[1]Need for sanitation, methods of sewage disposal

Waste-water is essentially the water supply of community after it has been fouled by variety of users. Waste water may be defined as the combination of the liquid or water carrying waste removed from the residences, institutions, commercial and industrial establishments.

Waste-water Engineering is defined as the branch of the environmental engineering in which the basic principles of the science and engineering are applied for the problems of the water pollution control. The ultimate goal of the waste water management is the protection of the environment in a manner commensurate with the economic, social and political concerns.

Need for sanitation

Sanitation :

Sanitation refers to public health conditions related to clean drinking water and adequate treatment and disposal of human excreta and sewage. A sanitation system includes the capture, storage, transport, treatment and disposal or reuse of human excreta and wastewater.

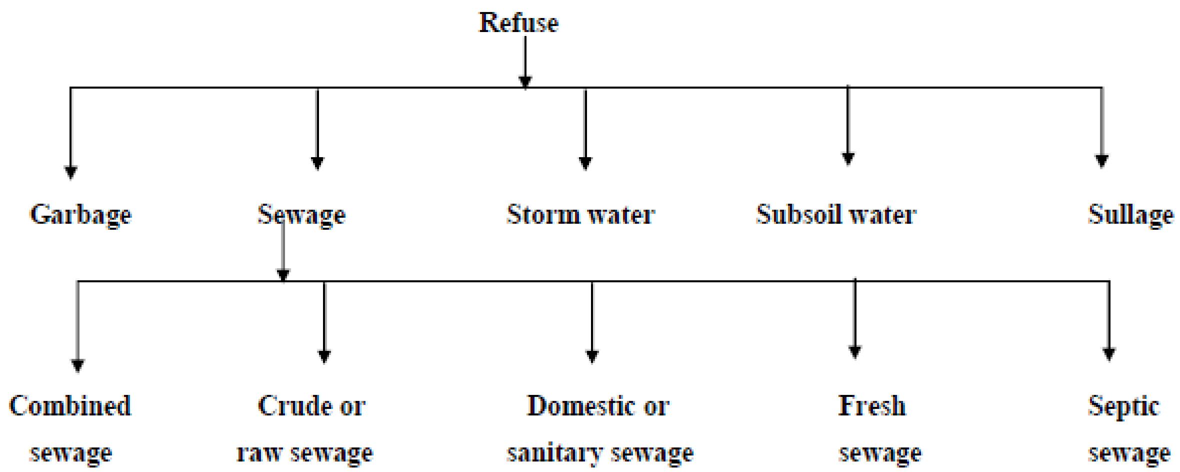
Necessity for Sanitation

In every town or a city, wastes of different types such as spent water from bathroom, kitchen, lavatory basins, house and street washings, from various industrial processes, semi liquid waste of human and animal excreta, dry refuse of house and street sweepings, etc., are produced daily.

If proper arrangement for the collection, treatment and disposal of these wastes produced from the town or city are not made, they will go on accumulating and create foul conditions that the safety of the structure such as buildings, roads will be in danger due to accumulation of spent water in their foundation. In addition to these, diseases causing bacteria will breed up in stagnant water and health of public will be in danger. Total insanitary conditions will be developed in town or city.

The necessity of sanitation is to maintain such environment as it will not affect the public health in general. Thus sanitation aims at the creation of such condition of living, which will not result into serious outbreak of epidemics. In other words it is a preventive measure for the preservation of health of community. Therefore, to overcome all these problems proper collection and treatment of sewage is required.

Definitions of some common terms used in the sanitary engineering



Refuse

The term 'refuse' is used to indicate what is rejected or left as worthless. For the study of sanitary engineering it is divided into five categories i.e. **garbage, storm water, subsoil water, sullage and sewage**

Garbage

The term garbage is used to indicate dry refuse and it includes decayed fruits, grass, leaves, paper pieces, vegetables etc.

Storm water

The term storm water is used to indicate the rain water of the locality.

Sub soil water

This indicates ground water which finds entry into sewer through leaks.

Sullage

The term sullage is used to indicate the waste water from bathrooms, kitchens, washing places, wash basins etc. It does not include discharge from lavatories, hospitals, slaughters houses etc., which has a high organic content.

Sewage

The term sewage is used to indicate the liquid waste from the community and it includes sullage, discharge from latrines, urinals, industrial waste and storm water.

i) ***Fresh sewage:*** The term used to indicate the sewage which has been recently originated or produced.

ii) ***Crude or raw sewage:*** This indicates the sewage that is not treated.

iii) ***Domestic or sanitary sewage:*** This indicates the sewage mainly derived from residential or business buildings or institutions.

iv) ***Combined swage:*** This includes the combination of sanitary sewage and storm water with or without industrial waste.

v) ***Septic sewage:*** This indicates the sewage which is undergoing the treatment process.

2. Methods of sewage disposal

METHODS OF SEWAGE DISPOSAL

Sewage Disposal

Aims and Objectives of sewage disposal

1. Proper disposal of human excreta to safe place, before it starts decompositions and may cause insanitary condition in the locality.

2. To takeout all kinds of waste water in the locality, immediately after its production, so that mosquitoes, flies, bacteria, etc., may not breed in it and cause nuisance.

3. Final disposal of sewage on land or in nearby water-courses after some treatment so that receiving land or water may not get polluted and safe for its further use.

4. In unsewered areas, the treatment of sewage from individual house should be done by septic tank or other suitable means, and the effluent should be disposed off.

5. If sewage is disposed off on the land, it should have such a degree of treatment that it may not affect the subsoil in any way.

