}} \times (.020)^{\frac{1}{2}}$$

$$\therefore V = 4.5066\,D^{\frac{2}{3}}$$

Thus, $Q = AV$

$$\Rightarrow 6 = 0.1535D^2 \times 4.5066\,D^{\frac{2}{3}}$$

$$\therefore D = 2.25\text{ m} \quad \text{(Ans.)}$$

2016

Problem: 11.1 (Ranga wala)

Design a screen for an average discharge of 0.20 m^3/sec.

Solution: Assuming fluctuation factor = 2

and, velocity of flow = 1 m/sec.

$\therefore$ The maximum discharge, $Q_{max} = f\, Q_{avg}$

$= (2 \times 0.2) = 0.4\ m^3/sec.$

Now, $Q_{max} = A \times V$ where, A = cross-sectional area of screen.

$\Rightarrow A = \frac{Q_{max}}{V}$

$\therefore A = \frac{0.4}{1} = 0.4\ m^2$

Keeping 100% as excess openings,

$\therefore$ Effective area $= (0.4 + 0.4) = 0.8\ m^2$

Assume, the depth of screen = 800 mm = 0.8 m

$\therefore$ effective width of screen $= \frac{0.8}{0.8} = 1\ m$

Adopt medium screen having size of opening = 40 mm = 0.04 m

$\therefore$ Nos. of openings $= \frac{\text{width}}{\text{size of opening}} = \frac{1}{0.04} = 25$

Nos. of flat $= (25 - 1) = 24$

Assume the flat thickness = 5 mm and angle thickness at both ends = 25 mm

$\therefore$ Total width of screen $= (25 \times 0.04) + (24 \times 0.005) + (2 \times 0.025) = 1.17\ m$

(Ans.)

Problem: 11.2

Design a detritus tank for an average flow of 200 Litres per second. Make suitable assumption, where necessary.

Solution:

(1) Width of tank: Assume, a detritus tank of rectangular shape. with effective depth as 1.2 m

Assuming, The maximum flow to be three times of average flow.

$\therefore Q_{max} = (3 \times 200) = 600$ litres $= 0.6\ m^3$

Let, the velocity of flow in the tank = 300 mm/sec. = 0.3 m/sec.

Now, $Q_{max} = AV$

$\Rightarrow A = \frac{Q_{max}}{V} = \frac{0.6}{0.3} = 2\ m^2$

width of the tank $= \frac{\text{Area}}{\text{depth}} = \frac{2}{1.2} = 1.67$ say 1.70

(2) Length of tank: Assume a detention period of 3 minutes.

Then, the length of the tank = velocity of flow × detention period

$= (0.3 \times 3 \times 60) = 54$ m

Make an allowance of about 6 m for inlet and outlet arrangement.

Hence, the total length of the tank $= (54 + 6) = 60$ m

(3) Total depth of the tank:

Provide the bottom depth of 500 mm for accumulation of detritus; and free board at the top is kept as 300 mm.

Hence, the total depth = $(1.2 + 0.3 + 0.5) = 2\,m$

(Ans.)

Problem - 11.3:

Design a primary clarifier for a town having a population of 34000. The formation of sewage may be assumed at 150 lpcd.

Solution:

Daily flow of sewage = $(34000 \times 150) = 51,000,00$ Litres/day.

Assume, detention period of 2 hours.

thus, tank capacity $= \left(\frac{51,000,00 \times 2}{24}\right) = 425000$ litres.

$= 425\ m^3$

Assume, the effective depth as 2.5 m

$\therefore$ surface area of tank $= \frac{\text{Volume}}{\text{depth}} = \frac{425}{2.5} = 170\ m^2$

$\Rightarrow l \times b = 170\ m^2$

Let, $l = 4b$; Hence, $4b \times b = 170$

$\Rightarrow b = 6.52\ m$ say $6.5\ m$

$\therefore l = 4b = (4 \times 6.50) = 26.00\ m$

Provide additional 4 m for inlet and outlet arrangment

$\therefore$ Total length of the tank $= (26 + 4) = 30\ m$

Provide 1 m depth for sludge accumulation and 500 mm depth of free board.

∴ The total depth of the tank = (2.5 + 1 + 0.5) = 4 m

∴ The dimension of the tank = 30 m × 6.5 m × 4 m

provide one more unit of settling tank to act as a stand-by unit.

Problem - 11.4

A domestic sewage contains 400 p.p.m of suspended matter. If the primary sedimentation tank is designed to remove 70 % of suspended matter, calculate the quality of sludge which is formed. Assume that the sludge is to contain 5 % of solids.

Solution: Initial suspended solids = 400 p.p.m

suspended solids removed = (0.7 × 400) = 280 p.p.m

∴ the quantity of sludge containing 5% solids formed,

$$= \frac{280}{0.05} = 5600 \text{ litres.}$$

(Ans.)

Grit Chamber

2018

Design a grit chamber for a horizontal velocity of 250 mm/sec. and a flow ranges from a minimum of 20000 m^3/day to maximum of 80000 m^3/day. Average flow is 50 000 m^3/day.

