KIIT POLYTECHNIC

LECTURE NOTES

ON

WATER SUPPLY

&

WASTE WATER ENGINNERING

Compiled by

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Chapter-1

Quantity of water

Q. What is water demand? (2marks)

Ans: Water demand is defined as the amount of water in liter required by a person per day.

Q. What do you mean by LPCD? (2marks)

Ans: lpcd means litre per capita demand.

Q. Define fire demand. (2marks)

Ans. The water demand which is required for the purpose of fire break is called fire demand.
A huge amount of water is required for this purpose for which the provision is made in the water work to supply sufficient quantity of water.

Q. Write down the methods of population forecasting. (2marks)

Ans: Following are the various methods of population forecasting.

1) Arithmetical increase method.
2) Geometrical increase method.
3) Incremental increase method.
4) Decrease rate of growth method.
5) Graphical method.
6) Comparative method.
7) Zoning method.
8) Ratio and correlation method.
9) Logistic curved method.

Q. What are the various factors affecting rate of demand? (2marks)

Ans: Following are the various factors affecting per capita demand.

1. Size of city
2. Climatic condition
3. Habit of people
4. Industrial and commercial activity
5. Quality of water supply
6. Pressure in the distribution system
7. Development of sewerage facility
8. System of supply
9. Cost of water
10. Policy of metering and method of charging

Q. What is per capita demand? (2marks)

Ans: It is defined as the total quantity of water required by a person per year in liters.

$$\text{Per capita demand} = \frac{\text{Total quantity of water required (liter)}}{\text{Design population}} \times 365$$

Q. Explain the types of water demand. (7marks)

Ans: There are mainly 5 types of water demand in a city.

1. Domestic water demand
2. Commercial and industrial water demand.
3. Public demand.
4. Fire demand.
5. Compensate losses.

1. Domestic water demand:-

- It includes water required in houses for drinking, cooking, bathing, washing, and gardening etc.
- It also includes the requirement of water for domestic animal.
- These demands mainly depend on the habits, social status, climatic condition and customs of people.
- In India this demand is about 135 liter per day per capita and in developed countries, it is very high.
- The detail of domestic consumption is as given follows.

Drinking – 5 liter
Cooking – 5 liter
Bathing – 55 liter
Cloth washing – 20 liter
Utensil washing – 10 liter
Flushing of water closet – 30 liter
House washing – 10 liter

Total =135 liter per day per capita.

2. Commercial and Industrial water demand:-

- Commercial demand includes the water demand in commercial centers like office, hotels, restaurant, shopping center, cinema houses, health center, laundries, dairies etc.
- This demand is also assumed as 25-45 liter per capita per day.
- The industrial water demand depends upon the types of industry like cloth mill, paper mill, cotton mill, sugar mill, chemical industries etc.
- These demands are generally assumed as 20-25 percent of the total water demand of the city.

3. Public demand:-

- It includes the water requirement for public places such as sanitary units, parks, swimming pool, washing and sprinkling on roads etc.
- This demand is considered as 5 percent of total demand of water in the city.

4. Fire demand:-

- The water demand which is required for the purpose of fire break is called fire demand.
- A huge amount of water is required for this purpose for which the provision is made in the water work to supply sufficient quantity of water.
- The water required for fire demand is calculated by the following formulae.

a) Buston's formula
$$Q=5663\sqrt{P}$$
b) Kuichling's Formula
$$Q=3182\sqrt{P}$$

Where Q=Amount of water in liter/minute.
P=Population in thousand.

5. Compensate losses:-

- This water demand refers to water which is wasted in the water lines due to defective pipe joints, cracks in the pipe, faulty valves and fittings etc.
- This loss is also due to unauthorized or illegal connection an unawareness of consumer.
- Generally this demand is 15% of the total water demand of the city.

Q. Explain the factors affecting the rate of demand? (7 marks)

Ans: Following are the various factors affecting per capita demand.

8. Size of city
9. Climatic condition
10. Habit of people
11. Industrial and commercial activity
12. Quality of water supply
13. Pressure in the distribution system
14. Development of sewerage facility
15. System of supply
16. Cost of water
17. Policy of metering and method of charging

1. Size of city :-

Per capita demand for big city is generally large as compared to that of small city. Because huge amount of water is required for maintaining clean and healthy environment in big cities .

Commercial and industrial activities are also more in big cities.

2. Climatic condition :-

In hot and dry places the consumption of water is more because of bathing, cooling, air conditioning and sprinklings are involved. But in cold places less water is required.

3. Habits of people :-

Rich & upper class communities consume more water due to high living standard but middle class communities consume average quantity of water and the poor consume very less amount of water.

4. Industrial and commercial activity:-

Presence of industrial and commercial activities increases the water consumption by large amount.

5. Qualities of water supply:-

If the quality and taste of water is good then water consumption will be more as people will not use other courses like tube well, hand pump etc.

6. Pressure in distribution system:-

If pressure in distribution system is high and sufficient to make the water to reach third or fourth floor then water consumption will definitely be more.

7. Development of sewerage facility :-

Water consumption will be more if the city is provided with flush system but the consumption will be less if the old conservation system of latrine is adopted.

8. System of supply:-

If the supplied water is continuous system i.e. for 24 hours, then water consumption will be more.

If the supplied system is for peak period, only during morning & evening the consumption will be less.

9. Cost of water:-

If the rate of water is high, less amount of water will be consumed where as if the cost is low, very high amount of water will be consumed.

10. Policy of metering and method of changing:-

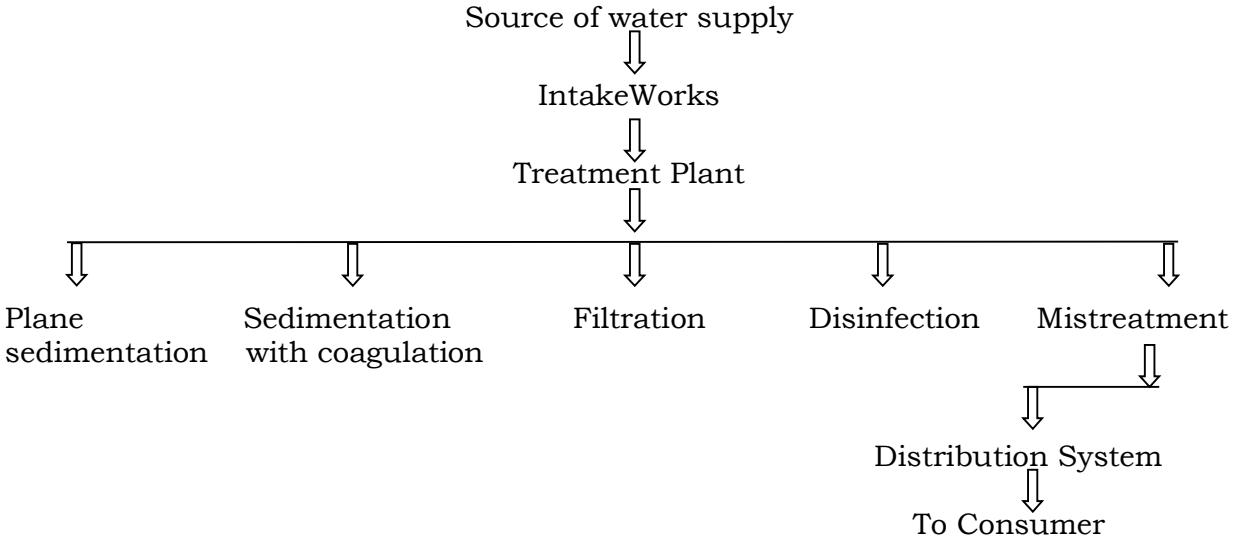
When the water supplies are unmetered and charging is fixed, and then people will not consume water economically which leads high wastage and high consumption of water.

But for a good metering system, water consumption will be less. `

Q. Draw the flow chart of water suppy scheme. (7 marks)

Ans:

Flow chart of a water supply scheme:-



Chapter 2

Sources of water

1. **what is aquifer?**

Aquifer is the previous layer of earth surface through which water can easily pass.
The aquifer consists of sand or gravel strata containing sufficient water which gives good supply of drinking water.

2. **Define Confined aquifer.**

When an aquifer is confined on both its upper & lower base by impervious rock formation, then it is called confined aquifer.

3. **Define unconfined aquifer.**

When an aquifer is not confined by impervious rock formation at both the end, then it is called unconfined aquifer.

4. **What is rain water harvesting?**

It is a process of harvesting, cultivating or collecting rain water in various storage systems to use it in different purposes at the time of need.
It is harvested by over head storage tank and by other form of storage.

5. **What do you mean by specific yield?**

It is defined as the ratio of the volume of total water obtained by gravity drainage to the total volume of the material drained.

All problems: (recuperation test, confined and unconfined aquifer)

Chapter 3

Quality of water

1.What is potable water? (2marks)

Ans. Potable water is defined as the water which is not necessarily physically or chemically pure but it must not contain anything which is harmful to human body.

2.what do you mean by hardness ? (2marks)

Ans. Hardness of water is define as the property of water by virtue of which water exhibit some special characteristics due to which it not produce foam in soap solution, it create problem in textile or dyeing industry and it gives high boiling point to water which imparts bad taste to food. Hardness is due to presence of CA+ and Mg+ ion in water.

3. what is turbidy? (2marks)

Ans. Turbidity of water is the property of water due to which light cannot pass through it and which makes the water looks cloudy.

4.what is palatable water? (2marks)

Ans. Palatable water is that water which is physically chemically and biologically pure and also tasty and aesthetically attractive.

Or

Palatable water is that water which contains some mineral to give some taste to the water.This water also assists in food assimilation.

5.what is bacteria? (2marks)

Ans. Bacteria are of three types as follows

1). Aerobic bacteria :-
The bacteria which grows in presence of air.

2). An Aerobic bacteria :-
The bacteria which grows in absence of air.

3). Facultative bacteria :-
The bacteria which grows both presence and absence of air.

6. Explain the physical test of water.(5marks)

Ans. Physical test of water is carried out to determine physical characteristics of water.

It includes the test for determination:-

a) Turbidity
b) Colour
c) Taste & odour
d) Temperature

a). Turbidity:-

- The volatile particle present in water interferes with the passage of light which impose the turbidity of water.
- Turbidity also caused due to clay and silt particles, discharge of sewage and waste to the water etc.
- Turbidity indicates cloudy appearance in water. Which is aesthetically unattractive and also harmful to the human being?
- It is expressed in PPM & measured in different turbidity meter.
- The permissible limit of turbidity for drinking water is 5-10 PPM.

b) . Colour :-

- The dissolved organic matter from decayed vegetation or from some organic materials like colored soil imparts colour to the water.
- Colour produces and undesirable appearance.
- It spoils clothes and affects various industrial processes.
- It is also objectionable from aesthetic and physical point of view.
- It can be easily detected by naked eye.
- It is measured by comparing in ' Nessler ' tube . Colour of water is measured on cobalt scale.
- For public water supply, the no of cobalt scale should not exceed 20 and should be less than 10.

c) . Taste and odour :-

- The dissolved organic material and inorganic salts and dissolved gases imparts taste and odour to the water
- For drinking purpose the water must not contain any undesirable taste and odour which make the water unpleasant
- The odour is expressed as disagreeable earthy, fishy, grassy, mouldy, sweety etc
- The taste is expressed as brakes, saline, salty, sweety.

d) . Temperature :-

- The water used for drinking and different purposes should be cool having normal temperature.
- The desirable temperature of portable water is 10° C.
- It is measured in ordinary thermometer
- Temperature more than 25°C is objectionable

Q.7. What are the various impurities present in water?
(7marks)

Ans. Various impurities present in water are categorized into fallowing 3 types.