6. To improve the aesthetic effect of the city or town.

7. For better land use pattern and also to build houses as compact units.

Methods of sewage Disposal

The solid and a liquid waste are to be properly collected and conveyed at suitable spots for treatment and disposal. The refuse formed in any sanitary system should be rapidly, conveniently and safely carried to its disposal site as to maintain a clean environment. Following are the two methods used for the collections and disposal of refuse of a locality.

1. Conservancy System

2. Water Carriage System

1. Conservancy System

This method is also called as "Dry System". This system is in practice from very ancient times. In this system, the waste products of society had been collected, carried and disposed off manually to a safe point of disposal by the sweepers

Various types of refuse and storm water are collected, conveyed and disposed off separately. Garbage is collected in dustbins placed along the roads from where it is conveyed by trucks ones or twice a day to the point of disposal. all the non combustible portion of garbage such as sand dust clay etc are used for filling the low level areas to reclaim land for the future development of the town. The combustible portion of the garbage is burnt.

Human excreta or night soil are collected separately in conservancy latrines. The liquid and semi liquid wastes are collected separately. After removal of night soil, it is taken outside the town in trucks and buried in trenches. After 2-3 years the buried night soil is converted into excellent manure. In conservancy system, the sullage and storm water are carried separately in closed drains to the point of disposal where they are allowed to mix with river water without treatment.

Merits

1. It is cheaper in initial cost because storm water can pass in open drains and conservancy latrines are much economical.

2. The quantity of sewage reaching disposal point is less.

3. The storm water goes in open drains; the sewer section will be small.

4. Night soil which is buried can be used as fertilizers after 2 to 3 years.

Demerits

1. For burying human excreta more space of land is required.

2. Building can't be designed as one compact unit because; latrines are to be provided away from the living room due to foul smell.

3. There is every possibility the liquid refuse may yet get an access in the sub-soil and pollute the ground water.

4. In the presence of conservancy system, the aesthetic appearance of the city cannot be increased.

5. Decomposition of sewage causes insanitary conditions which are dangerous to public health.

6. This system depends on the mercy of sweepers every time.

2. Water Carriage System

In this system, waste products are mixed up with sufficient quantity of water and are taken out of the city by properly designed sewer system where they are disposed off after necessary treatment in sanitary manners. The treated sewage effluents may be disposed off either in a running body of water such as streams or may be used for irrigating crops. The sewage so formed in water carriage system consists of 99.9% of water and remaining 0.1% of solid matter.

Merits

1. It is a hygienic method because all the excremental matters are collected and conveyed by water only and no human agency is employed for it.
2. In this system, the sewage is carried through underground pipes and these pipes do not occupy floor area on road sides or impair the beauty of the surroundings.
3. In multi storied Buildings where the water closets one above the other can be easily constructed and connected to a single vertical pipe.
4. Land required for disposal work is less as compared with conservancy system.
5. The usual water supply is sufficient and no additional water is required in water carriage system.
6. The system does not depend on manual labour at every time except when sewers are clogged.
7. Sewage after treatment can be used for various purposes.

Demerits

1. The system is very costly in initial stages.
2. The maintenance of this system is very costly.
3. During monsoon, large volume of sewage is to be treated, where as very small quantity is to be treated in the remaining period of year.

Comparison of conservancy and water-carriage system

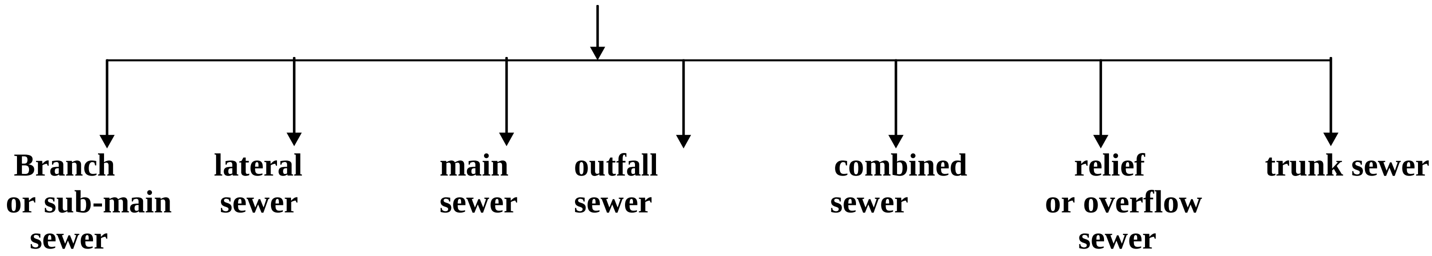
Conservancy System	Water-Carriage System
Very cheap in initial cost.	It involves high initial cost.
Due to foul smells from the latrines, they are to be constructed away from living room, so building cannot be constructed as compact units.	As there is no foul smell, latrines remain clean and neat and hence are constructed with rooms, therefore buildings may be compact.
The aesthetic appearance of the city cannot be improved	Good aesthetic appearance of city can be obtained.
For burial of excremental matter large area is required.	Less area is required as compared to conservancy system.
Excreta is not removed immediately hence its decomposition starts before removal, causing nuisance smell.	Excreta are removed immediately with water, no problem of foul smell or hygienic trouble.
This system is fully depended on human agency. In case of strike by the sweepers; there is danger of insanitary conditions in city, which may cause spreading of disease	As no human agency is involved in this system ,there is no such problem as in case of conservancy system
As sewage is disposed of without any treatment, it may pollute the natural water courses	Sewage is treated upto required degree of

	sanitation

3. Types of sewerage systems

Sewerage System
The entire system of collecting, carrying &disposal of sewage through sewers is known as sewerage system.