Solution: Given,

Maximum flow of sewage = 80000 m^3/day = 0.923 m^3/sec.

Assume, detention period = 60 sec.

∴ length of the grit chamber, L = Horizontal velocity × detention period

= (0.25 × 60) m

= 15.0 m.

volume of the grit chamber = Q_{max} × detension time.

= (0.923 × 60) m^3

= 55.38 m^3

Cross section of grit chamber = $\frac{\text{volume}}{\text{Length}}$

$= \frac{55.38}{15}$ m^2

= 3.692 m^2

≃ 3.7 m^2

Assume, the width of grit chamber = 3 m

∴ depth of grit chamber = 1.23 m ≃ 1.25 m

Provide 25% additional length to accumulation inlet and outlet zones, Hence the length of chamber = (15 + 0.25 × 15) m

= 18.75 m

provide 0.3 m free board and 0.25 m accumulation zone depth,

Hence the total depth of grit chamber

$$= (1.25 + 0.3 + 0.25) = 1.8 \text{ m}$$

(Ans.)

Filtration of Sewage

Problem - 12.1 (Rangawala)

Design a trickling filter for treating 6 millions litres of sewage per day. The B.O.D of sewage is 120 p.p.m.

Solution:

(1) Kg of B.O.D per volume of filter bed:

Total B.O.D = (120 × 6) = 720 Kg / day

Assume, the rate of filter loading as 1440 Kg of B.O.D per ha.-m per day

$\therefore$ volume required = $\frac{720}{1440}$ = 0.50 ha-m.

Assume effective depth of filter = 1.8 m (1 ha = 10000 m²)

$\therefore$ surface area of filter = $\frac{0.50 \times 10000}{1.80}$ = 2778 m²

(2) Kg of BO.D per volume of filter media:

Assume, the rate of filter loading as 16 Kg of BOD per day per 100 m³ of fiter media.

$\therefore$ Volume of filter media = $\frac{720}{16} \times 100$ = 4500 m³

$\therefore$ surface area of filter = $\frac{4500}{1.8}$ = 2500 m²

(3) surface area of filter bed:

Assume the rate of filter loading as 25 million litre/ha/day

$\therefore$ surface area of filter = $\left(\frac{6}{25} \times 10000\right)$ m²

= 2400 m²

(4) volume of filter bed:

Assume the rate of filter loading as 12 million litre/ha m/day

∴ volume required = $\frac{6}{12}$ = 0.5 ha-m

∴ The surface area of filter = $\frac{0.5 \times 10000}{1.8}$ = 2778 m²

Adopt a circular tricling filter of diameter 45 m

∴ Area of one filter = $\frac{\pi}{4} \times 45^2$ = 1590 m²

∴ Nos. of unit required = $\frac{2778}{1590}$ = 1.75 ≃ 2

provide 1 stand-by unit with required 2 Units.

Activated sludge process

2011

Problem-13.3 (Rangawala)

An acctivated sludge plant with mixed volatile suspended solids (MLVSS) as 2000 mg/l treats with an ultimate B.O.D of 900 mg/l and 300 mg/l VSS which are 86% biodegredable. If the plant effluent contains 20 mg/l ultimate B.O.D and 15 mg/l VSS, determine the daily VSS accumulation and the oxygen requirement for a flow of 0.40 m³/sec. Take synthesis constant p as 0.55 and the endogenous respiration constant q as 0.15.

Solution:

we know, VSS accumulation,

$$V_a = (r V_i + p X_r) - qV$$

given, $V_i = 300$ mg/l

$X_r = (900 - 20) = 880$ mg/l

$r = (100 - 86) = 14\% = 0.14$

$p = 0.55$

$q = 0.15$

Thus, $V_a = (0.14 \times 300 + 0.55 \times 880) - 0.15 \times 2000$

$= 226$ mg/l

As, effluent contains 15 mg/l VSS,

∴ The net accumulated mass of VSS $= (226 - 15) = 211$ mg/l

Hence, $V_a = (211 \times \underset{\text{Given}}{0.4} \times 1000) = 84400$ mg/sec.

$= \left(\frac{84400 \times 24 \times 3600}{10^6}\right) = 7292.16$ kg/day

For oxygen requirement,

$O_2 = 0.39\, X_r + 1.429\, V$

$= (0.39 \times 880) + (1.42 \times 0.15 \times 2000)$

$= 769.2$ mg/l

O_2 in kg per day $= \left(\frac{7692 \times 0.4 \times 24 \times 3600}{1000}\right) = 26583.552$ kg/day.

$\frac{10^3}{10^6}$

$\simeq 26584$ kg/day.

(Ans.)

Problem- 13.6

Compare the area requirements for trickling filter (0.14 kg B.O.D /m3-d) and activated sludge (0.65 kg B.O.D /m3-d) for the flow from a town of 30000 population. D.W.F is 250 litres per capita per day with 3000 mg/l B.O.D. Assume a filter depth equal to 2.50 m and 3.50 deep aeration tank. The primary sedimentation removes 40% of the supplied B.O.D

Solution: D.W.F = 250 litres per capita per day

Population = 30000

∴ Total daily water flow, $Q = (250 \times 30000)$ litre/day

$= 7.5 \times 10^6$ litre/day

$= \frac{7.5 \times 10^6}{24 \times 3600} = 86.8$ l/sec.