1. Suspended impurities
2. Dissolved impurities
3. Colloidal impurities

1. **Suspended impurities :-**
   These impurities are the dispersion of solid particles that are not large enough to be removed by filteration. It includes clay, algae and fungi, organic and inorganic matter and mineral matters etc. These are microscopic and cause turbidity in water.
   The concentration of suspended impurities is measured by turbidity.
   Organic impurities like vegetables matters cause colour, taste and acidity.
   Animals cause harmful disease & germs bacteria cause disease, algae and protozoa cause odour turbidity and colour in the water.
2. **Dissolved impurities :-**
   When water moves over rocks, soil etc. some impurities are dissolved in it.
   This may contain organic compounds, inorganic salts, gases etc.
   It is expressed in PPM
   The carbonate & bicarbonate of Ca++ & Mg++ causes hardness and alkalinity.
   Nacl cause taste (Salty)
   Manganese cause black or brown colour
   Iron oxide of sodium causes taste, hardness, corrosiveness.
   Lead cause lead poisonic.
   As cause “AS” poisonic.
   Oxygen cause corrosion of metals
   Co_2 cause acidity and corrosion of metals.

H_2s cause rotten egg odour

3. Colloidal impurities :-

These impurities are very finely dispersed particles of water. These particles are so small that they can not be removed by ordinary filtration. These are not visible to naked eye.

These colloidal impurities are generally associated with organic matter containing bacteria.

Most of the colour of water is due to this colloidal impurity

Chapter 4

Treatment of water

1.Sedimentation of water

What do you mean by sedimentation?(2marks)

Ans. Sedimentation is the process of water treatment in which water is allowed to stand still for some period for settling of the dust particles or sediments at the bottom.

Necessity or purpose of sedimentation :- (5marks)

The following is the purpose of sedimentation

- To reduce heavy sediment load before the water enters the coagulation tank
- To make the process of coagulation more easy.
- To reduce the amount of coagulant
- To reduce the cost of coagulation process
- To make the working of other treatment process more efficient.

Explain the classification of sedimentation tanks. Give any one in detail. (7marks)

Ans. Depending upon the nature of working, the sedimentation tank is of two types.

i. Fill & draw type sedimentation tank.
ii. Continuous flow type sedimentation tank.

1. **Fill & draw type sedimentation tank (7marks)**
   Working :-
   - These tanks are also known as intermittent type or quiescent type sedimentation tank.
   - The working of this tank is very simple.
   - The water is filled in the tank and then it is allowed to rest for a certain time.

- After the particles in suspension are settled down, the clear water is drawn off to the next chamber.
- Then the tank is cleaned of silt and filled again with water.
- A total period of 30 to 36 hour is required to put the tank again in working condition.
- So at least two tanks will be required for this type of process.

Design consideration :-

- The cubical shape of tank represents the storage capacity.
- Provision is made at the bottom of the tank for accumulation of silt.
- The outlet valve is provided at the top of silt deposit zone.
- Inlet and outlet for water is arranged at the opposite end of the tank.

Uses :-

- This tank is mostly out of use at present as it causes many disadvantages.
- This operation requires manual labour and expert supervision.
- In this tank the loss of head = Height of silt zone.
- The minimum unit of tank required is 3 in place of 1 unit only.
- There is considerable wastage of time for filling, emptying, cleaning of the tank.

Continuous flow type tank **(7marks)**

Working :-when the velocity of flow is reduced ,large amount of suspended impurities from water can be easily removed.

- This is the principle behind the continuous flow type sedimentation tank.
- In this tank, the water enters the tank in one end and travels towards the outlet at the other end.
- Its velocity is reduced by means of baffle walls.
- This baffle wall contains open links at different links at different levels.
- The velocity of flows is so adjusted that the time taken by the particle to move from one end to other is slightly more than that required for settlements.

- Impure water enters at one end and the clear water exit at other end continuously.
- The silt is deposited at the bottom of the tank, after sufficient accumulation the flush valve is opened and the tank is cleaned.

Design Consideration :-

The design aspects of these tanks areas given below.

a) Velocity of flow

b) Capacity of tank

c) Inlet & Outlet arrangement

d) Shape of tank

e) Miscellaneous consideration

Velocity of flow: - The velocity of flow should remain uniform through out the tank. It is generally not allowed to exceed 150mm/min to 300mm/min.

Capacity of tank:-

$C=Q\times t$

Where Q= Rate of flow per hour or discharge

t=Detention period in hour

the detention period varies from 4 to 8 hours & overflow rate varies from 500-700 ltr/hr/m^2

Inlet and outlet arrangements:-

The inlet and outlet arrangements should be properly designed and is located in such a way that they don't form any obstruction to the flowing water.

Shape of tank:-There are fallowing 3 shapes of tank as given below.

Rectangular shape with horizontal shape with radial flow hopper bottom tank with vertical flow.

Miscellaneous consideration:-

- A tank should be water tight provided with roofs.
- All the control valves should be situated outside with proper head stocks.
- The floor of the tank should be given necessary slope as required.
- Free board of 300 to 600 mm should be provided.
- There should be provision for overflow and washout in a single pipe.
- A depth of 500 to 600mm should be provided at the bottom for sludge collection.
- There should be adequate provision for sludge.

Uses & Advantages:-

1) These tanks are widely used in modern time as they possess many advantages
2) Less labour & supervision is required.
3) Little loss of head is occurred as the outlet is situated near the top of the tank.Time of operation is less as the flow of water is continuous.

2.COAGULATION OF WATER

Q. What is coagulation?

Ans. The coagulation of water is defined as the process by which impure water is prepared for successful purification by using some chemical substance known as coagulant.

Q. What is floc? (2marks)

- After the coagulant dissolved in water being thoroughly mixed, it produce a thick gelatinous precipitate .This precipitate is called Floc.
- It has the property of arresting the suspended particles during its downward travels.

Q. What is flocculation? (2marks)

Ans. It is defined as the process of floc formation by the reaction of coagulant with impure water.

Q. What is coagulant ? (2marks)

Ans. Coagulant are the chemicals which form floc after mixing with water to remove the chemical impurities from water.

Q. What is the principle of coagulation? (5marks)

Ans. The principle of coagulation is explained in the fallowing two considerations.

1. **Floc formation :-**

- After the coagulant dissolved in water being thoroughly mixed, it produce a thick gelatinous precipitate .This precipitate is called Floc.
- It has the property of arresting the suspended particles during its downward travels.

2. **Electric charge :-**

- The flock cause positive electric charge which attract the negatively charge colloidal particle of clay or impurities.
- So they cause the removal of such particles from water.

Q. Give short notes on Flocculation :- (5 marks)

- It is defined as the process of flock formation by the reaction of coagulant with impure water.
- The flock produced is heavy hence it starts settling down at the bottom of the tank.
- As it is descends it absorbs and catches more and more suspended impurities present in water.
- The size of flock increases slowly and it is sufficiently wide to arrest the colloidal & organic matter present in water.

Q. What the various types of coagulant used for coagulation process? (7 marks)

Fallowing six are the usual coagulants which are used for coagulation process.

1) Aluminium Sulphate
2) Chlorinated Coppers
3) Ferrous sulphate & Lime
4) Magnesium Carbonate
5) Poly electrolyte
6) Sodium aluminate

1) Aluminium Sulphate :- This is called filter alum or alum only

- Its chemical composition is $Al_{2(}SO_4)_{3,}18H_2O$
- It is an effective coagulant. It commonly supplied and used in the form of flakes all solid lumps. This coagulant is found to be very effective between PH range 6.5 to 8.5

Advantages :-

- It also reduces taste and odour in addition to turbidity.
- It is cheap, simple in working.
- It produces crystal clear water.

Disadvantages :-

- It is difficult to de water the sludge

- It is also not easy to dispose it up.
- The effective PH range is found to be too small .So to adjust the PH range the treatment is costly.

2) Chlorinated Coppers :-

- When chlorine and solution of ferrous sulphate are mixed, ferric sulphate and ferric chloride is formed. This combination is known as chlorinated coppers.
- Each one is effective as flak and the combination is also quite effective.
- This coagulant is effective in removing colour of water.
- Both can be used independently with lime to act as coagulant and ferric hydroxide is formed which forms the flock.

3) Ferrous sulphate and lime:-When ferrous sulphate & lime are added to the water ferrous hydroxide is formed which is further oxidized by dissolved oxygen in water to form ferric hydroxide.

This ferric hydroxide from the flock.

As flock formed by ferrous sulphate & lime is heavier than alum sinks more rapidly.

Disadvantages :-

- Lime is to be used along with ferrous sulphate.
- Skilled supervision is necessary for the proper dosage of both the chemicals.

4) Magnesium carbonate: - When magnesium carbonate is dissolved & mixed with water along with lime,$Mg(OH)_2$ & $Caco_3$ are formed which are insoluble in water.

The sludge formed in this process is in the form of slurry.

This coagulant is not favored at present .it may proof to be popular in future.

Advantages:-

- It is possible to recycle & rescue the coagulant.
- It removes organic colour & turbidity.
- It completely removes iron & manganese.
- The flock formed is heavier & larger than the flock by using alum.

5) Poly electrolytes: - These are special type of polymers.

- They are classified as anionic, cationic and non-ionic.

- Only cationic poly electrolytes can be used effectively as independent coagulant.
- The use of this still in pilot stage. They may proof to be an alternative to the alum in future.

6) Sodium aluminates :- ($Na_2Al_2O_4$)

- This coagulant when dissolved and mixed with water reacts with salts of calcium & magnesium.
- This coagulant removes temporary hardness and also permanent hardness.
- For this coagulant the effective range PH value is 6-8.5
- However the coagulant is costly, it can not be adopted for treating water on a large scale.

FILTRATION OF WATER

Q.What is filtration? (2marks)

Ans. Filtration is the process of treatment of water to remove biological impurities from water by passing water through a bed of thin granular material.

Q. What is the theory of filtration?
(5marks)

Ans. The theory of filtration is based on the fallowing 4 factors.

1) Mechanical Straining
2) Flocculation & Sedimentation
3) Biological Metabolism
4) Electrolytic Charges

1) Mechanical Straining :-

- The suspended particles which are unable to pass through the water is free from impurities.
- Thus this particle is removed by the action of mechanical straining.

2) Flocculation & Sedimentation :-

- The void between sand grains of the filter act more or less like small sedimentation tank.
- The particles of impurities are arrested in this void.
- Thus the suspended impurities are removed by filter by the action of sedimentation

3) **Biological Metabolism :-**

- The growth and live process of living cell is known as the biological metabolism.
- The action of filter is explained on the basis of biological metabolism.
- When bacteria are caught in the voids a geological film is around the sand grain.
- This film contains large colonies of living bacteria.

- Thus the bacteria fed on the impurities from the water and convert the impurities into harmless compound.

4) Electrolytic Charges :-

- The action of filter is also explained by the anionic theory.
- It states that when two substances of opposite electric charges come in contact, they become neutralized.
- Sands grains of filters are charged with electricity of some polarity.
- When the suspended and dissolved matter of opposite polarity come in contact to them. They neutralized each other.
- Hence the chemical characteristic of water is changed.

Q. Explain the slow sand gravity filter with neat sketch.(7marks)

Slow sand gravity filter :-

Purpose :- In this filter the water is allow to pass slowly through a layer of sand placed above the base material.

This purification process simultaneously improves physical, chemical & biological characteristic of water.

This filter is well suited for rural areas in developing countries due to its simple operation & maintenance procedure.

Essential Parts :-

This filter consists of fallowing essential parts

1) Enclosure tank
2) Under drainage system
3) Base material
4) Filter media of sand
5) Appurtenances

1) Enclosure tank :-

- A water tight tank is constructed either in stone or brick masonry.
- It sides & floats are coaled with water proof material.
- It's bed slope is 1 in 100 to 1 in 200 towards central drain
- It's depth is about 2.5 to 3.5 m

2) Under drainage system :-

- It consists of a central drain and some later drains as shown in the figure.
- The drains are of pipes laid with open joint.

- The lateral drains are also formed by placing two rows of bricks at right angles to each other.

3) Base material :-

- The base material is gravel .It is placed on the top of under drainage system.
- Its depth varies from 300-750 mm
- It is graded and laid in layer of 150 mm
- The top most layers are of small size gravel and lowest layer is of bigger size gravel.

Layer	**Depth**	**Size**
Top most	150mm	3-6 mm
Intermediate	150mm,150mm	6-20mm,20-40mm
Lowest	150mm	40-60 mm

Total =600mm

4) Filter media of sand :-

- A layer of sand is placed above the gravel. The depth of sand layer varies from 600mm-900mm.It's effective size varies from 0.2 to 0.3 mm.