Sewer



Components of Sewerage System

Sewer
The underground conduits or drains through which sewage is conveyed to a point of discharge or disposal are known as sewers.
Followings are the types of sewers used in collection of sewage
Lateral Sewer: The sewer obtaining its discharge directly from buildings is known as lateral sewer.
Branch or sub-main sewers: The sewer which obtains its discharge from relatively small area, few laterals and delivers into main sewer is known as Branch sewer.
Main Sewer: The sewer which obtains its discharge from a few branches or sub-main sewer in known as main sewer.
Trunk Sewer**:** The sewer which obtains its discharge from two or more main sewer is known as trunk sewer.
Outfall sewer: The sewer which transport sewage to the point of treatment.
Combined sewer**:** The sewer which carries domestic sewage and storm water in known as combined sewer.
Relief or overflow sewer**:** The sewer which is meant to carry the excess discharge from an existing sewer

Classification of Sewerage System
1. Combined system

2. Separate System

3. Partially separate system

Combined System
When only one set of sewer is laid carrying both the sanitary sewage and the storm water is called as combined system. Sewage and storm water both are carried to the treatment plant through combined sewers.
Merits
1. Size of the sewers being large, chocking problems are less and easy to clean.
2. House plumbing can be done easily and it proves economical as one set of sewers are laid.

3. Because of dilution of sanitary sewage with storm water nuisance potential is reduced and can be easily and economically treated.

Demerits

1. Size of the sewers being large, difficulty in handling and transportation.
2. Load on treatment plant is unnecessarily increased.
3. It is uneconomical if pumping is needed because of large amount of combined flow.
4. Unnecessarily storm water is polluted.

Suitable conditions for combined system

1. Rainfall in even throughout the year.
2. Both the sanitary sewage and the storm water have to be pumped.
3. The area to be sewered is heavily built up and space for laying two sets of pipes is not available.
4. Where Effective or quicker flows have to be provided.

Separate System

In this system, two sets of sewers are laid .The sanitary sewage is carried through one set of sewers called sanitary sewers, while the storm water is carried through another set of conduits called drains. The sewage is carried to the treatment plant and storm water is directly discharged into the river or streams for disposal

Merits

1. Size of the sewers is small.
2. Sewage load on treatment unit is less.
3. Rivers or streams are not polluted.
4. Storm water can be discharged into rivers without any treatment.

Demerits

1. Sewers being small, cleaning is difficult.
2. Frequent choking problem will be there.
3. System proves costly as it involves two sets of sewers.
4. The use of storm sewer is only partial because during non-monsoon seasons, they will be idle and forms the dumping places for garbage and rubbish and may get clogged.

Suitable conditions for separate sewerage systems

1. Where rainfall is uneven.
2. Where sanitary sewage is to be pumped.
3. The drainage area is steep, allowing to runoff quickly.
4. Sewers are to be constructed in rocky strata. The large combined sewers would be more expensive.

Partially Combined or Partially Separate System

Sometimes a part of storm waters especially that originating from the roofs or paved courtyards of buildings, is allowed to be admitted into the sewers and similarly, the domestic sewage is allowed to be admitted into the drainage. The resulting system is called as partially separate or partially combined system.

Merit

1. The sizes of sewers are not very large as some portion of storm water is carried through open drains.
2. Combines the advantages of both the previous systems.
3. Silting problem is completely eliminated.

Demerit

1. The cost of pumping is increased at the disposal point than separate system because a portion of storm water is mixed with sanitary sewage.
2. During dry weather, the velocity of flow may be low.
3. The storm water is unnecessary put load on to the treatment plants.
4. Pumping of storm water in unnecessary over-load on the pumps.

Comparison of Separate and Combined System

Separate system	Combined System
The quantity of sewage to be treated is less, because no treatment of storm water is done.	As the treatments of both are done, the treatment is costly
In the cities of more intensity of rainfall, this system is more suitable.	In the cities of less intensity of rainfall, this system is suitable.
As two sets of sewer lines are to laid, this system is cheaper because sewage is carried in underground sewers and storm water in open drains.	Overall construction cost is higher than separate system.
In narrow streets, it is difficult to use this system.	It is more suitable in narrow streets.
Less degree of sanitation is achieved in this system, as storm water is disposed without anytreatment.	High degree of sanitation is achieved in this system .

4. Dry weather flow, Wet weather flow

Sewer appurtenances: Manholes, catch basins, oil and grease traps. P, Q and S traps. Material of sewers, shape of sewers, laying and testing of sewers, ventilation of sewers basic principles of house drainage.

Quantity of Sewage

In order to find out the suitable section for the sewer, it is necessary to determine the quantity of sewage that will flow through the sewer.
1. Sanitary sewage or Dry Weather Flow [D.W.F]

2. Storm water or Wet Weather Flow [W.W.F]

Dry Weather Flow (DWF): Domestic sewage and industrial sewage collectively called as DWF. It does not contain storm water. It indicates the normal flow during dry season of the year.

Dry Weather Flow (DWF)

Sanitary sewage is mostly the spent water of the community into sewer system with some groundwater and a fraction of the storm runoff from the area, draining into it.

Sanitary sewage is also called as the Dry Weather Flow (D.W.F), which includes the domestic sewage obtained from residences and industries etc., and the industrial sewage or trade waste coming from manufacturing units and other concerns. Dry Weather Flow (D.W.F) is the quantity of water that flows through sewer in dry weather when no storm water is in the sewer.

Source of Sanitary sewage

1) Water supplied to the public for domestic purpose by local authorities.