$Q \simeq 87$ l/sec.

Scanned by CamScanner

Applied B.O.D = 300 mg/l

As, 40% of applied B.O.D is removed in primary sedimentation

∴ the B.O.D of effluent entering secondary treatment unit

$= (0.60 \times 300)$ mg/l

$= 180$ mg/l

B.O.D in Kg/day $= \left(\frac{180 \times 87 \times 24 \times 3600}{10^6}\right)$ Kg/day

$= 1353.024$ Kg/day

$\simeq 1353$ Kg/day

For trickling Fiter:

Rate of B.O.D removal $= 0.14$ kg/m³-day

∴ Volume required $= \frac{1353}{0.14} = 9664.29$ m³

~ 9665 m³

Now, depth $= 2.5$ m

Area required $= \frac{9665}{2.5} = 3866$ m²

For aeration tank:

Rate of B.O.D removal $= 0.65$ Kg/m³

∴ volume required $= \frac{1353}{0.65} = 2081.54$ m³

~ 2082 m³

$\therefore$ Area required $= \frac{2082}{3.5} \doteq 594.86 \simeq 595\ m^2$

$\therefore$ Area required for trickling filter $= \frac{3866}{595} \simeq 6.5$ times of aeration tank

(Ans.)

Scanned by CamScanner

Oxidation Pond

2015, 2014

Problem - 15.2 (Rangawala)

Design an oxidation pond for treating sewage from a hot climatic residential colony having population of about 5000 persons. The contribution of sewage is at the rate of 120 litres per capita per day and the 5-day B.O.D of the sewage is 300 mg/l.

Solution:

Quantity of sewage to be treated $= (5000 \times 120)$ litres/day

$= 600000$ litres/day

$= 600\ m^3/day$

B.O.D content $= \left(\frac{600 \times 300}{1000}\right)$ Kg/day

$= 180$ Kg/day

Assuming the organic loading in the pond as 300 kg/ha/day

$\therefore$ surface area required $= \left(\frac{180}{300}\right) = 0.6$ ha. $= (0.6 \times 10000)\ m^2$

$= 6000\ m^2$

Hence, $L \times B = 6000\ m^2$

Assuming, $L = 2B$

$\therefore 2B \times B = 6000$

$\Rightarrow B = 54.77$ m say 55 m.

$\therefore L = 2B = (2 \times 55) = 110$ m.

Scanned by CamScanner

Assume, the effective depth of tank = 1·2 m. with total depth of 2·2 m (free board = 1 m).

$\therefore$ capacity provided = (110 × 55 × 1·2) = 7260 m^3

We know,

capacity = sewage flow/day × Detention time in days

$\therefore$ Detention time = $\frac{7260}{600}$ = 12·10 say, 12 days.

Adopt an oxidation pond of dimensions 110 m × 55 m × 2·20 m and a detention period of 12 days.

Design of inlet pipe:

Assume an average velocity of sewage as 900 mm/s and daily flow for 8 hours only.

$\therefore$ Discharge = $\left(\frac{600}{8 \times 60 \times 60}\right)$ = 0·021 m^3/sec.

Area of inlet pipe required = $\frac{Q}{V}$ = $\left(\frac{0{\cdot}021}{0{\cdot}9}\right)$

$\therefore \frac{\pi}{4} D^2$ = 0·023 m^2.

$\therefore$ Dia. of inlet pipe, D = $\sqrt{\frac{4 \times 0{\cdot}023}{3{\cdot}1416}}$ = 0·17 m

say (200 mm)

The dia. of outlet pipe, D_o = 1·5 D_i = (1·5 × 200) mm

= 300 mm

(Ans.)

(Slide)

Problem: Design the size of a facultative pond needed to treat waste water of $B.O.D_5$ of 400 mg/l. Given the following data:

Effluent B.O.D = 60 mg/l

waste water flow = 2000 m^3/d $\quad * (K_p)_T = (K_p)_{20} (1.05)^{T-20}$

Depth of pond = 1.5 m

lowest temperature = 24°C

Removal rate constant for pond, $K_p = 0.35$/day at 20°C

Solution: We know,

$$\frac{L_e}{L_i} = \frac{1}{1+K_p t}$$

Here, $L_e = 60$ mg/L

$L_i = 400$ mg/L

$(K_p)_{24} = 0.35 \times 1.05^{24-20}$

$= 0.425$ per day

$$\Rightarrow \frac{60}{400} = \frac{1}{1+0.425t}$$

$\Rightarrow 60 + 25.5t = 400$

$\Rightarrow t = 13.33$ days.

Detention time $= \frac{V}{Q}$

$\therefore$ the volume $= Qt = (2000 \times 13.33) = 26666.67\ m^3$

$\therefore$ surface area $= \frac{\text{Volume}}{\text{depth}} = \frac{26666.67}{1.5} = 17777.78\ m^2$

(Ans.)