The finer the sand, the better is the filtering efficiency.

5) Appurtenances :-

- Various appurtenances are installed for efficient working of the filter vertical air pipe passing through layer of sand is provided.
- It helps in proper functioning of filtering layers.
- The devices for measuring loss of head, controlling depth of water above sand & maintaining rate of flow are suitably installed.

Working :-

- Water is allowed to enter the filter through inlet chamber.
- It descends through filter media and gets purified.
- Then it is collected in outlet chamber and taken to storage tank.

Cleaning :-

- For the purpose of cleaning the top layer of sand is removed up to a depth of 15 to 25 mm.
- Then the water is admitted to the filter.

- After a number of cleaning ,the effective depth of media is reduced.
- To maintain the efficiency a fresh layer of graded sand of 150mm depth is again added to the filter.

Rate of filtration :-

The rate of filtration for a normal slow sand filter varies from 100-200 lit/hr/m^2 of filter area.

Efficiency :-

Bacterial Load :-This filters are highly efficient in the removal of bacterial load up to 98 to 99%.

Colour :-This are less efficient in removing colour.they remove up to only 20 to 25% .

Turbidity :-This filters removes turbidity to the extent of 50PPM.

Q. Explain the rapid sand gravity filter with neat sketch. (7marks)

Ans :

Rapid sand gravity filter :-

Purpose :-

In this filter the rate of filtration is increased by increasing the size of sand to minimize the friction to water passing.

Essential Parts :-

The essential part of a typical rapid sand gravity type filter consist the fallowing parts.

1) Enclosure tank
2) Under drainage system
3) Base material
4) Filter media of sand
5) Appurtenances

1) Enclosure tank :-

- A water tight masonry or concrete water tank is constructed.
- The floors and sides are also coated with water proof material.
- It's depth is about 2.5 to 3.5 m.

2) Under drainage system :-

- There are various forms of under drainage system of a rapid sand filter.
- Commonly two types under drainage

1) Perforated pipe system.

2) Pipe & strainer system.

1) Perforated pipe system :-

- In perforated pipe system there is a central drain system are made up of lateral drains are attached with a distance of (150-300)mm.
- The lateral drains are provided with holes at the bottom side.
- This system is economical and simple in operation.

2 Pipe and strainer system :-

- In pipe and strainer system there as also a certain drain attached with lateral drains.
- In this system the strainer are placed on the lateral drains instead of holes.
- A strainer is a small brass pipe closed at top containing holes on its surface.
- In this system compressed air is used for purpose of washing the filter.

3 Base Material :-

- The base material is gravel, placed on the top of under drainage system.
- The gravel particles should be cleared ,free from clay,dust,slit and should be durable, hard & strong.
- It's depth varies from (450-600)mm laid in layers of 150 mm

Layer	**Depth**	**size**
Top most layer	150mm	(3-6)mm
intermediate layer	150mm	(6-12)mm
Lowest layer	150mm	(12-20)mm
	150mm	(20-40)mm

Total=600mm

4 Filter media :-

A layer of sand is placed above gravel .it's depth varies from (600-900)mm coarse sand is used as filter media of size 0.35 to 0.6mm

5 Appurtenances :-

In this filter special devices are provided as given below.

1) Air compressor :-

The washing of filter is carried out by compressed air or by water jet.

2) Wash water through :-

The dirty water after washing of filter is collected in wash water through these is of cast iron or concrete or steel placed above sand bed level.

3) Rate control :-

To control the filter rate special devices like venture rate controller is fitted at the out let of filter.

Working & cleaning :-

The working of a rapid gravity filter is explained as fallows.

1) Valve-1 (Inlet valve)
2) Valve-2 (Filtered water storage tank valve)
3) Valve-3 (Waste water valve to drain water from inlet chamber)
4) Valve-4 (wash water storage tank valve)
5) Valve-5 (Waste water valve to drain water from main drain)
6) Valve-6 (Compressed air valve)

Working :-

- The valve-1 is opened and water from coagulation sedimentation tank is allowed to enter the filter.
- The valve-2 is opened to carry filtered water to the storage tank.
- All other valves are kept closed.

Cleaning :-

- The cleaning of the filter is carried out as fallows.
- The valve (1) & (2) are closed.
- The valve 4 & 6 are opened out.
- Here the wash water is forced in the upward direction with the help of compressed air to clean the filter.
- Then the valve (6) is closed and the valve (3) is open to carry dirty water to the wash water drain.
- After washing of filter is over, the valve 3 & 4 are closed and 1 & 5 are open out.
- Then the filtered water at the beginning is allowed to drain out.
- Then the valve 5 is closed & 2 is opened out to put the filter into the normal working condition.

Rate of filter :-

The main advantages of rapid sand filter is that it's rate of filtration is high up to (3000-6000) lit/hr/$m^{2.}$

Efficiency :-

1) Bacterial load :-

   The filters are less effective in the removal of bacterial load. Only up to (80-90) is expected.

2) Colour :-

- This is highly efficient in colour removal.
- It's intensity can be brought down below 10 on cobalt scale.

3) Turbidity :-
The filter can be removed turbidity to the extent of (30-40)PPM.

Q. Explain Pressure filter with neat sketch:- (7 marks)

- The pressure filters are more or less similar to the rapid sand filters.
- Pre-filter indicates that a filter is enclosed in space and the water passes under pressure greater than the atmospheric pressure.
- This pressure can be developed by pumping it may vary from 0.3 to 0.7 N/mm^2.

Construction :-

- This filter is closed steel cylinders either riveted or welded.
- They may be of horizontal or of vertical type.
- It's diameter varies from 1.5m to 3m
- Its height varies from 3.5m to 8m.
- The man holes are provided at top for inspection.

Working :-

- The water mixed with coagulant is directly admitted to pre-filter and flocculation takes place.
- In normal working condition all valves are closed except those for raw water and filtered water.
- Then the water is admitted through inlet and then it is filtered & collected in central drain.
- It is conveyed to the filtered water storage tank.

Cleaning :-

- Compressed air is used to clean sand grains.
- The valve for raw water & filtered water is closed and valve for wash water drain are opened
- The cleaning of these filter may be required more frequently.

Rate of filtration :-
The rate of filtration of pre filter is very high. It is about 6000 to 15000 $liters/hr/m^2$.

Efficiency :-This filters are less efficient than rapid sand filters. In terms of bacterial load, colour & turbidity.

Suitability :-This filters are not suitable for public water supply project.

Q. Give the comparison between slow sand filter and rapid sand filter.(5 marks)

	Slow sand gravity filter	**Rapid sand gravity filter**
1	Base material of gravel varies from 3 to 65mm in size & 300 to 750mm in depth.	Base material of gravel varies from 3 to 40mm in size and 600 to 900mm in depth.
2	Coagulation is not required	Coagulation required
3	Requires large area for its installation	Requires small area for its installation
4	Simple in construction	Requires small area for its installation.
5	Cost of operation is low	Cost of operation is high.
6	Depreciation of plant low	Depreciation of plant is high
7	High cost both land & material	It is cheap & quite economical.
8	It is efficient in removing bacteria but less efficient in removal of colour & turbidity.	Less efficient in removal of bacteria but more efficient in the removal of colour & turbidity.
9	Size of sand varies from 0.20 to 0.30mm.	Size of sand varies from 0.35 to 0.60 mm.
10	Head loss is 150 to 750mm	It is 3m to 3.50m
11	Cleaning period is 1 to 3 months	Cleaning period is 2 to 3 days
12	Rate of filtration 100 to 200 liters/hr	3000 to 600ltr/hr/m^2 of filter area.
13	Skilled supervision not required	Supervision required.
14	It is constructed of local labour and material. it is suitable for small towns & villages where land is cheap.	It is suitable for big cities where land cost is high.

DISINFECTION OF WATER

What do you mean by disinfection? (2marks)

Ans. Disinfection is defined as the process of removing the other impurities and harmful bacteria which is still present in water after the physical, chemical & biological treatment of water.

What do you mean by chlorination? (2marks)

Ans. Chlorination is defines as the treatment of water by addition of chlorine for disinfection purpose.
Simply it is a process of reaction of chlorine with water to disinfect it.

What is chlorine demand? (2marks)

Ans. It is defined as the exact amount of chlorine demanded by the raw water for disinfection purpose to perform the fallowing two purposes

1) To remove bacteria from water
2) To oxidize organic matter present in water.

What is residual chlorine? (2marks)

Ans. It is that chlorine which comes out as a residue after satisfying the chlorine demand of raw water in the chlorination process for disinfection of water.

What are the minor methods of disinfecting water? (7marks)

There are 7 minor methods of disinfection are explained below.

1) Boiling method
2) Excess lime treatment
3) Iodine or bromine treatment
4) Ozone treatment

5) Potassium permanganate
6) Silver treatment
7) Ultra-violet ray treatment

1) Boiling method :-

When water is boiled above a certain temperature the bacteria are killed.

- It is the most effective method of disinfection.
- The main disadvantages of this method are to boil water on a large scale is impracticable.

2) Excess lime treatment :-

- This treatment is given to water for removal of dissolved salts.
- Excess lime treatment works as a very good disinfecting material.
- But this treatment increases the PH value of water up to 9.5
- In this treatment the bacteria can be removed to the extent of 99.9-100%.
- The disadvantages are to remove excess lime after the treatment.

3) Iodine & Bromine treatment :-

- When water is treated with iodine & bromine, it is disinfected.
- It's dosage is 8 PPM and contact period is about 5 minute.
- But this use is limited to small water supply such as swimming pool, private plants etc.

4) Ozone treatment :-

- When a high-tension electric current is passed through a stream of air in a closed chamber, ozone (O_3) is produced.
- In ozone the third atom "O" is loosely bound.
- So ozone easily breaks down and a nascent oxygen 'O' is produced which is a powerful disinfectant in killing bacteria.
- It's dosage is 2-3 PPM & contact period is 10 minutes.
- This treatment is very much costlier and complicated.

5) Potassium permanganate :-

- It is a disinfectant which works as a powerful oxidizing agent and is very effective in killing cholera bacteria.
- The use of this disinfectant is restricted to village well & ponds.
- After this treatment a dark brown coating is produced on vessels which are difficult to remove.

6) Silver treatment :-

- Silver has the property of infecting water,
- Metallic silver is placed as filter media which absorbs the impurities of water while passing through it.

- Its dosage is from 0.5 to 1 PPM and contact period is about 15 minutes - 3 hours.
- This treatment does not develop any smell or taste in water and not harmful to human body.
- As silver is very costly, it is limited to private individual houses only.

7) Ultra violet ray treatment :-

- As UV ray is very effective in killing all types of bacteria, so it is a good method of disinfection.
- The water used in this treatment should be colourless and turbidity should not be more than 15PPM.
- This treatment does not develop any taste or colour in water and there is no danger of over dosage also.
- This treatment is very costly. It can be for private institution.

Q. What are the various forms of chlorination? (7marks)

Ans. Depending upon the stage of treatment at which chlorine is added various forms of chlorination are termed as given below.

1) Plain chlorination
2) Pre chlorination
3) Post chlorination
4) Double chlorination
5) Break point chlorination
6) Super chlorination
7) De chlorination

1) Plain chlorination (2marks)

- When chlorine is simply added to raw water to control the growth of algae and to remove bacteria, then the chlorination process is called plain chlorination.
- It removes organic matter and colour from water.
- This treatment is useful when raw water is sufficiently clear.
- The dosage of chlorine in this process should be about 0.5PPM or more.

2) Pre chlorination :-

- When chlorine is added to raw water before any treatment, then the process is called pre chlorination.
- Chlorine is added in small dosage before the water enters sedimentation tank.

Advantages :-

- It reduces taste and odour
- It improves coagulation
- It keeps the filter media of sand clean
- It controls the growth of algae

3) Post chlorination :-

- When chlorine is applied to water after all the treatment purification is completed, and then the process is called post chlorination.
- It is a standard treatment where chlorine is after water leaves the rapid sand filter.