1. Water supplied to various industries for various industrial processes by local authorities.
2. Water supplied by local authority to various public places such as schools, hostels, Railway stationsetc.
3. Water drawn from well by individual houses for the domestic purpose.
4. Water drawn from lakes, wells, canals by industries for their purpose.
5. Infiltration of ground water into sewer through leaky joints.
6. Unauthorized entrance of storm water during rainy season into the sewer line.

5. Factors effecting dry and wet weather flow on design of sewerage system

Factors Affecting sanitary sewage

1) Population
2) Rate of water supply.
3) Type of area served (Industrial, Commercial, Etc…)
4) Ground water infiltration and exfiltration

1.Population: The quantity of sanitary sewage or DWF directly depends on the population at the end of the design period. As the population increases, the quantity of sanitary sewage also increases. The quantity of water supply is equal to the rate of water supply multiplied by the population. There are several methods used for forecasting the population of a community.

2.Rate of water supply: The quantity of wastewater discharged into a sewer system is less than the amount of water supplied to the community. This is because of losses due to leakage from pipes, lawn sprinkling and manufacturing process etc. hence the rate of consumption of both public as well as private supplies must be taken into account. In estimation of quantity of sewage, the anticipated rate of water consumption at the end of the design period must also be studied

3.**Type of area to be served:** Quantity of sanitary sewage depends upon the type of area such as Residential, industrial or Commercial. The quantity of sewage produced in residential area directly depends on the quantity of water supply to that area. This type of sewage is generally expressed as litres per capita perday.

Quantity of sewage produced by an industrial area varies from industry to industry depending upon their various industrial processes. Quantity of sewage from public and commercial places can be determined by studying the development of such area. The rate of flow of sewage in such areas is expressed in liters per day per sq. meter of area

4. Groundwater infiltration and exfiltration:

i. Infiltration: In case of sewers which are laid below ground water table and in water clogged areas, an allowance should be made for the water entering the sewers through leaky joints. Infiltration represents a slow response process resulting in increased flows mainly due to seasonally-elevated groundwater entering the drainage system, and primarily occurring through defects in the pipe network. The quantity of ground water infiltration depends upon the following factors such as the nature of soil,, materials of sewers, number and conditions of sewer joints, depth of the sewer below ground water table etc

The recommended quantity of ground water infiltration in case of sewers below ground water table is as follows

a) 250-500 L/day/man-hole

b) 500-50,000 L/day/hectare of drainage area

c) 500-5000 L/day/km length of sewer/cm diameter of sewer

ii. **Exfiltration**: represents losses from the sewer pipe, resulting in reduced conveyance flows and is due to leaks from defects in the sewer pipe walls as well as overflow discharge into manholes, chambers and connecting surface water pipes. The physical defects are due to a combination of factors including poor construction and pipe joint fittings, root penetration, illicit connections, biochemical corrosion, soil conditions and traffic loadings as well as aggressive groundwater.

Exfiltration losses are much less obvious and modest than infiltration gains, and are therefore much more difficult to identify and quantify. However, being dispersed in terms of their spatial distribution in the sewer pipe, exfiltration losses can have potentially significant risks for groundwater quality.

6 Estimation of storm water flow

Estimate of Sanitary Sewage (DWF):

Sanitary sewage is mostly the spent water of the community into sewer system with some groundwater and a fraction of the storm runoff from the area, draining into it. Before designing the sewerage system, it is essential to know the quantity of sewage that will flow through the sewer.

Quantity of Sewage:-

It is usual to assume that the rate of sewage flow, including a moderate allowance for infiltration equals to average rate of water consumption which is 135 litre/ head /day according to Indian Standards. It varies widely depending on size of the town etc. this quantity is known as Dry Weather Flow (D.W.F). It is the quantity of water that flows through sewer in dry weather when no storm water is in the sewer.

Rate of flow varies throughout 24 hours and is usually the greatest in the fore-noon and very small from midnight to early morning. For determining the size of sewer, the maximum flow should be taken as three times the D.W.F.

Design Discharge of Sanitary Sewage

The total quantity of sewage generated per day is estimated as product of forecasted population at the end of design period considering per capita sewage generation and appropriate peak factor. The per capita sewage generation can be considered as 75 to 80% of the per capita water supplied per day. The increase in population also result in increase in per capita water demand and hence, per capita production of sewage. This increase in water demand occurs due to increase in living standards, betterment in economical condition, changes in habit of people, and enhanced demand for public utilities.

Wet Weather Flow (WWF): Domestic sewage, industrial sewage and storm water collectively called as WWF. It indicates the maximum flow of sewage during wet season.

Estimate of quantity of storm water (WWF):-

Generally there are two methods by which the quantity of storm water is calculated:
1. Rational method
2. Empirical formulae method

In both the above methods, the quantity of storm water is a function of the area, the intensity of rainfall and the co-efficient of runoff.

Rational method:-
Runoff from an area can be determined by the Rational Method. The method gives a reasonable estimate up to a maximum area of 50 ha (0.5 Km2).

The rational method makes the following assumptions:

- Precipitation is uniform over the entire basin.
- Precipitation does not vary with time or space.
- Storm duration is equal to the time of concentration.
- A design storm of a specified frequency produces a design flood of the same frequency.
- The basin area increases roughly in proportion to increases in length.
- The time of concentration is relatively short and independent of storm intensity.
- The runoff coefficient does not vary with storm intensity or antecedent soil moisture.
- Runoff is dominated by overland flow.
- Basin storage effects are negligible.