(Slide)

Problem: A facultative type aerated pond is to serve 10000 people and treat sewage of following properties.

waste water flow = 150 l/capita.d

Influent 5-day B.O.D = 54 g/capita.d

Design the pond to achieve an effluent BOD of 30 mg/l

(Assume winter temperature of lagoon to be 16°C.

K_p = 2.2/day at 20°C)

Solution: $(K_p)_{16} = 2.2 \times 1.05^{(16-20)} = 1.81$ per day.

Given,

$L_i = \left(54 \times \frac{1000}{150}\right) = 360$ mg/l

we know, $\frac{L_e}{L_i} = \frac{1}{1+K_p t} = \frac{1}{1+1.81t}$

$\Rightarrow \frac{30}{360} = \frac{1}{1+1.81t}$

$\Rightarrow t = 6.08$ days.

$\therefore$ volume, $V = Qt = (150 \times 10000 \times 6.08) = 9.12 \times 10^6$ liter

$= 9120\ m^3$

Assuming, the depth = 3 m

$\therefore$ surface area of pond $= \frac{9120}{3} = 3040\ m^2$

(Ans.)

(Slide)

problem: A maturation pond is capable of reducing the number of e. typhi by 99.5%. compute pond retention time and volume needed for treating a daily sewage flow of 250 m^3/d. take K (bacterial die away rate) = 0.8/day

Solution: The rate of die away of faecal organisms in a single maturation pond,

$$\frac{N_e}{N_i} = \frac{1}{1+K't}$$

given,
$K' = 0.8/day$
$N_e = (100-99.5)$
$N_i = 100$

Here,

$$\frac{N_e}{N_i} = \frac{100-99.5}{100} = 5\times10^{-3}$$

$$\therefore 5\times10^{-3} = \frac{1}{1+0.8t}$$

$\Rightarrow t = 248.75$ days say 249 days.

$\therefore$ volume $= Qt = (250\times249) = 62250\ m^3$

(Ans.)

B.O.D

Formulae:

- The amount of B.O.D remaining at any time 't'

$$L_t = L(10^{-Rt})$$

- The amount of B.O.D exerted at any time 't'

$$X_t = L - L_t = L - L(10^{-Rt}) = L(1-10^{-Rt})$$

- The value of R can be obtained,

$$R_T = R_{20}(1.047^{T-20})$$

where, $R_{20} = 0.1$ per day

Problem: Rangawala (9.1 – 9.12)

Problem- 9.3, 9.4

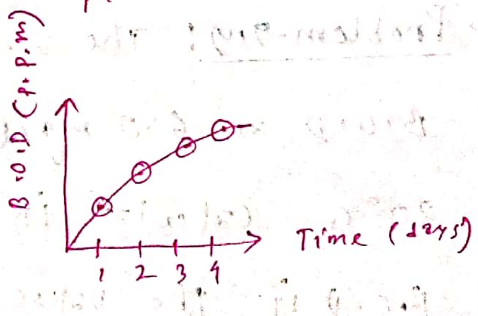
Determine the B.O.D for a sewage having 5-day B.O.D at 20°C as 200 p.p.m. Determine the * 1-day B.O.D at 20°C (2015, 2014)
* 2-day B.O.D
* 3-day B.O.D
* 4-day B.O.D and plot the graph B.O.D Vs. Time

Solution: We know,

$$X_t = L(1-10^{-Rt})$$

$$\Rightarrow 200 = L(1-10^{-0.1\times 5})$$

$$\Rightarrow L = 292.5 \text{ p.p.m}$$



Now, $L_t = L(10^{-Rt})$

$$\Rightarrow L_1 = (292.5 \times 10^{-0.1\times 1}) = 232.4 \text{ p.p.m}$$

Hence, 1-day B.O.D, $X_1 = L - L_1$

$= (292.5 - 232.4)$ p.p.m

$= 60.1$ p.p.m.

Ans.

Problem-9.5

A sample of sewage has 4-day 20 °C B.O.D value 80% of the final. Find the rate constant per day.

Solution: $X_4 = L(1 - 10^{-4R})$

$\Rightarrow \frac{X_4}{L} = 1 - 10^{-4R}$

$\Rightarrow 0.8 = 1 - 10^{-4R}$

$\Rightarrow 10^{-4R} = (1 - 0.8)$

$\Rightarrow -4R = \log(0.2)$

$\Rightarrow R = 0.175$ per day.

(Ans.)

Problem-9.9: The analysis of an industrial waste indicated its B.O.D as 600 mg/l with value of R as 0.15 per day at 20 °C. Calculate its 5 day B.O.D. What would be its 5-day B.O.D if the value of R dropped to 0.10 per day?

Solution: given, $R = 0.15$ per day

$L = 600$ mg/l

$\therefore X_5 = L(1 - 10^{-5R})$

$= 600 \times (1 - 10^{-5 \times 0.15})$

$= 492$ mg/l

Now, if value of R is dropped to 0.10 per day

$X_5 = 600 \times (1 - 10^{-5 \times 0.1}) = 408$ mg/l

(Ans.)