4) Double chlorination :-

- When chlorine is added to raw water at more than one point then the process of chlorination is called double chlorination.
- This treatment is given when raw water is highly contaminated and contains large number of bacteria.

Advantages:-

- It has the same advantages of pre-chlorination treatment.
- One more advantage is load of impurity of filter is greatly reduced.

5) Break point chlorination (5marks) (individual short notes)

- If water is sufficiently pure and has no chlorine demand, then any chlorine that is added to such water is directly comes out as residual chlorine.
- This is shown by the imaginary line P in the graph.
- For water containing organic matter the chlorine has to perform the two functions.

1) To remove bacteria from water
2) To oxidize the organic matter present in water.

- To such water when chlorine is added it first remove the bacteria then it starts to accumulated up to a certain point 'A' represented on the curve 'Q'.
- At this stage, if further chlorine is added then a sudden decrease in residual chlorine occurs with some bad smell and taste.
- This indicates the utilization of extra chlorine for the second function i.e for oxidation of organic matter.

- If still further chlorine is added ,then a point 'B' is reached when bad smell and taste are suddenly disappeared and again residual chlorine is accumulated as before represented by line 'R'
- This point 'B' is known as break point and the chlorination at this point is known as break point chlorination.

6) Super chlorination(2marks)

- It is defined as the process chlorination beyond the stage of break point.
- The residual chlorine content after break point is 0.5-2 PPM.

7) Dechlorination (2marks)

- The process of removal of excess chlorine from water is called dechlorination.
- This process is done in such a way that there should be some residual chlorine remains in water for further disinfection.

What is Break point chlorination?(2marks)

Ans. The break point chlorination is a method of determining the chlorine demand of water in which the exact amount of chlorine demanded by the raw water after performing it's two function breaks through the water .

This point is called break point & the chlorine is called break point chlorination.

WATER SOFTENING

What do you mean by water softening? (2marks)

Ans. water softening is defined as the process of making hard water soft by different suitable methods.

Q. What do you mean by hardness? How many types of hardness are there? (5marks)

Ans. Hardness of water is defined as the quality of water which is due to the presence of carbonate, bicarbonate, sulphate, nitrate and chlorides of calcium and magnesium.

Types of hardness :-It is of two types

1. Temporary hardness
2. Permanent hardness

1) Temporary hardness :-

- The hardness of water occurs due to the presence of carbonate and bicarbonate Ca & Mg is called temporary hardness.
- This hardness is easy to remove by adopting some simple methods like boiling or adding lime.
- It is also known as carbonate hardness.

2) Permanent hardness :-

- This hardness is due to the presence of sulphate, chlorides & nitrate of Ca & Mg ion.
- This hardness can not remove easily.
- This is removed by adopting some special water softening treatment.
- It is also called non carbonate hardness.

Q. What is the necessity of water softening? (5marks)

Ans.The softening of water is necessary for the fallowing purposes.

1) To improve taste of food
2) To reduce the consumption of soap in washing of clothes.
3) To reduce the formation of scale in boilers.
4) To increase the life of fabrics.
5) To neutralize the effect on colour in dyeing system.
6) To reduce the corrosive effect on pipes.

Q. Explain the zeolite method of water softening? (7marks)

Ans. **Zeolite process :-**

- This process also known as the Base Exchange or ion exchange process.
- The zeolites are compounds of aluminium silica and soda.
- They have got the excellent property of interchanging base.
- Zeolite can be obtained from nature or may be prepared synthetically.
- The natural zeolite is also known as green sand whose exchange value is (7000-9000)gm of hardness per m^3 of zeolite.
- The most common artificial zeolite is permeotit which is manufacture from felspar ,kaolin clay and soda.
- The exchange value of permeotit is (35000-41000)gm of hardness of m^3 of zeolite.
- When the hard water contact with zeolite ($2Sio_2Al_2O_3Na_2O$) the calcium & magnesium are removed and sodium is given in exchange.
- Thus the hard water is softened and it's sodium content is increased.
- After some interval of time the sodium present in zeolite is removed.
- This 'Na' ion is very easily regenerated by passing a solution of salt through the zeolite.
- Thus an exchange occurs again and sodium of salt is taken by zeolite.
- This process is known as the process of regeneration.
- The bed is then washed to remove calcium chloride or magnesium chloride for half an hour.
- Now the filter bed is ready for use again.

Equipment required :-

- The filters used in zeolite process is similar to the pressure type filter.
- In this case the layer of sand is replaced by a layer of zeolite.
- The depth of zeolite layer varies from (750-800)mm.

- The softened water is collected by the under drainage system and discharge for use by the outlet pipe.

Advantages & disadvantages :-

Advantages :-

- In this process ,the sludge is not formed hence, the problem of sludge disposal does not arise.
- The zeolite unit is compact in design .It can be easily operated and does not require any skilled supervision.
- There is no problem of the disposition of a layer of calcium carbonate in the distribution system.
- This process reduces hardness of water to zero.
- The process is completely automatic and highly skilled labour is not required.
- The process proves to be economical where salt is cheaply available.

Disadvantages :-

- The zeolite process can not be adopted for highly turbid water.
- The zeolite process is unsuitable for water containing iron and manganese
- The zeolite unit should be carefully operated to avoid injury or damage to the equipment, quality of water and bed of zeolite.

Conveyance of water

what do you mean by intake? (2marks)

Ans. An intake is defined as a structure which is constructed across the structure of water so as to permit the withdraw of water from the source.

How many types of intakes are there? (7marks)

Ans. Intake is divided into four types.

1) Canal intake
2) Reservoir intake
3) River intake
4) Portable intake

1) Canal intake :-

- An intake chamber is constructed in canal section as a result the water way is reduced which increases the velocity of flow.
- So it is necessary to provide pitching on the D/S & U/S portion of canal near intake.
- The entry of water in the intake chamber takes through coarse screen and the top of the outlet pipe is provided with the fine screen
- The inlet to outlet pipe is of bell mouth shape with perforations and outlet valve is provided to control the entry of water in to the outlet pipe .
- To reach up to the bottom of the intake, the steps should be provided in zigzag manner.
- The flow of velocity through the outlet is normally kept 1.50m/sec.
- The flow of velocity through the bell mouth shaped inlet limited to 300mm/sec.

2) Reservoir or Lake intake :-

- It consists of an iron intake well placed near the dam which is connected to the top of the dam by foot bridge.
- Intake pipes are located at different levels with a common vertical pipe.
- Each intake pipe is provided with bell mouth entry with perforations of fine screen on it's surface.
- When the valve of an intake pipe is opened the water is drawn off from the reservoir to the outlet pipe through the common vertical pipe.
- To reach up to the bottom of intake from the floor of valve room, the steps should be provided in zigzag manner.

3) River intake :-

- In river intake an approach channel is constructed to lead the water from the U/S side to the jack well.
- The penstocks with screens are provided at different levels.
- The suction pipe is provided with stainer at it's lower end .
- The water from jack well is pumped and send to the treatment plant.
- To prevent the back flow of water a valve should be provided from the rising main leading to the treatment plant.
- To reach up to the bottom steps are provided with zigzag manner.
- A cross approach channel is excavated up to the jack well, if the river has wide basin.

4) Portable intake :-

- It means movable intake.
- It consists of a truck fitted with a pumping plant.
- The truck is brought to the sight & place such a position that it becomes possible to immerse the suction pipe of the pump.
- The end of the pipe is kept just above the bed level of water source.
- The water lifted by portable intake is relatively free from suspended solids.

Q. What are the different types of pipes used in water supply with merits & demerits of each type? (7 marks)

Fallowing are the various types of pipes which are used in water supply.

1) Asbestos cement pipe
2) Cast iron pipe
3) Cement concrete pipe
4) Copper pipe

5) Galvanized iron pipe
6) Laid pipe
7) Plastic pipe
8) Steel pipe
9) Wood pipe
10)Wrought iron pipe

1) Asbestos cement pipe :-

- These pipes are made from a mixture of asbestos, fibers, cement.
- These pipes are used to conveyed water under very low pressure and their use in conveying and supplying water is very much restricted.

Advantages :-

- The inside surface of pipe is very smooth.
- The joining of pipes is very good and flexible.
- The pipes are anti corrosive & cheap in cost.
- The pipes are light in weight and hence easy to handle & transport.
- The pipes are suitable for distribution pipes of small size.

Disadvantages :-

- The pipes are brittle.
- The pipes are not durable.
- The pipes can not be laid in exposed places .
- The pipes can be used only for very low pressure.

2) Cast iron pipes :-

- These pipes are extensively used for the conveyance of water .They are available in sizes up to diameter about 1200mm or more.

Advantages :-

- The cost is moderate.
- The pipes are easy to join.
- The pipes are not subject to corrosion.
- The pipes are strong and durable.
- The service connections can be easily made.

Disadvantages :-

- The breakage of these pipes are large.
- The carrying capacity of these pipes decreases with increase in life of pipes.
- The pipes are not used for pre greater than $0.7N/mm^2$.

- The pipes become heavier & uneconomical specially when their sizes increase beyond 1200mm diameter.

3) Cement concrete pipes :-

- This pipe may be plain, reinforced or pre stressed with diameter varying from 500mm to 250mm or more.
- The RCC pipes are adopted for heads up to about 75mm & for larger heads pre stressed cement concrete pipes are used.

Advantages :-

- The inside surface of pipes can be made smooth.
- The maintenance cost is low.
- The pipes are durable of life 75 years.

Disadvantages :-

- The pipes are heavy and difficult to transport.
- The pipes are likely to crack during transportation.
- The pipes are affected by acids, alkalis and salty water.

4) Copper pipes :-

- This pipe does not bend due to hot water.
- Hence their use is restricted for conveyance of hot water in building & steam boilers.
- They are bent easily.

5) Galvanized iron pipes :-

- These pipes are widely used for service connections and their diameter vary from 6mm to 75mm.

Advantages :-

- The pipes are cheap, light in weight & easy to handle and transport .
- The pipes are easy to join.

Disadvantages :-

- These pipes are liable to incrustation and can be easily affected by acidic or alkaline waters.
- The useful life of pipes is short about 7 to 10 years.

6) Lead pipes :-

- These pipes are usually not adopted for the conveyance of water. If proper care is not taken the lead pipes may cause lead poisoning. They can easily be bent and hence these pipes are used less number of specials will be required.

7) Plastic pipes :-

- Plastic is a new material of modern age .Its various uses in many field have made it very popular . The use of plastic in the conveyance of water has increased due to various types of plastic pipes are available in market.The polythene pipes are black in colour & are resistant to most of the chemicals except nitric acid and very strong acids , fats , oils etc.

Advantages :-

- There is freedom from damage due to thawing and freezing of water in closed pipes.
- The pipes are cheap.
- The pipes are flexible and possess low hydraulic resistance.
- The pipes are free from corrosion.

Disadvantages :-

- The coefficient of expansion for plastic is high.
- The pipes are less resistance to heat.
- Some types of plastic may impact taste to the water.

8) Steel pipes :-

- The mild steel is used for manufacture of steel pipes . The joints of steel pipes are either riveted or welded and hence they vary both in length & diameter.

Advantages :-

- The pipes are available in long lengths and hence the number of joints are less.
- The pipes are cheap in first cost.
- The pipes are light in weight and there fore it becomes easy to transport them.

Disadvantages :-

- The maintenance cost is high.
- The pipes require more time for repairs during breakdown and hence they are not suitable for distribution pipes.

9) Wood pipes :-

- These pipes are usually prepared of staves or planks of wood held together by steel bands.

- As alternate condition of dryness and wetness lead to wet rot , these pipes are lead to be constantly filled with water . These pipes are light in weight but they can not bear high pre.

10) Wrought iron pipes :-

- These pipes are light in weight and they can be easily cut ,threaded and worked .But they are found to be costly and less durable as compared to the cast iron pipes and hence they are not generally used in the conveyance of water.

Distribution of water

Q. Describe briefly the method of distribution of water supply.(7 Marks)

Ans. Depending upon the topography of country the distribution system are classified as the following three categories.

1. Gravity system
2. Gravity and pumping systems combined
3. Pumping system
   (page no. 248, Rangwala with figure)

Q. What are the different lay out of distribution system, elaborate merits and demerits with sketch. (7 Marks)

Ans. There are mainly 4 types of distribution system.