This method is mostly used in determining the quantity of storm water. The storm water quantity is determined by the rational formula:

$$Q = \frac{C.i.A}{360}$$

Where,
Q= quantity of storm water in m3/sec
C= coefficient of runoff
i= intensity of rainfall
A= area of drainage in hectare

Runoff coefficient:-

In rational method, the value of runoff coefficient, C is required. The whole quantity of rain water that fall over the ground does not reach the sewer line. A portion of it percolates in the ground, a portion evaporates, a portion is stored in ponds and ditches and only remaining portion of rainwater reaches the sewer line. The runoff coefficient depends mainly on characteristics of ground surface as porosity, wetness, ground cover etc., which varies from 0.01 for forest or wooded area to 0.95 for a water tight roof surfaces.

As every locality consists of different types of surface area, therefore for calculating the overall runoff coefficient the following formula is used:

Runoff coefficient (overall)

$$C = \frac{A_1C_1 + A_2C_2 + A_3C_3 + \cdots + A_nC_n}{A_1 + A_2 + A_3 + \cdots + A_n}$$

Where:
 A1, A2 ,A3….are different types of area and
 C1, C2, C3…..are their runoff coefficient respectively.

Empirical formula for rainfall intensities:-

The empirical formula given by British Ministry of Health is given by:

$i = \frac{760}{t+10}$ (for storm durations of 5-20 min)

$i = \frac{1020}{t+10}$ (for storm durations of 20-100 min)

where;
i = intensity of rainfall in mm/hour
t = duration of storm in minutes

Empirical formula method:-

For determining the runoff from very large areas, generally empirical formulae are used.
All the empirical formulae are applicable only under certain specific conditions such as slope of land, imperviousness, rate of rainfall etc.

1. Mc maths formula:

$$Q = \frac{C.i.A}{148.35}\sqrt[5]{\frac{S}{A}}$$

2. Burki-Zeiglar formula:

$$Q = \frac{C.i.A}{141.58}\sqrt[4]{\frac{S}{A}}$$

3. Fuller's formula:

$$Q = \frac{C.M^{0.8}}{13.23}$$

4. Talbot's formula:

$$Q = 22.4M^{1/4}$$

5. Fanning's formula:

$$Q = 12.8M^{5/8}$$

Where:
Q= runoff in m^3/sec
C= coefficient of runoff
i = intensity of rainfall in cm/hour
S = slope of area in metre per thousand metre
A = area of drainage in hectares
M = area of drainage in square km

7.Time of concentration flow, numerical.

Time of concentration of flow:

The time taken for the maximum runoff rate to develop, is known as the time of concentration, and is equal to the time required for a drop of water to run from the farthest point of the watershed to the point for which the runoff is to be calculated.

The time of concentration, tc, of a watershed is often defined to be the time required for a parcel of runoff to travel from the most hydraulically distant part of a watershed to the outlet.

It is not possible to point to a particular point on a watershed and say, the time of concentration is measured from this point. Neither is it possible to measure the time of concentration. Instead, the concept of tc is useful for describing the time response of a watershed to a driving impulse, namely that of watershed runoff.

In the context of the rational method then, tc represents the time at which all areas of the watershed that will contribute runoff are just contributing runoff to the outlet. That is, at tc,
the watershed is fully contributing. We choose to use this time to select the rainfall intensity for application of the rational method. If the chosen storm duration is larger than tc, then the rainfall intensity will be less than that at tc. Therefore, the peak discharge estimated using the rational method will be less than the optimal value. If the chosen storm duration is less than tc, then the watershed is not fully contributing runoff to the outlet for that storm length, and the optimal value will not be realized. Therefore, we choose the storm length to be equal to tc for use in estimating peak discharges using the rational method.

The time of concentration refers to the time at which the whole area just contributes runoff to a point.

$$\mathbf{t_c = t_e + t_f}$$

Where,
tc = time of concentration
te = time of entry to the inlet (usually taken as 5 – 10 min)
tf = time of flow in the sewer

Time of concentration is made up of inlet time (over land flow) and channel flow time (time of flow).
Time of entry (inlet time or overland flow): is the time required for water to reach a defined channel such as a street gutter, plus the gutter flow time to the inlet.

Channel flow time: is the time of flow through the sewers to the point at which rate of flow is being assessed. The channel flow time can be estimated with reasonable accuracy from the hydraulic characteristics of the sewer. The channel flow time is then determined as the flow length divided by the average velocity.

The inlet time is affected by numerous factors, such as rainfall intensity, surface slope, surface roughness, flow distance, infiltration capacity, and depression storage. Because of this, accurate values are difficult to obtain. Design inlet flow times

1 Calculate the diameter and discharge in a sewer of circular sewer laid at a gradient of 1 in 500 when running half full. With the velocity of 2 m/sec. Use Mannings formula taking N=0.012

$$d = 0.5\,D \text{ and } \theta = 180°$$

$$\therefore \quad a = \frac{1}{2} \times \frac{\pi}{4} D^2 = \frac{\pi}{8} D^2$$

$$p = \pi D \frac{\theta}{360°} = \pi D \frac{180}{360} = \frac{\pi D}{2}$$

and $$r = \frac{\pi}{8} D^2 \times \frac{2}{\pi D} = \frac{D}{4}$$

Now $$v = \frac{1}{N} r^{2/3} s^{1/2}$$

$$\therefore \quad 2 = \frac{1}{0.012} \left(\frac{D}{4}\right)^{2/3} \left(\frac{1}{500}\right)^{1/2} = 1.4789\, D^{2/3}$$

From which $D = 1.573$ **m**

Hence $$Q = a \times v = \frac{\pi}{8} (1.573)^2 \times 2$$

$$= 1.942 \text{ cumecs}$$

2. Define BOD and Explain with a neat sketch, the salient features of oxygen sag curve

Biochemical oxygen demand or B.O.D. is the amount of dissolved oxygen needed by aerobic biological organisms in a body of water or wastewater sample to break down organic material present in a given water or wastewater sample at certain temperature (200C) over a specific time period (5 days).