Problem - 9.10:

If 90% of BOD is satisfied in 5 days, calculate the rate constant.

Solution: $X_5 = L(1 - 10^{-5R})$

$\Rightarrow \frac{X_5}{L} = 1 - 10^{-5R}$

$\Rightarrow 0.9 = 1 - 10^{-5R}$

$\Rightarrow 10^{-5R} = 0.1$

$\Rightarrow -5R = \log(0.1)$

$\Rightarrow$

$\therefore R = 0.20$ per day.

(Ans.)

Problem-9.12: (2018, 2016, 2012, 2010)   B.O.D_5

For a waster sample, the 5-day B.O.D at 20°c is 250 mg/l and is 70% of the ultimate. What will be 4-day B.O.D at 30°C

Solution: $x_5 = L(1-10^{-5R})$

$\Rightarrow \frac{x_5}{L} = 1-10^{-5R}$

$\Rightarrow 0.7 = 1-10^{-5R}$

$\Rightarrow 10^{-5R} = 0.3$

$\Rightarrow -5R = \log(0.3)$

$\therefore R_{20} = 0.104$ per day

$R_{30} = R_{20} \times (1.047^{T-20}) = 0.104 \times (1.047^{30-20})$

$\therefore R_{30} = 0.165$ per day.

$\therefore x_4 = L(1-10^{-4R})$

Here, $L = \frac{250}{0.7} = 357.143$ mg/l

$\therefore x_4 = 357.143 \times (1-10^{-4 \times 0.165}) = 279$ mg/l

(Ans.)

Simple Pit latrine

Example-1 (ITN- Page-146)

Design a low cost simple pit latrine for a family of six person. The soil in the area is fairly permeable and stable. The ground water table is 5 m below ground level. Determine the size of pit required for a period of five years. The family uses water for anal cleansing.

Solution: consider a dry pit. Hence $C = 0.06\ m^3/p/yr$

We know, $V = 1.33 \times C \times P \times N$

$= 1.33 \times 0.06 \times 6 \times 5$

$\therefore$ required volume of pit $= 2.4\ m^3$

(i) consider a circular pit of diameter 1.25 m

$\therefore$ cross sectional area of pit, $A = \frac{\pi}{4} \times (1.25)^2$

$= 1.23\ m^2$

$\therefore$ depth of pit, $d = \frac{V}{A}$

$= \frac{2.4}{1.23} = 1.95\ m$ (say 2m)

Hence, excavate a pit of depth = 2m. (Ans.)

(ii) Consider a rectangular pit of section 1.25m × 1.25m

$\therefore$ cross sectional area of pit $= (1.25 \times 1.25) = 1.56\ m^2$

$\therefore$ the required depth, $d = \frac{V}{A} = \frac{2.4}{1.56} = 1.54\ m$ (say, 1.6m)

$\therefore$ choose a pit of depth = 1.6 m. (Ans.)

Exceercise Question – 11

In an effort to discourage people from open defecation the local authority in a village offers pre-cast concrete rings of 1.0 m diameter and concrete slabs to cover the pits at a very stablized rate. Design a simple pit latrin for an average family of 7 persons who uses water for cleansing. The ground water table is below 5.0 m and the latrine is to serve the family for at least 4 years.

Solution: consider a dry pit. Hence $c = 0.06 \ m^3/p/yr$

we know, volume of pit, $V = 1.33 \times C \times P \times N$

$= 1.33 \times 0.06 \times 7 \times 4$

$= 2.2344 \ m^3$

As, concrete rings of 1.0 m diameter is used,

Hence, pit diameter should be of 1.0 m.

$\therefore$ cross sectional area, $A = \frac{\pi}{4} \times (1)^2 = 0.7854 \ m^2$

$\therefore$ depth of pit, $d = \frac{V}{A} = \frac{2.2344}{0.7854} = 2.845 \ m$

(say 2.9 m)

Excavate a pit of depth = 2.9 m

(Ans)

VIP Latrine

Example-2

Design a VIP latrine for a family of eight. The family uses water for anal cleansing. The ground water table is only 2.0 m below the ground surface.

Solution: consider a dry pit. Hence, $C = 0.06\ m^3/P/yr$

(i) single pit: N = 3 years. (assume)

volume of pit, $V = C \times P \times N$

$= (0.06 \times 8 \times 3)\ m^3$

$= 1.44\ m^3$

suitable pit dimension would be 1.0 m × 1.44 m, with a depth of 1.5 m including 0.5 m free space.

(1+0.5) → freespace

Thus the pit base is still 0.5 m above the ground water table, so the pit will remain dry.

(ii) Alternating twin pit:

if emptying cycle is three years,

then, $V = C \times P \times N$

$= (0.06 \times 8 \times 3) = 1.44\ m^3$

∴ Thus, the dimension of each pit would remain the same

i.e. 1.0m × 1.44m × 1.5m.

since, the pit bottom is very close to the ground water table, it is suggested that the pit bottom be sealed with a clay lining of 0.5 m.

ROEC Latrine

Example - 3.