1) Dead end system
2) Grid iron system
3) Circular system
4) Radial system

1) Dead end system :- (5marks short notes)

- This system is also known as free system.
- In this system , there is one main supply pipe , from which a number of sub main pipes are originated.
- The sub main pipes are again divided into branch lines , from which service connections are given to the consumer.

- This system is suitable for localities , which expands irregularly and where the water pipes have to be laid at random due to the absence of any planned road network.

Advantages :-

- The distribution network can be solved easily .
- It can accurately calculate the discharge
- In this system less number of cut off valves are required.
- It is cheap, simple and easily be extended.

Disadvantages :-

- During repair , large portion of distribution area is affected.
- There are chances of water to be polluted due to stagnation and it may endanger the public life.
- This may prove to be serious in some cases.

2) Grid iron system :-(5marks short notes)

- This system is also known as as the interlaced system or reticulation system.
- In this system the mains ,sub-mains are interconnected with each other.
- This system is more suitable for well planed towns and cities.

Advantages :-

- Water reaches at different places through more than one routes, thus the size of pipes are reduced.
- In this system , due to different interconnections ,the dead ends are eliminated .
- In this system ,water remains continuous circulation and no chance to be polluted due to stagnation.

Disadvantages :-

- The cost of laying water pipe is very more .
- This system requires larger length of pipes .
- It is very labourious , complicated and difficult to calculate the size of pipes and to work out the pressure.
- More number of cut off valves are required in this system.

3) Circular system :- (5marks short notes)

- This system is also known as ring system.
- In this system a ring of main pipes is formed around the distribution area.
- The distribution area may be either circular or may be rectangular blocks.
- The main pipes are laid on the periphery of those blocks .

- ❖ The ring system is very suitable for towns and cities having well planned roads.

4) Radial system (5marks short notes)

- ❖ This system is just the reverse of the ring system.
- ❖ In this system , the water is taken from the main pipes and pumped into the distribution reservoir, which are well situated at centers of different zones.
- ❖ The water is then supplied through radially laid pipes.
- ❖ This system is more suitable for towns having roads, laid out radially.

Advantages :-

- ❖ This system gives very quick services.
- ❖ This system ensures high pressure and efficient water distribution.
- ❖ In this system, calculations for design of sizes of pipes are also simple.

CHAPTER-9

PIPE APPURTENANCES

- ➢ The distribution pipes are provided with various pipe appurtenances to make the distribution of water easy and effective.
- ➢ Fallowing are some pipe appurtenances given below.

1) Air valve
2) Bib cracks
3) Fire hydrants
4) Reflux valve
5) Refiels valve
6) Scour valve
7) Suice valve
8) Stop cracks
9) Water meter

Reflux valve :-

- These are also known as the check valves or non return valves.
- A reflux valve is an automatic device which allows to go in one direction only.
- This is a swing type of reflux valve which is widely used .
- When water moves in the direction of arrow, as shown in figure , the valve swings around the pivot and it is kept in an open position due to pressure of water.
- When the flow of water in this direction ceases the water tries to flow in a backward direction. In this case the valve occupies is seat and it thus prevents the passage of water in the reverse direction .
- The reflux valve is invariably placed in water pipe which obtains water directly from pump. When pump fails to stops, the water will not return back to the pump and thus the pumping equipment will be saved from damage.

Scour valve :-

- These are also known as the blow off valve or drain valves or washout valves.
- These are ordinary sluice valves which are located at dead ends and depressions or lowest points in mains.
- They are operated with head and closed down as soon as clear water is seen passing through them.

Sluice valve :-

- These are also known as gate valves or shut off valves or stop valves.
- These valves control the flow of water and helpful in avoiding the water mains into suitable section.
- They are generally placed at a distance about 150m to 200m and at all junctions.
- For long straight mains , the sluice valve can be installed at a distance of about 1Km also to divide the pipe in different section.

Stop cocks :-

- These are small sized sluice valves and they are installed in service pipes serving the bib cocks.
- They operate in the same principle of sluice valve and they are usually used up to size of about 50mm.

- They are placed on water pipe leading to flushing tanks, water tanks etc.

Water meters :-

- These are the devices which are installed on the pipes to measures the quantity of water flowing at a particular point along the pipe.
- The reading obtained , from the meters help in working out the quantity of water supplied and thus consumers can be charged accordingly.
- The water meters are usually installed to supply water to industries , hotels etc.

  Fallowing are the requirements of a good water meter.
- It should accurately measure the discharge of water to the permissible tolerance of about 2%.
- It should be capable of resisting even small quantity of flow of water.
- It should be easy to repair and maintain in good working conditions.
- It should contain an arrangement in the form of a screen at the inlet so that the entry of grit is prohibited.
- It should not be too costly.
- The entire assembly of the meter should be non-corrosive.

EXPECTED QUESTIONS

1. Give short notes on.

a) Bib cocks.
b) Relief values.
C) Reflux values.
d) Scour valves.

SANITARY ENGINEERING

CHAPTER-1

-: Introduction:-

Sanitation :-

Sanitation is defined as a preventive measure for the preservation of health of community in general and individual in particular which aims are the creation of such a living condition that will not result into serious out break of epidemic.

Purpose of Sanitation :-

- The main purpose of sanitation is to maintain such environments which will not affect the public health in general.
- To create such a living condition which will not result into serious outbreaks of epidemic.
- For the proper disposal of all kinds of waste material to a place before it starts causing in sanitary condition.
- Finally to make the environment clean & hygienic.

Principle of Sanitation:-

1. Collection and conveyance :-The basic principle of sanitation is to remove any waste matter as possible after its formation.
2. Interior decoration :-The interior decoration of building should be such that it will not catch dust easily or there should be arrangement to clean them carefully.
3. Orientation of building :-The building should be so oriented w.r.to local climatic condition that all the rooms are properly lighted & ventilated naturally.
4. Prevention of dampness :-The construction of building should be damp proof.
5. Supply of water :-There should be plenty full supply of pure water to the building.
6. Treatment of waste :-All the waste matter received from the building should be disposed off only after giving proper treatment to it.

Some important definition (most important)

I. **Bacteria** :-Bacteria are the microscopic unicellular plants or organisms which are divided into 3 groups namely. (2MARKS)

a. Aerobic
b. Anaerobic
c. Facultative

Aerobic Bacteria :-The bacteria which requires light and free oxygen for their existence and development are called aerobic bacteria.

Anaerobic Bacteria :-The bacteria which do not requires light and free oxygen for their existence and development are called anaerobic bacteria.
Facultative :-Those bacteria which can exist both in presence and absence of oxygen are called facultative bacteria. But they grow in plenty in absence of air.

2. **Refuse :-** Refuse is the term used to indicate what is rejected or left as worthless. It is of five catagories.

1. Garbage
2. Sewage

3. Strom water
4. Subsoil water
5. Sullage

Garbage:- Garbage is the dry refuse which include decade fruits, grass, leaf ,paper pieces ,sweepings ,vegetables etc.

Sewage :-Sewage is the liquid waste from a community which includes sullage , discharge from latrins, urinals,industrial waste & storm water.

Night Soil :- Night soil is the term used to indicate the human and animal excreta.

Fallowing are some terms related to sewage.

Combined sewage :-It indicates combination of sanitary sewage & storm water with or without industrial waste.

Raw or crude sewage :-The sewage which is not treated called raw sewage

Weak Sewage :-the sewage containing less suspended solid matter called weak sewage.

Domestic or sanitary sewage :-The sewage which is derived from residential and business building & institution etc. are called domestic sewage.

Dry weather flow :-It indicates the normal flow of sewage during dry season of the year.

Fresh sewage :- It indicates the sewage which has been recently originated or produced.

Septic sewage :-It is the sewage which is undergoing the treatment process.

Wet weather flow :-It indicates the normal flow of sewage during rainy season of the year. It is of the following types.

1. Storm water :-Storm water is used to indicate the rain water of the locality.
2. Sub soil water :-It is the ground water which finds its entry into sewers through leaks
3. **Sullage :-**Sullage is the waste water from bathroom, Kitchens, etc. It does not create any bad smell.

Sewer :- The underground conducts or drains through which sewage is conveyed is known as sewer.(2 marks)

Sewerage :-The entire science of collecting and carrying sewage by water carriage system through sewers is known as sewerage(2 marks).

Q. What are the various types of sewers :- (7 marks)

1. **Branch or sub main sewer :-**The term is used to indicate the sewer which obtains its discharge from a few laterals and delivers it to the main sewer. It serves only a relatively small area.
2. **Combined sewer :-**The sewer which carries domestic sewage and storm water is known as combined sewer.
3. **Common sewer :-**The sewer in which all the inhabitants have equal legal rights is called common sewer.
4. **Depressed sewer :-**When an obstruction is met with the sewer is constructed lower than the adjacent sections to overcome the obstruction, such a section of sewer is known as depressed sewer.
5. **Intercepting sewer** :- The sewer which intercepts the discharge from a number of main or out fall sewers and carries the flow to the point of treatment & disposal.
6. **Lateral sewer :-**The sewer obtaining its discharge directly from buildings called lateral sewer.
7. **Main sewer :-**The sewer which obtains its discharge from a few branch or sub main sewer .It serves to a large area.
8. **Out fall sewer :-**The length main or trunk sewer between the connection of the lowest branch and final point of disposal is known as an outfall sewers.
9. **Relief or overflow sewer :-** The sewer which is meant to carry the excess discharge from an existing sewer is relief or overflow sewer.
10. **Trunk sewer :-** The sewer which obtains its discharge from two or more main sewers is called trunk sewer.

CHAPTER-2

COLLECTION & CONVEYANCE OF REFUSE

Q. Classify the various types of methods used for collection and conveyance of refuse. Explain any one. (7 marks)

There are fallowing two methods which are employed for collection & disposal of refuse.

- Conservancy system
- Water carriage system

1. **Conservancy system :-**This is also known as dry system.

- In this system the different types of refuse are collected separately and then each type is carried and disposed of suitably.
- The garbage or dry refuse is collected from roads and streets in pans or baskets.
- It is then conveyed by carts , trucks to some suitable place.
- Then the garbage is separated into two categories.
  i. Flammable
  ii. inflammable
- The flammable matter burnt into inclinators and inflammable matter is buried into low lying areas.
- The night soil is collected in pans from lavatories and the sewage is carried by labours in carts , trucks etc.

- Then it is buried into the ground and is converted into manure.
- The storm water and sullage are collected and conveyed separately by closed or open channels and then they are discharged in natural rivers.

Disadvantages :-fallowing are disadvantages of conservancy system.

1. **Cost :-**The system seems to be cheap in the beginning but its maintenance & establishment cost are very high.
2. **Design of building :-**In this system the lavatories are to be constructed separate from main building .Therefore it does not permit compact design of the building.
3. **Labour problem :-**This system entirely depends on mercy of labour and if labour goes on strike ,due to any reason ,the public health is put into great danger.
4. **Land for disposal :-**The sewage especially the night soil requires considerable land for this disposal.
5. **Night soil carts :-**It is highly undesirable to allow night soil carts pass through main roads of the city.
6. **Open drain :-**If storm water & sullage are carried in open drains it results in instantly condition mainly in rainy seasons.
7. **Pollution of water :-**There are chances for liquid waste from lavatories to be soaked into ground .Thus polluting underground supply of water.
8. **Risk of epidemic :-**If sewage is not properly disposed of ,there are chances for the outbreak of epidemic which may result in serious disaster.

2. Water carriage system :-

- In this system the water is used as a medium to convey the sewage to the point of final disposal.
- The quantity of water to be mixed is quite sufficient and dilution ratio is so high that the mixture behave like water.
- The sewage is conveyed in suitably design & maintained sewers.
- In this system the garbage is collected & conveyed similar to that conservancy system and storm water is carried separately in sewer line.
- The initial cost of installation of the system is very high but it is economical in long term.
- This system becomes very difficult to be adopted in poor area.
- This system is a modern method of conveyance of sewage.