Oxygen Sag Curve:

The oxygen sag or oxygen deficit in the stream at any point of time during self purification process is the difference between the saturation DO content and actual DO content at that time.

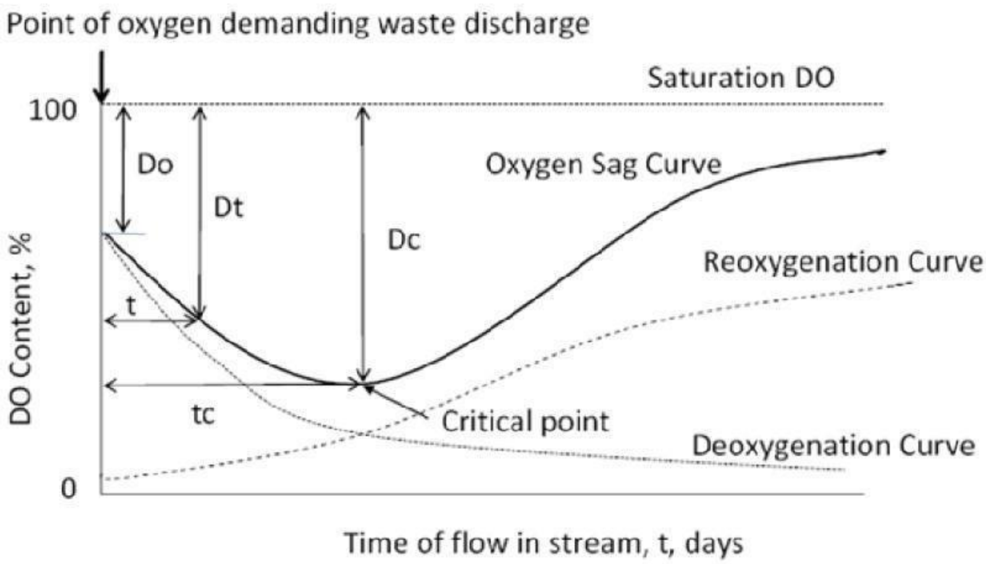
OR

The amount of resultant oxygen deflect can be obtained by algebraically adding the de - oxygenation and re -oxygenation curves. The resultant curve so obtained is called oxygen sag curve

Oxygen Deficit, D = Saturation DO – Actual DO

The saturation DO value for fresh water depends upon the temperature and total dissolved salts present in it and its value varies from 14.62 mg/L at 0oC to 7.63 mg/L at 30ºC, and lower DO at higher temperatures.

The DO in the stream may not be at saturation level and there may be initial oxygen deficit (D). At this stage, when the effluent with initial BOD load Lo, is discharged in to stream, the DO content of the stream starts depleting and the oxygen deficit (D) increases. The variation of oxygen deficit (D) with the distance along the stream, and hence with the time of flow from the point of pollution is depicted by the Oxygen Sag Curve. The major point in sag analysis is point of minimum DO, i.e., maximum deficit. The maximum or critical deficit (Dc) occurs at the inflexion points (as shown in fig) of the oxygen sag curve.



Deoxygenation, reoxygenation and oxygen sag curve

De-oxygenation curve: The curve which represents (or) showing the depletion of D.O with time at the given temperature

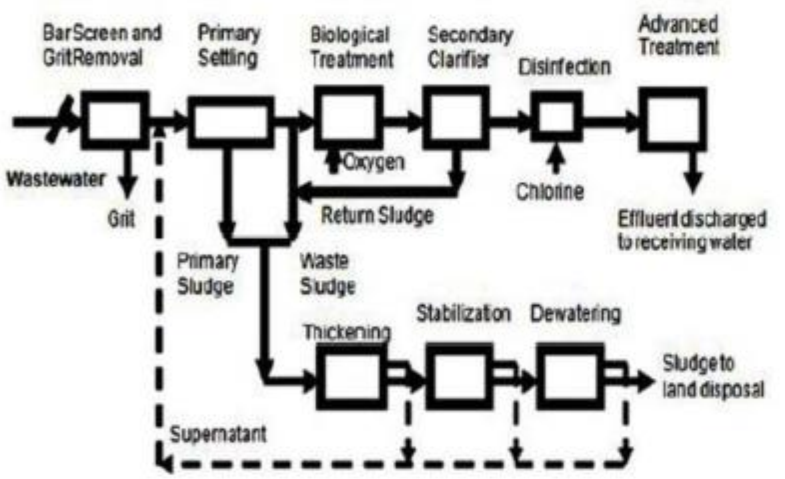
Re-oxygenation Curve: In order to counter balance the consumption of D.O due to the de – oxygenation, atmosphere supplies oxygen to the water and the process is called the re – oxygenation.

When wastewater is discharged in to the stream, the DO level in the stream goes on depleting. This depletion of DO content is known as de-oxygenation. The rate of de- oxygenation depends upon the amount of organic matter remaining (Lt), to be oxidized at any time t, as well as temperature (T) at which reaction occurs. The variation of depletion of DO content of the stream with time is depicted by the de-oxygenation curve in the absence of aeration. The ordinates below the de-oxygenation curve indicate the oxygen remaining in the natural stream after satisfying the bio-chemical demand of oxygen. When the DO content of the stream is gradually consumed due to BOD load, atmosphere supplies oxygen continuously to the water, through the process of re-aeration or re-oxygenation, i.e., along with de-oxygenation, re-aeration is continuous process.