A farmer excavated a pit measuring 1.5 m × 2.0 m × 2.5 m (depth) to use the excavated soil in the construction of an extra room for his son who is coming home after graduation from a college in town. Now he wants to convert this pit into a latrine to serve his family of six members for a long period. His son does not like to see excreta below while defecating. The water supply in the village is through handpump tubewells which means that the quantity of water avaiable for latrine use is limited. Further more the groundwater table is very low. Anal cleansing practice in the village is by using water. Design a suitable sanitary latrine to be built over the excavated pit.

Solution: The possible solutions satisfying the above conditions could be install offset pit pour flush or ROEC Latrine. The pour-flush require more water than ROEC latrine. Therefore ROEC type latrine is recommended.

Assume, a dry pit. Hence $C = 0.06\ m^3/P/year$

Keeping a provision of 0.5 m lining, the effective volume of pit, $V = \text{width} \times \text{length} \times \text{depth}$

$$= (1.5 - 0.5) \times (2.0 - 0.5) \times 2.5$$

$$= 3.75\ m^3$$

Hence, $3.75 = 1.33 \times C \times P \times N$

$\Rightarrow 3.75 = 1.33 \times 0.06 \times 6 \times N \Rightarrow N = 7.83$ years.

Hence, this latrine is satisfactory for about 8 years.

(Ans.)

2011

Pour Flush Latrine

Example-4

Design a leach pit for both single and alternating twin-off-set pit pour-flush latrines serving a family of eight members living in a peri-urban area. waste water flow is 12 lpcd and soil is a porous silty loam.

Solution:

(i) pit volume with respect to infiltration:

for porous silty loam, $I = 20$ l/m²day

Total waste water flow, $Q = (8 \times 12) = 96$ l/day

Area required for infiltration,

$$A_i = \frac{Q}{I} = \frac{96}{20} = 4.8 \text{ m}^2$$

Assume, a circular pit of dia. 1.2m

$$\therefore \text{volume} = \frac{A_i D}{4}$$

$$= \left(\frac{4.8 \times 1.2}{4}\right) = 1.44 \text{ m}^3$$

(ii) pit volume with respect to solid storage:

considering, solid accumulation rate, $C = 0.04$ m³/p/year.

and emtying interval, $N = 2$ years.

$$\therefore V_s = C \times P \times N = (0.04 \times 8 \times 2) = 0.64 \text{ m}^3$$

Single pit pour flush system:

The effective volume, $V = (V_i + V_s) = (1.44 + 0.64)$ m³

$= 2.08$ m³ say 2.25 m³

(contd)

consider, pit dia. = 1.2 m

∴ Area of pit = $\frac{\pi}{4} \times (1.2)^2 = 1.13\ m^2$

∴ pit depth, $h = \frac{V}{A} = \frac{2.25}{1.13} = 1.99\ m \simeq 2m$

Assuming free space of 0.5 m.

∴ Total pit depth = (2 + 0.5) = 2.5 m

design consideration is that pit depth should not exceed 1.8 m. Hence, considering pit of dia = 1.5 m

Then, $V_i = \frac{A_i D}{4} = \frac{4.8 \times 1.5}{4} = 1.8\ m^3$

∴ $V = (1.8 + 0.64) = 2.44\ m^3$

∴ pit depth, $h = \frac{2.44}{\frac{\pi}{4} \times 1.5^2} = 1.38\ m \simeq 1.4\ m$

providing 0.4 m free space,

Hence the total depth of pit = 1.8 m.

Alternating twin pit system:

As, $V_i > V_s$ Hence the effective volume for alternating twin pit system will be, $V = 1.44\ m^3$ for each pit

Assuming 1.2m dia. of each pit,

$d = \frac{1.44}{\frac{\pi}{4} \times 1.2^2} = 1.27m \simeq 1.3\ m$

considering 0.5 m free space, total depth of each pit = 1.8m

(Ans)

Exercise-13   2016, 2015, 2012

Design a leach pits for a twin offset pit pour-flush sanitation unit for a family of 8 members having a life period of 2 years. The average waste water flow rate is about 10 litres per person per day. The soil is porous silty loam with a long term infiltration rate of about

Solution:

(i) volume with respect to infiltration:

for porous silty loam, $I = 20 \ l/m^2\text{-day}$

Total waste water flow $= (10 \times 8) = 80 \ l/day$

$\therefore$ Area required, $A_i = \frac{Q}{I} = \frac{80}{20} = 4 \ m^2$

Assume,

a circular pit of dia. 1.5 m

$\therefore$ volume of pit $= \frac{A_i D}{4} = \frac{4 \times 1.5}{4} = 1.5 \ m^3$

(ii) volume with respect to solid storage:

considering, solid accumulation rate, $C = 0.04 \ m^3/p/year$ and

emptying period, $N = 2$ years.

Hence, pit volume, $V_s = C \times P \times N$

$= (0.04 \times 8 \times 2)$

$= 0.64 \ m^3$

Case-1: single pit pour flush.

Effective volume for single pit,

$V = V_i + V_s = (1.5 + 0.64) = 2.14\ m^3$

Assume a circular pit of dia 1.5 m.