Advantages :-

1. Cost :- This system is costly at the beginning period at the time of installation but it is economical in long term due to less maintenance.
2. Compact design :-The system permits compact design of the building as lavatories can be accommodated in any part of the building .It is thus

very helpful for modern multistory building in which the toilets or sanitary blocks can easily be constructed on each floor.

3. Hygienic :-It is hygienic in nature as the night soil or foul matter etc. are carried in this system in a close conduct.
4. Land for treatment works :-The area of land required for treatment plant & sewage disposal in this system is much small than that required in case of conservancy system.
5. Methods of treatment :-It becomes easier to apply modern methods of sewage treatment .The sewage from entire area can be carried to treatment plant & after proper treatment it can be suitably disposed off.
6. Water requirement :-It is said that the system requires more water for flushing of solid matter .But in practice no considerable amount of water is required for functioning of this system except the usual water supply.

Q. Comparison between conservancy system & water carriage system:- (5 marks)

Sl	Conservancy System	Water Carriage System
1	It does not permit compact design of structure.	It permits compact design of structures
2	It is laid above ground hence it is visible but non-hygienic.	It is necessarily laid below .It is not visible by hygienic.
3	It requires small quantity of water to the extent of about 30-40 liters per capita per day.	It requires large quantity of water to the extent of about 100-120 liters per capita per day.
4	There exists put refraction.	There are no put refraction.
5	It has been normally considered as system for rural conditions.	It has come up basically as an urban system.
6	The labour force required is much more.	Only few laboures are required.
7	There is presence of segregation.	There is absence of segregation.
8	It is cheap in initial cost but expensive in maintenance works.	It is expensive in initial but maintenance cost is low.
9	There are chances for the	The risk of outbreak of epidemic is

	outbreak of epidemic.	greatly reduced.
10	It is not require help of skilled & technical personnel.	It requires skilled and technical personnel.
11	The city remains dirty & foul smelling.	The city appears neat & clean.
12	It is likely that underground sources of water may be polluted due to soaking of liquid wastes from the latrines.	There is practically no risk of pollution of underground sources of water.

System of sewerage :-

There are 3 system of sewerage

1. Separate system
2. Combined system
3. Partially separate system

1. **Separate system :-**In this system two sets of sewers are laid ,one for carrying sewage and other for carrying storm water.

- The storm water is directly discharged to the river of stream and the sewage is treated in the treatment plant and after proper treatment the effluent is also discharge into the river.

Advantages :-

- The load on the treatment unit become less.
- The natural water is not unnecessarily polluted.
- The sewers are small in size.
- The storm water can be discharged into natural stream without any treatment .
- The system proves to be economical when pumping is required for lifting of sewage.

Disadvantages :-

- The cleaning of sewers is difficult as they are small in size.
- The maintenance cost are high.
- The self clinging velocity is not easily achieved.
- The system requires two sets of sewers which may prove to be costly.

- The storm water sewers will come into operation during monsoon only, hence they can become the dumping places for garbage during summer & winter which may thus be choked.

2. **Combined System :-** In this system only one set of sewer is laid.

- It carries both sewage & storm water.
- The sewage & storm water are carried to the sewage treatment plant.

Advantages :-

- It is easy to clean a combined sewer as it is of large size.
- The maintenance cost is reasonable.
- The storm water reduces the strength of sewage by dilution.
- As the system requires only one set of sewers so it prove to be economical.

Disadvantages :-

- During extraordinary heavy storm the combined sewer may overflow which may put the public health in danger.
- The combined sewer is not properly designed gets easily silted which may create foul in dry season.
- The sewers are very large in diameter .
- The storm water is unnecessarily polluted.

3. **Partially separated system :-**

- In this system the arrangement is made to permit early washings by rain into the sewers carrying sewage.
- When the quantity of storm water exceeds a limit it is then allowed in open drains for conveyance to natural river.

Advantages :-

- It combines the advantages of both the separate system and combined system.
- In this system the entry of storm water avoids silting in sewers.
- The sewers are of reasonable size.

Disadvantages :-

- The quantity of storm water admitted in sewer may increase the load on pumping & in the treatment unit.
- In dry weather the velocity of flow is very low.

CHAPTER-3

QUANTITY OF SEWAGE

The sewage consists of fallowing two categories.

1. Dry weather flow (DWF)
2. Wet weather flow or storm water (WWF)

1. Dry weather flow :-

- Dry weather flow means the sewage flows in the dry season or in the summer season.
- It is denoted as DWF
- It consists of two types of sewage.

1. Sanitary sewage
2. Industrial sewage
3. **Wet weather flow :-**

- It is denoted as WWF
- Wet weather flow is the flow of sewage in rainy season
- It only consists the storm water.
- It is calculated by the formula KiAR.

Where K=$\frac{1}{360}$

A=Area in hectares

R=Intensity of rainfall

I=Average impermeability factor

I is calculated as

EXPECTED QUESTIONS.

1.

a) Define D.W.F.
b) What is sanitation?
c) What is mean by wet weather flow?
d) Define Bacteria. How many types of bacteria are there?

1. Give short notes on-
   a) Refuse.
   b) Garbage.
   c) Sewage
   d) Sullage
   e) Sewer.
2. What are the methods of collection and conveyance of refuse? Explain any one.
3. Give the comparison between conservancy system and water carriage system.
4. What is the system of sewerage? Give comparison of there advantages and disadvantage.

CHAPTER-4

DESIGN OF SEWER

Self clinging velocity :-
It is the maximum velocity which is developed in a sewer by laying the sewer in such a gradient that the slitting of particles in the sewer is prevented.

Non scouring velocity :-
It is the maximum permissible velocity in a sewer such that no scouring action will take place.

Hydraulic formula for design of sewers

Chezy's Formula :-

$V = c\sqrt{mi}$

Where 'V' is the velocity of flow in m/sec

'm' is the hydraulic mean depth in meter.

'i' is the slope or hydraulic gradient

'c' is chezy's constant

Bazin's Formula :-

$$C=\frac{157.6}{1.81+k/\sqrt{m}}$$

Where k is the Bazin's constant

Manning's Formula :-

$$V=\frac{1}{N}(m)^{2/3}(\tau)^{1/2}$$

Where N=Manning's constant

Kutter's Formula :-

$$C=\frac{23+\frac{0.00155}{t}+\frac{1}{N}}{1+(23+\frac{0.00155}{t})\frac{N}{\sqrt{m}}}$$

Crimp and Brugesn formula:-

$V = 83.5\ m^{2/3}\ \tau\ v^2$

Hazen and william's formula:-

$V = 0.85\ c\ (m)^{0.63}\ (\tau)^{0.54}$

$M = \frac{area}{permieter} = \frac{\gamma}{2} = \frac{d}{4}$

1. Calculate the velocity of flow in a sewer of dia 1.2m. The sewer is laid at gradient 1 in 400. What will be the discharge through this sewer when running one half full?

Ans. given-

V =?

d = 1.2m

N = 0.012

m = d/4

Q = ?

According to mannings's formula

$V = 1/N\ (m)^{⅔} (\tau)^{1/2}$

$= \frac{1}{0.012} \left(\frac{d}{4}\right)^{⅔} \left(\frac{1}{400}\right)^{1/2}$

$= \frac{1}{0.012} \left(\frac{1.2}{4}\right)^{⅔} \left(\frac{1}{400}\right)^{½}$

= 83.3 X 0.448 X 0.05

= 1.867 m/sec.

Dischage = Area X velocity

Running on half full $= \frac{\Lambda r2}{2}$ x V

$= \frac{\Lambda\, x\, (1.2/2)2}{2}$ X 1.867

= 1.056 m^3/sec

EXPECTED QUESTIONS.

1. Define Self cleansing velocity.
2. Define on covering velocity.

CHAPTER-5

HOUSE DRAINAGE

TRAP

Definition:-Trap is defined as a depressed or bend sanitary fitting which always remains full of water. It is also termed as to contain the water seal which is measured as the vertical distance between the dip of a trap.

Function:-

1. Its function in a drainage system is to prevent the passage of foul air or grasses through it.

2. It avoids the nuisance which will be developed due to entry of bad smelling gases into the house.

Requirement of a good trap :-

- ❖ It should be capable of being easily cleaned.
- ❖ It should be easily fixed with the drain.
- ❖ It should be free from any inside projection.
- ❖ It should be of simple construction.
- ❖ It should pass adequate water seal.
- ❖ It should pass self cleaning property.
- ❖ The internal and external surface should be smooth.

Types of traps:-

The traps are classified in the fallowing two ways.

i. According to shape
ii. According to use

According to shape:-

According to shape the traps are of three types

i. P-trap
ii. Q-trap
iii. S-trap

P-trap:-

- ➢ This trap has the shape of letter 'P' as shown in figure.
- ➢ The legs of trap are at right angle to each other.

Q-trap:-

- ➢ This trap has the shape of letter 'Q' as shown in figure
- ➢ The legs of the trap meet at an angle other than 'Q' right angle.

S-trap :-

- ➢ This trap has the shape of letters as shown in figure.
- ➢ The legs of the trap are parallel.

According to use :-

According to use the traps are of 3 types

1. Floor trap
2. Gully trap
3. Intercepting trap

Floor trap:-

- ➢ It is made of cast iron.
- ➢ It is provided at the points of entry of waste water in the house.
- ➢ It is placed in bathroom, kitchen, sinks etc.
- ➢ It forms the starting point of waste water flow.
- ➢ A cover is provided at its top as shown in figure to prevent the entry of solid matter.

- This trap is also called "**Nahni trap**"

Gully trap :-

- A gully trap is usually made up off stone ware and a cast iron grating is provided at its top.
- It is fitted inside a masonry chamber as shown in figure.
- A water seal of 60-70mm is provided in this trap.
- It forms the starting point horizontal flow of sewage.
- It is generally situated near external face of the wall and kept slightly higher than ground level.
- It lead the sewage either to the sewer or to the inspection chamber.

Intercepting trap :-

- This trap has water sill of about 100mm .
- It is provided in last manhole of house drainage system.
- It conveys sewage from house to public sewer..
- The main aim of this trap is to prevent the entry of sewer gases from public sewer to house.
- It is also called interceptor.

Vent pipe :-

- The pipe installed for the purpose of ventilation is called vent pipe.
- It should be open at top and bottom .
- This opening should be at suitable levels for the flow of foul gases.
- It is placed in the chamber or manholes from which sewage starts flowing.

Soil pipe :-

- It is defined as the pipe which carry discharges from soil fittings such as urinals , water, closets etc.
- It should be of good material & workmanship.
- It should be water tight.
- It must stand a water test up to 1st floor.
- These pipes are kept of uniform diameter.

Flushing cisterns :-

- In order to flush the water closets & urinals , flushing cisterns are installed.
- It is made of cast iron or porcelain. They are provided at a height of about 2m from floor level.
- These are decent in appearance. These are operated by simply turning a handle.
- Its capacity varies from 5-15 liters.

Water closet :-

Water closet is defined as a sanitary fitting which is design to receive human excreta from the person using it.

EXPECTED QUESTIONS.

1. Answer the following questions.

   a) Define trap.
   b) Define gully trap
   c) What is floor trap.
   d) Define vent pipe.
   e) What do you mean by soil pipe.
   f) Define water closet.
   g) What do you mean by flushing cisterns.

1. What is the function and requirements of trap.
2. What is trap? How many types of traps are thee? Explain with sketch.

CHAPTER-6

QUALITY OF SEWAGE

Analysis of sewage:-

The sewage is analyzed by the fallowing three categories.

1. Physical test
2. Chemical test
3. Biological test

1) **Physical test :-**In physical analysis the test are carried out to examine sewage for the fallowing.

- Color
- Odour
- Temperature
- Turbidity

1. Color :-

- If the colour is yellowish , grey, light brown, it indicates fresh sewage.
- If the colour of sewage is black or dark it indicates septic or state sewage.

2. Odour :-

- The natural fresh domestic sewage has practically no odour and is not objectionable.
- The state sewage has peculiar odour specially that of hydrogen sulphite.
- The presence of certain industrial waste will impact special odour to the sewage.

3. Temperature :-

- The temperature of normal domestic sewage is slightly higher than that of water.
- If the temperature is below normal, it indicates the presence of ground and surface water mixed.
- If the temperature is above normal , it indicates the presence of hot industrial water.