3. Draw and explain briefly the flow Diagram of Municipal waste water treatment plant with their operation units

Flow diagram of Municipal wastewater treatment plant

The influent or wastewater collected from residences or industries are first subjected to **Screening** process to remove the floating matters present in the sewage. The water which comes out of screening tanks is passed through the **Grit chambers** or **Detritus tanks** to remove the grits or sand particles. Then effluent which comes out of grit chamber is subjected to **Primary Sedimentation tanks** in order to remove the large suspended organic solids which is achieved by settling process where water is allowed to flow in slower rate, then heavy denser particles settles down at the bottom of the tank. The settled organic particles at the bottom of the primary sedimentation tanks is called **primary sludge.** The effluent which comes out of the primary settling tank is subjected to **Biological treatment or Secondary treatment** where, decomposition of organic matter takes place by aerobic bacteria with the supply of oxygen. Then stabilized organic particles along with the water is passed through the **Secondary clarifier** where the stabilized organic particles settles at the bottom of the tank. The sludge which is settled at the bottom of the tank is again recirculated back and mixed with effluent which comes of primary sedimentation tank which is part of **Activated Sludge Process** and remaining sludge is mixed with primary sludge and then subjected to **Sludge digestion process**. In sludge digestion process, wastewater is first subjected to **Thickening**, where number of solid sludge particles are increased by separating from liquid. The liquid which rests over the solid sludge particles are removed out is called as supernatant. The solid sludge which consists of moisture content is removed out in



Dewatering process. The dry form of sludge is used as manure for improving the fertility of soil. The effluent which comes out of secondary clarifier is fed into disinfection tank where chlorine is added to the wastewater to kill germs and pathogenic bacteria's present in the water. Then water which comes out of disinfection tank containing germs are removed out in final or advanced or tertiary treatment process after that, the water can be directly discharged to nearby water courses.

Treatment process as a whole classified into 4 types

1) Priliminary treatment process
2) Primary treatment process
3) Secondary or Biological treatment process
4) Tertiary or final or advanced treatment process

Preliminary treatment process:

This treatment process consists of separating the floating materials like dead animals, tree branches, papers, pieces of rags or wood etc., present in the sewage and also to remove heavy settable inorganic solids. This process also helps in removing oil and grease particles present in the sewage. This process reduces the BOD of wastewater by about 15 to 30%.

The units used in preliminary process are

a) **Screening** - For removal of floating matters like papers, rags, pieces of clothes etc.
b) **Grit chambers or Detritus tank** – For removal of grits and sand particles.
c) **Skimming tanks –** For removal of oil and grease particles present in the sewage.

Primary treatment process: This treatment process consists of removing large suspended organic solids. This is usually achieved by **sedimentation process**. The liquid effluent from primary treatment process consists of large amount of suspended organic matters having BOD of 60% of original. The organic solids which are separated out in the sedimentation tank are often stabilized by anaerobic decomposition in a digestion tank. This residue is used for landfills or soil conditioners.

Secondary treatment process: This treatment process further treats the effluent which is coming out from primary sedimentation tanks. This treatment process is achieved by biological decomposition of organic matter which can be carried out either under aerobic or anaerobic condition.

Treatment process in which organic matter is decomposed by aerobic bacteria is called aerobic decomposition. Units which are used in this treatment process are

Filters – Interment sand filters as well as trickling filters. Intermittent sand filters are used for treatment of wastewater by attaching microorganisms to the filter medium and treated water is collected in the underdrains at the bottom of sand filter and is transported to a line for further treatment or disposal. Trickling filters are used to remove organic matter from wastewater. Trickling filter is an aerobic treatment system that utilizes microorganisms attached to the medium to remove organic matter from wastewater.

Aeration tanks – Wastewater is is mixed with microbes in the aeration tank and oxygen is supplied. Microbes consume that supplied oxygen and decomposes the organic matter present in the wastewater and thus water is cleaned.

Oxidation ponds – Oxidation ponds are also known as stabilization ponds or lagoons. Within an oxidation pond heterotropic bacteria degrade organic matter in the sewage which results in production of cellular material and minerals. The production of these supports the growth of algae in the oxidation pond.

Aerated lagoons: Aerated lagoons or aerated basins is a holding and treatment pond provided with artificial aeration to promote the biological decomposition of wastewater. Treatment process in which organic matter is decomposed anaerobic bacteria is called **anaerobic decomposition**. Units which are used in this treatment process are,

a) **Anaerobic lagoons**: These are also called as manure lagoon which are manmade earthen basins filled with animal waste that undergoes anaerobic decomposition and it will be converted into excellent manures.

b) **Septic tanks**: These are water-tight box made of concrete or fiber glass to separate solids and liquids by settling process. Tanks are used for reception and processing of sewage which is achieved by sedimentation along with anaerobic sludge digestion. The effluent from the secondary biological treatment will usually contain a little BOD of 5 to 10% of original

Final or Advanced or Tertiary treatment process: This process removes remaining organic load after secondary treatment and to kill pathogenic bacteria present in the sewage and this achieved by chlorination

Tertiary Treatment

Tertiary treatment or advanced waste water treatment includes operation and process used to remove organic load left after the secondary treatment and in particular to kill the pathogenic bacteria. It is normally carried out by chlorination.