$\therefore$ depth of pit, $h = \dfrac{2.14}{\frac{\pi}{4} \times 1.5^2} = 1.21\ m$ (say, 1.25 m)

Considering 0.5 m clear space, the total pit depth $= (1.25 + 0.5)$

$= 1.75\ m$

Case-2: Alternating twin pour flush.

As, $V_i > V_s$. Hence the effective volume for each pit

should be $1.5\ m^3$

Assume a circular pit of dia. 1.5 m.

$\therefore$ depth of pit $= \dfrac{1.5}{\frac{\pi}{4} \times 1.5^2} = 0.85\ m$ (say 0.9 m)

Assuming clear space of 0.5 m,

the total depth of each pit $= (0.9 + 0.5)$

$= 1.4\ m.$

(Ans)

Septic Tank

Example-5

Design a septic tank to serve a house hold of ten persons who produce 90 lpcd of waste water. The tank is to be desludged every three years.

Solution:

Sedimentation: Minimum Mean hydraulic retention time,

$$t_h = 1.5 - 0.3 \log (Pq)$$

$$= 1.5 - 0.3 \log (10 \times 90)$$

$$= 0.61 \text{ days}$$

The volume required for sedimentation,

$$V_h = 10^{-3} (Pq)\, t_h = 10^{-3} \times (10 \times 90) \times 0.61$$

$$\therefore V_h = 0.55 \text{ m}^3$$

Sludge digestion: Assume, $T = 25°C$

$$t_d = 30 \times (1.035)^{35-T} = 30 \times (1.035)^{35-25} = 42.32 \text{ days.}$$

volume required for sludge digestion,

$$V_d = 0.5 \times 10^{-3} \times P t_d = 0.5 \times 10^{-3} \times 10 \times 42.32 = 0.21 \text{ m}^3$$

Sludge storage: Assume, $C = 0.06$ m³/p/year as, $N < 5$ year

$$V_{sl} = CPN = 0.06 \times 10 \times 3 = 1.8 \text{ m}^3$$

overall effective tank volume,

$V = V_h + V_d + 1.4\, V_{s1}$

$= 0.55 + 0.21 + (1.4 \times 1.8)$

$= 3.28\ m^3$

Tank effective Depth:

Assume, cross sectional area, $A = 3.0\ m^2$

Max. depth of sludge, $d_{sl} = \frac{V_{s1}}{A} = \frac{1.8}{3} = 0.60\ m$

Max. submerged scum depth, $d_{ss} = \frac{0.4\, V_{sl}}{A} = \frac{0.4 \times 1.8}{3.0} = 0.24\,m$

Scum clear depth $= 0.075$ (minimum)

Sludge clear depth $= (0.82 - 0.26 \times A)$

$= (0.82 - 0.26 \times 0.3)$

$= 0.04\,m < 0.3\,m$

Hence, 0.3 m is adopted.

$\therefore$ total clear space depth $= (0.075 + 0.3) = 0.375\ m$

Depth for sedimentation $= \frac{V_h}{A} = \frac{0.55}{3} = 0.183\ m$
$< 0.375\ m$

$\therefore$ The total effective depth,

$d = (0.6 + 0.24 + 0.375) = 1.215\ m$

(say, 1.5 m)

The suitable dimensions of the tank can be chosen as:

1.0 m × 3.0 m × 1.5 m

Use a two-compartment septic tank with the first compartment volume of 3.0 m³ and the second compartment volume of 1.5 m³.

(1×2×1.5) (1×1×1.5)

Example-6

If the soil is sandy loam with a long term infiltration of about 30 l/m² day, Design a soakage pit for the disposal of effluent from the septic tank of previous example.

Solution: Effluent flow from septic tank $= (90 \times 10)$ l/day
$= 900$ l/day

Given, $I = 30$ litres/m² day

∴ Infiltration area required, $A = \frac{Q}{I} = \frac{900}{30} = 30 m^2$

Assuming, a 1.25 m diameter,

the effective depth of soakage pit,

$$d = \frac{3}{\pi \times 1.25} = 7.64 m \quad (\text{say}, 8 m)$$

However, if water table is high, two soakpits each of 1.25 m dia. and 4.0 m deep may be provided.

Exercise Question – 14 2014

Design a septic tank for a family of 10 persons with a desludging interval of 5 years. The average waste water flow is 15 litres per capita per day. Also design the soak pit for the disposal of the septic tank effluent. The soil is silty loam with a long term infiltration rate of 20 l/m²-day.

Solution:

Sedimentation: Minimum Mean hydraulic retention time,

$t_h = 1.5 - 0.3 \log (pq)$

$= 1.5 - 0.3 \log (10 \times 15) = 0.85$ days.

volume for sedimentation,

$V_h = 10^{-3} (pq) \times t_h$

$= 10^{-3} \times (10 \times 15) \times 0.85$

$= 0.13 \ m^3$

Sludge digestion: Assume, Design Temperature = 25°C

$t_d = 30 \times (1.035)^{35-T}$

$= 30 \times (1.035)^{35-25} = 42.32$ days.