4. Turbidity :-

- The sewage is generally turbid. It is due to the presence of suspended matter.

2) **(7 marks. Not so important)**

Chemical test :- Chemical analysis is carried out to examine the sewage for the fallowing.

1. Chlorine
2. Fat & greases
3. Nitrogen
4. Oxygen
5. PH value
6. Total solid

1. **Chlorine :-**Two types of chlorine test is carried out.
    - Chlorine demand test
    - Chlorine residual test

Chlorine demand test :-The amount of chlorine required for proper disinfection of sewage having unstable organic matter is called chlorine demand and test is called chlorine demand test.

Chlorine residual test :-After treatment of sewage some residual chlorine should be present in sewage for future disinfection. This amount of residual chlorine is calculated in this test.

Fat , greases and oils :-The quantity of fat ,grease and oil present in a sample of sewage is determined as either soluble matter.

It is undesirable in the sewage and it block the filter media.

3) **Nitrogen test :-** The nitrogen present in sewage either as free ammonia or albuminoidal ammonia or nitrites or nitrates.

- The presence of considerable amount of free ammonia indicates state or old sewage.
- The presence of nitrites indicates the intermediate stage of conversion of organic matter in stable forms.
- The presence of nitrates indicates the most stable form of nitrogenous matter present in sewage.

4) **Oxygen :-** The oxygen in a sample of sewage reported in the fallowing 3 ways.
   i) Dissolved oxygen
   ii) Oxygen consumed
   iii) Oxygen demand

1) **Dissolved oxygen (DO) :-** It is also called DO. It represent the amount of oxygen in dissolved state in sewage. Generally sewage has no DO.
   Its presence indicates the sewage is fresh.
2) **Oxygen consumed :-** In this test the quantity of oxygen consumed by the carbonaceous matter present in sewage is determined.
3) **Oxygen demand :-** It is the amount of oxygen demanded by the sewage for the oxidation of inorganic matter and organic matter. The amount of oxygen demanded by organic matter in sewage is called biochemical oxygen demand which is commonly called BOD. It is of two types. B.O.D & C.O.D.

BOD (BIOCHEMICAL OXYGEN DEMAND) (2marks)

The amount of oxygen required for microbes to carry out the biological decomposition of dissolved solids or organic matter in sewage under aerobic condition at standard temperature is known as BOD.

Chemical oxygen demand (COD):- (2 marks)

⇒ The COD can be defined as the amount of oxygen required to oxidize the organic matter chemically, by strong oxidizing agent, under acid conditions .

⇒ The COD of sewage is higher than its BOD .

⇒ The limiting Value of COD is 250 PPM

P^H value :-

◊ The test for P^H value decides the acidic or alkaline nature of sewage.

◊ This test is important as some treatment method depends on P^H value for efficient working.

◊ The fresh sewage is generally alkaline in nature.

◊ It becomes acidic as time passes.

◊ They properly oxidized influent should have a P^H value of 7.3 or so.

Total Solid :-

* The sewage contains organic and inorganic solids which may be in suspension solution or coeloidal form.
* It is necessary to know the total solids for determining the line of treatment.
* The test are generally made to determine the following.
  (1) Total solids
  (2) Suspended and dissolved solids
  (3) Settlable solids

BOD (BIOCHEMICAL OXYGEN DEMAND) (5 marks)

- The amount of oxygen required for microbes to carry out the biological decomposition of dissolved solids or organic matter in sewage under aerobic condition at standard temperature is known as BOD.
- The organic matter in sewage is classified into the fallowing two group.
- Carbonaceous matter
- Nitrogenous matter
- In the first stage ,the carbonaceous matter is oxidized and in the second stage the nitrogenous matter is oxidized.

- For complete oxidation ,100 days will be required but the rate of demand ,in the 1st stage is very rapid.
- So BOD test is made for a period of 5 days or 10 days.
- The 5 days BOD is about 60% and the 10 days BOD is 90% of the ultimate BOD.
- BOD is worked out either by direct method or by dilution method.
- In direct method it is directly measured man metrically.
- In dilution method it is calculated by the equation.

$BOD)_{5days}$ = Loss of oxygen in PPM × Dilution ratio

Q. For a 5days BOD test, a sample of sewage was diluted with water with a dilution factor of 100. If the contents of DO in the beginning and at the end of the test are 13 PPM and 8 PPM respectively, then calculate the 5day BOD and remark the nature of sewage.

Ans :-

Given Dilution factor (ratio)=100

Loss of oxygen in PPM =13 PPM – 8 PPM =5 PPM

Now $(BOD)_{5days}$ =Loss of oxygen in PPM × Dilution ratio

=5 × 100

=500 PPM

So the sewage is very strong. It requires heavy treatment before disposed.

Q. Calculate the 5day BDO of the unseeded sample of sewage.

Initial DO =9Mg/Lit(PPM)

Final DO = 5Mg/Lit

Bottle Volume = 300ml

Sample Volume = 6ml

Ans :-

Dilution ratio = Bottle Volume/Sample Volume

=300/6

=50

Loss of oxygen in PPM = 9PPM – 5 PPM

= 4 PPM

$(BOD)_{5day}$ = Dilution ratio × Loss of oxygen in PPM

=50×4

=200 PPM

Limitation of BOD test :- (5 marks)

Following are the limitations of BOD test.

1. If the sample of sewage contains toxic waste , it should be given pretreatment before applying the BOD test.

2. It should essential to have a high concentration of active bacteria present in the sample of sewage.

3. The effect of nitrifying organis in should be reduced before applying the test.

4. This test measures only the biodegradable organis ims.

5. The time required for this test is arbitrary & long.

Chemical oxygen demand (COD):- (5 marks)

⇒ The COD can be defined as the amount of oxygen required to oxidize the organic matter chemically, by strong oxidizing agent, under acid conditions .

⇒ The COD of sewage is higher than its BOD .

⇒ The limiting Value of COD is 250 PPM

⇒ The COD test is also done to measure organic matter present in industrial waste , having toxic compound.

⇒ The ratio of COD to BOD found to be vary from 1.2 to 1.5

⇒ If the ratio is greater than 3,then the sewage is considered as difficult to biodegradable.

⇒ If this ratio exceeds 10, then the sewage is considered as non-biodegradable.

CHAPTER-7

Sewage Disposal

Natural methods of sewage disposal :-

The methods of sewage disposal can be divided into two catagories.

a) Artificial method
b) Natural method

Natural method :-

The natural method of sewage disposal is again divided into two types.

1. Disposal by dilution (7 MARKS) OR (Self purification of river)
2. Disposal by land treatment. (7 MARKS)

Disposal by dilution :-

- In this process the raw sewage is thrown into natural water having large volume.
- In this process the sewage is purified by self purifying capacity of natural water.

Condition favorable for dilution :-

1 . It is possible only to provide primary treatment to the sewage i.e, removal of floating matter and settle able solids.

2 . The diluting waters are not used for the purpose of navigation for at least some reasonable distance on the d/s from the point of sewage disposal.

3 . The dissolved oxygen content of the diluting water should be high.

Self purification of natural water :- (7 MARKS)

Definition :-

- It is defined as the process purification of natural rivers by itself through regaining the oxygen from the atmosphere after disposal of sewage.
- When sewage is discharged into natural water its organic matter gets oxidized by the DO content in water.
- This deficiency of DO create in water is again filled up by the absorption of atmospheric oxygen. This phenomenon of natural water is called self purification of natural water or river.
- The self purification process of river consists of following zones.
    1. Degradation zone
    2. Active decomposition zone.
    3. Recovery zone
    4. Clear water zone

1 . Degradation zone :-

⇒ This zone is situated just near the point of entering sewage in to the stream.
⇒ In this zone the water is turbid with dark colour.
⇒ The decomposition of solid matter takes place and anaerobic decomposition held.

2 . Active decomposition zone :-

⇒ This zone is just after the degradation zone. In this zone the water is grayish and darker than previous zone.
⇒ The objectional odour of H_2S and other sulphus compound exist.
⇒ The scum may also be seen on the surface in this zone.

3 . Recovery zone :-

⇒ In this zone the stabilization of organic matter takes place and the BOD of water is reduced .
⇒ The DO content again start rising up above 40% of saturation value.
⇒ The bacterial load decreases as the food supply of bacteria diminishes

4 . Clear water zone :-

⇒ In this zone the stream attains the normal condition as were prevailing before sewage has discharge into it.

Land treatment method of sewage disposal :- (7 MARKS)

- In this process the sewage is applied on land.
- A part of sewage evaporates and the remaining portion percolates through the soil. Which is caught by the underground drain for disposal into natural water.

Sewage farming :- (2 MARKS definition. Most imp)

When sewage is applied on a land it adds to the fertilizing value of land and the crops can be profitably raised on such type of land. This phenomena is termed as sewage farming.

Condition favorable for land treatment :- (5 MARKS)

1. The area for the land treatment is composed of sandy, loamy soil over soft Murom. Such soils are easily aerated and it is easy to maintain aerobic conditions in them.
2. The rain fall in the area is low as it will assist in maintaining good absorption capacity of soil.
3. There is absence of river or other natural water sources.
4. There is demand for cash crops which can be easily grown on sewage farms.
5. There is availability of large open areas in the surrounding locality for practicing broad irrigation by sewage.

Methods of applying sewage :- (7 MARKS)

Following are the three methods of application of sewage on land.

1. Sprinkler or spray irrigation
2. Subsurface irrigation
3. Surface irrigation

1 . Sprinkler or spray irrigation :-

⇒ In this method the sewage is sprayed over the soil through nozzles.
⇒ This nozzles are fitted at the tips of pipes.
⇒ The sewage is sprinkled under pressure.
⇒ This process can also be used for watering gardens and lawns.
⇒ This method of sewage application is used for sandy soil and hilly land.

2 . Subsurface irrigation :-

⇒ In this method the sewage is supplied directly to the root zone of plants through underground pipe system.
⇒ The sewage pecolates through open joints and distributed in surrounding area through capillary action
⇒ This method is useful for places where rainfall is poor and demand for irrigation is high and water level is low.
⇒ This method is costly and gives less yield of crop.

3 . Surface irrigation :-

⇒ In this method the sewage is applied on surface of land.
⇒ It is also known as brood irrigation.
⇒ This method is widely adopted in practice.
⇒ The various modes of application of this irrigation are as given below :-

1. Basin method
2. Flooding method
3. Furrow method
4. Managed turf method
5. Zigzag method

1 . Basin method :-

- In this method the basins are constructed around the plants and they are filled by sewage.
- The sewage slowly percolate to the root zone of plant maintaining the root zone in damp condition.
- This method is useful to orchard and gardens of fruit trees

2 . Flooding method :-

- In this method the land to be treated with sewage is divided to rectangular plats of convenient dimensions.
- The subsoil drain pipes are provided to supply air to the soil and to remove the percolated effluent through the soil.

3 . Furrow method :-

- In this method the furrow and ridges are formed as shown in fig.
- The furrows are very small ditches of depth 300-500mm and width 1.2-1.5m
- The subsoil drain pipes collect percolated effluent and lead it to nearby natural water for disposal.
- The furrows are filled with sewage and from their sides and beds they saturate the root zone of plant which are grown on ridges.
- This method is useful when sewage is not to be kept in contact with beds of crop.

4 . Managed turf method :-

- In this method the turf is prepared i.e, the grass plants are sodded on the land. Then the sewage is applied from pipe laid underground.
- So the suspended solids are deposited at the roots of grass plant.
- The microbes attack the suspended solids and convert them into simple form of CO_2 and H_2O.

- The percolated effluent is collected in the intercepting canal and safely discharge into the natural waters.

5 . Zigzag method :-

- In this method the sewage is conveyed in the form of corrugation.
- The ridges are made of small earthen banks.
- Then the sewage flows in a zigzag path.
- The subsoil drains are provided to collect the percolated effluent.
- This method is very useful for lands which are practically revel.

What is sewage sickness? What are the preventive measures of sewage sickness?