Tertiary treatment may be aimed at the reuse of wastewater. The common processes that are used in this treatment are:

i. Removal of refractory organisms through adsorption.

ii. Removal of dissolved inorganic substances through chemical precipitation, ion recharge, reverses osmosis, electro dialysis, membrane filtration process and distillation, nutrient removal such as nitrogen and phosphorus etc

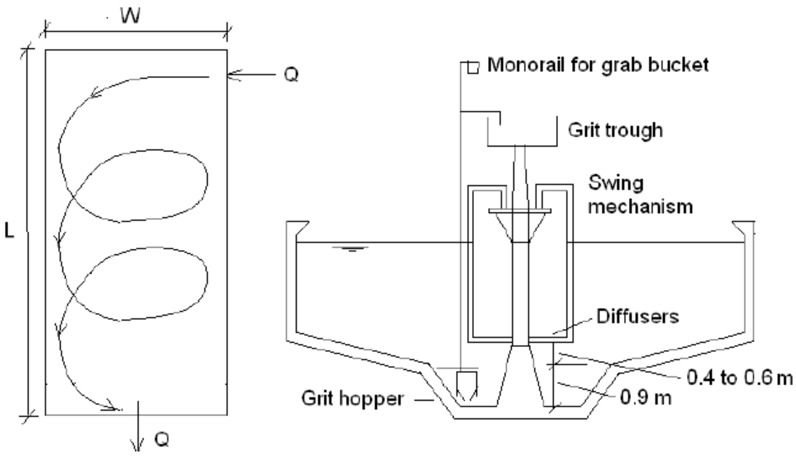
4. Draw a neat diagram and explain grit chamber and skimming tank

Grit chambers: Grit includes sand and other heavy matters which are inert inorganic such as metal fragments, rags etc. If not removed in preliminary treatments, grit in primary settling tank can cause abnormal abrasive wear and tear on mechanical equipment and sludge pumps, can clog by deposition and can accumulate in sludge holding tanks and digesters. Therefore grit removal is necessary to protect the moving mechanical equipment and pump elements from abrasion. Grit removal devices depends upon the differences in specific gravity between organic and inorganic solids to affect their separation.

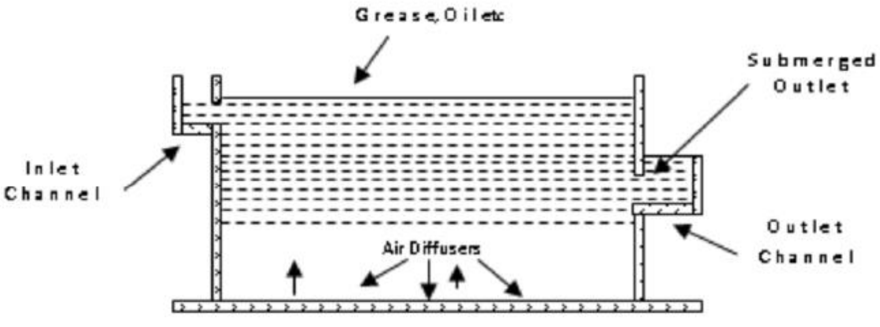
Types of Grit chambers:

Grit chambers are of two types, mechanically cleaned and manually cleaned. Mechanically cleaned grit chambers are provided with mechanical equipment for collection and washing of grit chambers, which are operated either on a continuous or intermittent basis. Manually operated grit chambers should have sufficient capacity for storage of grits between the intervals of cleaning.

Aerated Grit chambers: An aerated grit chamber is a special form of grit chamber consisting of a standard spiral flow aeration tank provided with air diffusion tubes placed at one end of the tank at about 0.6 to 1m from the bottom. The heavier grit particles with their higher settling velocities drop down to the floor, where as lighter organic particles will remain in suspension and carried with the roll of spiral motion due to the diffused air and eventually carried out of the tank.



Skimming tank: Skimming tanks are narrow rectangular tanks having at least two longitudinal baffle walls interconnected. They are used to remove grease and fatty oils from sewage. Air diffusors are provided at the bottom of the tank. Compressed air applied at the rate varying from 300 to 6000m3/million liters of sewage agitates the sewage, which prevents settling of solids. Air tends to change the oil and grease to a soapy mixture. This mixture is carried to the surface by the air bubbles, sum of which are entrained in it and may be skimmed off.



Skimming Tank

5. Define Deoxygenation constant. Determine the 1 day BOD and ultimate first stage BOD for a wastewater whose 5 day 20^o C BOD is 200 mg/L. The reaction rate constant k (base e) = 0.23 per day

When wastewater is discharged in to the stream, the DO level in the stream goes on depleting. This depletion of DO content is known as de-oxygenation

5b) Sol:- Given :- $t = 5$ days

$T = 20°C$.

$BOD = 200 mg/l$

$K(e) = 0.23/day$.

$BOD_5 = y_5 = L_0 - L_5$

$y_5 = L_0(1 - e^{-Kt})$.

$200 = L_0(1 - e^{-0.23\times5})$

$$L_0 = \frac{200}{1 - e^{-0.23\times5}}$$

$\Rightarrow L_0 = 292.67 \ mg/l$ //.

for a 1 day BOD, Here $K = 0.23$, $t = 1$.

$y_t = L_0 - L_t$, $y_t = L_0(1 - e^{-Kt})$

$y_1 = L_0(1 - e^{-0.23\times1})$

$y_1 = 292.67(1 - e^{-0.23})$

$y_1 = 60.13 \ mg/l$ //.

Here, 1 Day BOD i.e $y_1 = 60.13 mg/l$

The ultimate first stage BOD $= L_0 = 292.67 mg/l$