∴ volume required for sludge digestion,

$V_d = 0.5 \times 10^{-3} P t_d$

$= (0.5 \times 10^{-3} \ 10 \times 42.32)$

$= 0.21 \ m^3$

<u>Sludge storage:</u> Assume; $C = 0.05\ m^3/p/year$ As, $N = 5$ years.
↓
equal ধরার avg.

[illegible] $= \frac{0.06 + 0.04}{2} = 0.05$

(Anupam Sir)

Volume, $V_{sl} = CPN$

$= 0.05 \times 10 \times 5$

$= 2.5\ m^3$

$\therefore$ Total tank effective volume, $V = (V_h + V_d + 1.4\ V_{sl})$

$= (0.13 + 0.21 + 1.4 \times 2.5)$

$= 3.84\ m^3$

<u>Tank effective depth:</u>

Assume cross sectional area, $A = 3\ m^2$

Max. depth of sludge, $d_{sl} = \frac{V_{sl}}{A} = \frac{2.5}{3} = 0.83\ m$

Max. depth of submerge scum, $d_{ss} = \frac{0.4\ V_{sl}}{A} = \frac{0.4 \times 2.5}{3}\ m$

$= 0.133\ m$

Scum clear ~~clear~~ depth $= 0.075$ (minimum)

Sludge clear depth $= 0.82 - 0.26\ A = 0.82 - 0.26 \times 3.0$

$= 0.04 < 0.3\ m$

$\therefore$ 0.3 m is adopted.

$\therefore$ Total clear space depth $= (0.3 + 0.075) = 0.375\ m$

depth for sedimentation, $d_h = \frac{V_h}{A} = \frac{0.13}{3} = 0.043\ m < 0.375\ m$

∴ Total effective depth = (0.83 + 0.33 + 0.375) m

= 1.535 m (Say 1.75 m)

∴ The suitable dimension can be (1.0 m × 3.0 m × 1.75 m)

Use a two compartment septic tank with the first compartment volume of [3.5 m³] and second compartment ~~of~~ volume of [1.75 m³].

→ (1 × 2 × 1.75)

(1 × 1 × 1.75)

Soak pit design:

Effluent flow from septic tank = (10 × 15)

= 150 l/day

Given, I = 20 l/m² day

∴ Area for infiltration, $A = \frac{Q}{I} = \frac{150}{20}$

$= 7.5\ m^2$

Assuming diameter of 1.25 m

∴ the effective depth of soakage pit

$d = \frac{7.5}{\pi \times 1.25} = 1.91\ m$ (Say, 2m)

∴ Adopt a soakage pit of ~~dia~~ 1.25 m dia. and 2.0 m deep.

Exercise-15 2016, 2015, 2013, 2012, 2010

A common septic tank is to designed for three adjoining houses with a total of 21 users. The average waste water flow rate is 180 litre/capita/day. Design a suitable septic tank and show only the dimension of the septic tank.

Solution:

Sedimentation: $t_h = 1.5 - 0.3 \log(21 \times 180) = 0.43$ days.

$V_h = 10^{-3}(Pq) \times t_h = 10^{-3} \times (21 \times 180) \times 0.43$

$\therefore V_h = 1.63 \ m^3$

Sludge digestion: $t_d = 30 \times 1.035^{35-T} = 30 \times (1.035)^{35-25}$ [Assume, $T = 25°C$]

$\therefore t_d = 42.32$ days.

$V_d = 0.5 \times 10^{-3} P t_d = (0.5 \times 10^{-3} \times 21 \times 42.32)$

$\therefore V_d = 0.44 \ m^3$

Sludge storage: Assume, $C = 0.06 \ m^3/P/year$ and $N = 4$ years.

$\therefore V_{s1} = CPN = (0.06 \times 21 \times 4) = 5.04 \ m^3$

$\therefore$ Total effective volume, $V = (1.63 + 0.44 + 1.4 \times 5.04)$

$= 9.13 \ m^3$

~~E64~~ Effective tank Depth:

Assume, cross sectional area of tank, $A = 3\ m^2$

$\therefore$ Max. sludge depth, $d_{sl} = \frac{V_{sl}}{A} = \frac{5.04}{3} = 1.68\ m$

Max. submerge scum depth, $d_{ss} = \frac{0.4 \times 5.04}{3} = 0.67\ m$

scum clear depth = 0.075 m (minimum)

Sludge clear depth = $(0.82 - 0.26 \times 3) = 0.04\ m < 0.3\ m$

Hence, 0.3 m is adopted.

$\therefore$ Total clear space depth = $(0.075 + 0.3) = 0.375\ m$

depth for sedimentation, $d_h = \frac{V_h}{A} = \frac{1.63}{3} = 0.54\ m > 0.375\ m$

Hence, 0.54 m depth is adopted.

$\therefore$ The total effective depth, $d = (1.68 + 0.67 + 0.54) = 2.89\ m$ (say 3m)

$\therefore$ The tank dimension may be, $(1m \times 3m \times 3m)$

Use two compartment septic tank.

First compartment volume = $6\ m^3$ $(1 \times 2 \times 3)$

second compartment volume = $3\ m^3$ $(1 \times 1 \times 3)$

(Ans.)