Sewage Sickness :- (2 MARKS. Most imp)

If sewage is applied continuously on a particular land, the voids of soils are filled up or clogged . The free circulation of air is prevented and an aerobic condition developed . In this stage the land is unable to take any further sewage load. The organic matter decomposes and foul-smelling gasses are produced . This phenomenon of soil is called sewage sickness of land.

Preventive measures of sewage sickness:- PAGE 492, RANGWALA

Advantages and disadvantages land treatment method :-

Advantages :-

1. It increases the fertility of land
2. It is cheap where land is available in plenty.
3. The application of sewage on land is the best method of supplying manure to the soil.
4. The increased fertility of land results in profitable returns of crops.
5. The method does not require costly equipment for its working.
6. The method proves economical and safe where available irrigation water is scarce in quantity.
7. The water of irrigation canal is saved when this method is practiced.

Disadvantages :-

1. The crops grown on sewage farms are generally liked by ordinary public.
2. The method is not applicable for all seasons of year. In monsoon , some other arrangement of sewage disposal has to be found out.
3. The method requires large area of land, which may not be available in some cases
4. The types of crops grown on sewage treated land are limited in number.

CHAPTER-8

SEWAGE TREATMENT

The treatment of sewage is broadly classified into three types.

1. Primary treatment
2. Secondary treatment

3. Disinfection

1 . Primary treatment :-

In primary treatment the large solid from the sewage are removed and more complex compound are broken up and converted in to simpler compounds.

The primary treatment includes

I) Screen
II) Grid chamber
III) Detritus tank
IV) Skimming tank
V) Sedimentation tank

iii)Detritus tank :-

Purpose :-

The purpose of this tank is same that of a grid chamber.

It is a grid chamber having such velocity of flow that an appreciable amount of organic matter also settles down at bottom together with the grid.

Description :-

These tanks are generally rectangular in shape. The side of the tank are vertical and tapered at the bottom for the collection of destritus.

Design aspect :-

Depth :- The overall depth of this tank varies from 2.5m-3.5m

Detention period :- The detention period of this tank is about 3-4minutes

Velocity of flow :- The velocity of flow is kept between 200-400mm/sec

These are the grid chamber design to flow with a smaller velocity & longer detention period.

They are able to separate out not only he larger grid but also the very fine sand particles.

iv)Skimming tank :-

Purpose :-

The object of skimming tank is to remove the floating substances like grease , oil , soap , wood pieces , fruit skins etc.

Design aspect :-

Following are the design aspect

1 . Air defuser :- These are provided at the bottom of tank from which compressed air sek up the current resulting the rise of floating.

2 . Collection of floating substances :- The floating substances collected at the top of tank, are removed with hand or machine.

3 . Detention period :- The detention period of this tank are about 3 – 5 minutes.

4 . Outlet :- Submerged outlet is provided to prevent the floating substances from going to the outlet channel.

5 . Shape :- The shape of a skimming tank is generally elliptical or circular with depth 1m.

Clarifier :-

2 . Secondary treatment :-

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

This treatment involves 2 processes.

i. Filtration
ii. Activated sludge process

i)Filtration:-

The filters are of 4 types

I) Contact bed
II) Intermitted sand filter
III) Trickling filter
IV) Miscellaneous filter

I . Contacted bed :-

⇒ These are also called contact filters.
⇒ In this filter the sewage effluent is kept in contact with filtering media for some period.
⇒ As the sewage passes through filtering media, an organic film is produced around the particles.
⇒ Oxidation is carried out by aerobic bacteria.

Constructional features :-

⇒ It is a water tight tank filled with the filtering media of graves , ballast or broken stone.
⇒ The tanks are dug below ground level provided with concrete lihing.

Working :- The cycle of operation consists the 4 stages.

i. The tank is filled with sewage effluent .
ii. The effluent is allowed to stand on filter media for 2 hours.
iii. Then the tank is emptied and the effluent is allow to flow.
iv. Finally the contact bed is allow to stand empty for 6 hours.

It removes bacterial load 50 -75% organic matter 60 - 80% and suspended matter 80 – 90 %

III . Trickling filter :-

There are 2 types of trickling filter.

a) Standard rate trickling filter
b) High rate trickling filter

a)Standard rate trickling filter :-

1) Structural feature :-

Following are the structural feature of the trickling filter.

i. **Shape :-**The shape may be circular or rectangular.
ii. **Filter media :**-It consists of crushed rock or clinker. It is essential to provide filtering media of uniform size. Its size varies from 30 - 80mm.
iii. **Floor :**-The floor is generally made up of RCC of thickness 100 – 150mm. Its slope may be towards the central drain.

iv. **Under drainage system :-** Suitable under drainage system are arranged to collect the sewage from the bottom of the filter after filtration. It consists of specially manufactured block or half run tiles.

v. **Ventilation :-** Ventilation should be provided for successful working of filter. Suitable arrangements are done for this purpose.

vi. **Distribution :-** It function is to spread the influent evenly on the filtering media. Moveable and fixed , two types of distributors are used.

vii. **Dosing tank :-** The sewage is applied for 3 – 5 minutes . Then it is stopped for a period of 3-10 minutes. It is not applied continuously.

ii)Treatment of sewage :- The treatment of sewage in standard rate trickling filter is carried out in 3 stages.

1) **Primary sedimentation :-** It removes large suspended particles preventing the clogging of filter media.
2) **Filtration :-** The filter remove the total solid of sewage to some extent only. Its main function is to change the nature of suspended solid. So some post filtration treatment is essential for the effluent.
3) **Post filtration treatment :-** This is done by providing secondary clarifiers.

iii)Design aspect :-

Depth :- The effective depth is between 1.8-2.4m

Number :- The minimum number of trickling filter should be two. So that one can be taken out of use for repair.

Rate of filter loading :- It is 1000-2200kg of BOD per hectare meter per day.

iv)Advantages :-

1. The effluent is highly nitrified and stabilized
2. The mechanical wear and tear is small
3. The moisture content of sludge is as high as 99%
4. Its operation requires less electrical power.
5. Its working principle is very simple.

v)Disadvantages :-

1. Cost of construction is high.
2. Loss of head is high.

3. The process creates bad odour.
4. It requires large land area.

vi)Use :-This filtering process is popular at present especially of high rate type.

II) **High rate trickling filter :**

Definition :-these are like the standard rate trickling filters except the rate of loading on this filter is very high, which is increased by the process of recirculation of sewage .

These filters consist of pumping back and throwing the treated sewage effluent again in the early unit of treatment by which its quality is improved and rate of loading is increased.

Types :-These filters are of five types .

1) Accelo-filter system
2) Aero-filter system
3) Alternating double filtration
4) Bio filtration
5) Enclosed filtration

Advantages & Disadvantages

CHAPTER-9

ACTIVATED SLUDGE PROCESS

DEFINITION :-

- Activated sludge is the sludge which is obtained by setting of sewage in presence of abundant oxygen.

- This sludge is biologically active and contains a great number of aerobic bacteria and other micro –organisms.
- This bacteria and micro organisms have got an unusual property to oxidize the organic matter.

Property /Characteristics :-

- It contains fertilizing constituents.
- Its colour indicates the degree of aeration.
- Light brown colour indicate under aerated sludge.
- Golden brown colour indicates well aerated sludge
- Muddy brown colour indicates over aerated sludge
- The moisture content of activated sludge is very high i.e 95% of water.

Action of activated sludge :-

- In this activated sludge process , the activated sludge is mixed with raw sewage or practically treated sewage.
- The sewage is given the usual primary treatments first.
- Then the activated sludge is mixed properly with sewage which contains sufficient of oxygen.
- The micro organisms present in the sludge multiply rapidly.
- Then the organic solids present in the sewage are rapidly oxidized.
- The suspended and colloidal matters coagulate and form a readily settle able precipitate.
- After the precipitate settles down the efficient is clear. This effluent contains very low amount of organic matter and need not require any further treatment except chlorination.
- A portion of this settled sludge is sent for recirculation and the remaining part is sent to the sludge digestion tank.
- Finally this digested sludge is harmless.

Advantages & disadvantages

Flow diagram of activated sludge process.

CHAPTER-10

SLUDGE DISPOSAL

LAGOONING & PONDING :-

- A lagoon is a shallow pit formed by excavating the ground.
- Its depth is about (0.6-1.2)m
- At the bottom of the lagoon, a layer of ashes having depth 150mm is placed.
- The under drains of agricultural tile drains (100mm dia) and placed at bottom lagoon at a distance of 3m.
- The embracements are formed by the excavated material.
- The wet sludge is brought in to the lagoon and then left there to dry by natural process such as evaporation and percolation.
- The total period of drying is 2-6 months.
- Then the dried sludge is removed from the lagoon.
- The sludge disposed by lagooning is quite cheap but it offensive odour & fly nuisance.

Oxidation pond /oxidation ditch :-

Definition :-

It is an artificial pond of shallow depth formed for the retention of sewage for sufficient time.

It is also known as sewage stabilizing pond or lagoon.

These ponds are used to treat raw sewage or partially treated sewage.

Action :-

- The oxidation ponds purify sewage by dual action of aerobic bacteria and algae.
- The sewage is stored under climatic condition such as sunshine and warmth for the growth of algae.
- The aerobic bacteria obtain oxygen from the atmosphere and used in the decomposition process.

- The Co_2 produced during decomposition is broken up by algae by photosynthesis is in to C & O_2.
- The 'C' is used in producing more carbohydrates and the O_2 keeps the D.O content at high level.

Construction :-

These are constructed with shallow depth of (0.9-1.5)m shallow depth permits the penetration of sunlight and thus encourages the growth of algae.

The pond is constructed into compartments suitable sizes.

The sewage is allowed to flow in zigzag manner through these compartments.

Design aspects :-

- For proper development of algae , the detention period should be at least 7 days and preferably 2 to 6 weeks.
- The area required various form 250 to 1000 persons per hectors.
- The loading interim of B.O.D varies from 150 to 300 kg/hecter/day.

Use :-

The oxidation ponds are suitable for small towns with dry & warmth climate.

IMHOFF TANKS :-

These are the type of sludge digestion tank which have two storey's, hence also known as the two storey's digestion tank.

Components :-

1) Sedimentation chamber :-

- It is the upper compartment of the tank.
- The sewage is admitted to this chamber & flows with low velocity.
- The chamber are provided with suitable inlet and outlet devices.

2) Slot :-

- This is an opening provided in the bottom of sedimentation chamber.
- Through this opening , the settled solids of the sedimentation chamber pass in to the digestion chamber.
- The minimum width of slot is 150mm.

3) Digestion chamber :-

- This is the lower compartment of the imhoff tank.
- The solids settled in the sedimentation chamber are digested.
- The bottom of the chamber is in the form of inverted canes.

4) Natural zone :-

- The portion of inhoff tank between the bottom of sedimentation chamber and top of digestion chamber is known as natural zone .
- Its depth is about 450 to 500mm.

5) Gas vent :-

- It is the portion above the natural zone and by the side of the sedimentation chamber.
- It is also known as scum chamber.
- The gases formed in the digestion chamber are collected in the gas vent area.

6) Sludge removal pipe :-

- By this pipe the digested sludge at the bottom is removed.
- Its minimum diameter is 150mm-200mm.

7) Roofs :-

- The imhoff tanks are generally not provided with roofs .but when it is desired to avoid the nuisance due to bad smell of gases the roofs may be provided.
- Enough vents are provided in the roofs. Arrangement should be kept for inspection, repairs and cleaning of the tanks.

Design aspects :-

- The shape of sedimentation tank is rectangular with length less than 300m.
- The length to width ratio is (3-5)
- The total depth of imhoff tank varies from (6-11)m.
- Velocity of flow of sludge in the tank is 300mm/minute .
- Detention period varies from 2-4 hours.
- The digestion chamber has the minimum capacity of $0.057m^3$/capita.
- The area of scum chamber should be about 25% -30% of total plan area.

Uses :-

These tanks are suitable for small cities.

Sludge volume index :-

- It denoted as SVI.
- It is used to indicate the degree of concentration of sludge which reflects the physical state of sludge.

Sludge Bulking :-

An excellent activated sludge when overloaded becomes sick resulting in the setting of sludge in volume. This phenomena is called sludge buckling.