GOVT. POLYTECHNIC MAYURBHANJ

DEPARTMENT OF CIVIL ENGINEERING

LECTURE NOTES

ON

Water Supply & Waste Water Engineering

5TH SEMESTER

PREPARED BY:

SUBHASMITA NAIK

Sr. Lecturer

Date: 19.09.2022

Introduction :-

Water Supply engineering is a branch of civil engineering Consult with the developement of Source of water Supply, transmission, distri-bution and treatment of water.

They deals with :-

(i) Assessment of ground water, Surface water and drinking water Supply.

(ii) Surface water Collection and Storage.

(iii) Convensional water treatment plan for ground water and Surface water.

(iv) Requirement for Public Commercial and industrial activites.

Necessity of treated water Supply :-

Now a days. water requirement is increasing day by day as people lived in Small isolated area & they are habits and like style also changed. The roll of water Supply Skill is Collection, Convence treatment & distribut-ion of water forms in handy water is required for the following Purpose.

① Drinking & Cooking
② Bathing, washing of clothes and utencile
③ Washing of vehicles
④ Gardening
⑤ Swimming Pool, fountains
⑥ Fire fighting
⑦ ~~Trade~~ Trade and industries.

1 mark 2 marks

Per Capita Demands :-

→ The demand of water per person per day is known as per capita demand or per capita consumption.

→ To obtained the per capita demand.

$$= \frac{\text{The total Consumption of water in a year}}{\text{The total population} \times \text{number of days in a year}}$$

$$= \frac{\text{Yearly Consumption of water (in litter)}}{\text{Population} \times 365}$$

→ It is expressed as litter/day.

→ For an indian town the average per capita demand varies from 150 litter to 300 litter per day.

I.m.p 5 marks

Types of demand of water :-

① Domestic demand
② Commercial demand
③ Industrial demand
④ Public demand
⑤ Fire demand
⑥ Compensate loss

Date:- 20.09.2022

① Domestic demand :-

The domestic demand includes the water required in the house for drinking, bathing and washing of clothes & utensils, Sanitary blocks, Private vehicles, gardening etc. The requirement of water for domestic animal is also included in this demand for this purpose demand is assumed as 135 litters per day per Capita.

② Commercial demand :-

It includes the water demand in Commercial centre like office buildings, hotels, restaurants, shopping centre, cinema halls, motor garage, laundries, dairies etc. For this purpose the demand is assume as 25 litters to 40 litters per day per capita.

③ Industrial demand :-

The industrial demand of water depends on the types of industries in the area the number and types of industries. Such as cloth mill, Paper mill, Sugar mill, chemical industry, home pipe, rolling mill etc. The water demand for this purpose is generally assumed as 20 to 25 % of the total water demand of the city.

④ Public demand :-

It includes the water requirement for public places such as public sanitary blocks, Parks, Swimming Pool etc. The water demand for this purpose is considered as 5 % of total Consumption water in the town or city.

⑤ Fire demand :-

In case of any outbreak of fire in busy area of a town, sufficient quantity of water may not available for fire fighting from the surface ~~Sources~~ Sources such as Ponds, ditches, open well etc. Hence requisite of water of fire fighting should always be kept stored in under ground reservoir.

for safety, an additional amount of water is taken account which is 10%. The required quantity of water for fire demand is calculated by the following empirical formulae.

(i) The national board for fire underwriters formulae ⇒ $Q = 4637\sqrt{P}\,(1 - 0.01\sqrt{P})$

here, Q = litter per minute
P = population in thousand.

(ii) Free man's formulae

⇒ $Q = 1136.50\,\frac{P}{5} + 10$

(iii) Buston's formulae

⇒ $Q = 5663\sqrt{P}$

Q = litter per day

(iv) Kuchling's formulae

⇒ $Q = 3182\sqrt{P}$

Q = litter per minute

Compensate loss for safety and additional amount of water of 10% should be taken into amount.

⑥ Compensate loss :-

Some portion of water is always wasted due to the following reasons :—

(i) defective pipe joint
(ii) Crack in pipe line
(iii) Faulty valves and fitting
(iv) Consumer may keep the tap open.
(v) Public taps may be damaged
(vi) Unauthorized Connection.

Hence in the above cases 15% of water requirement should be taken as water allowance.

V.V.I 5 marks

Factors affecting demand :-

~~(i) Climatic Condition~~

The following are the various factors that affect the rate of demand :-

(i) Clamatic Condition :-

The demand of water is more in Summer and less in winter. Again demand varies according to hot and cold places. The demand is more on a very hot day and it is less on a cloudy or rainy day.

(ii) Cost of water :-

If the water tapes is implemented by providing water meter, then the consumption of water will be less. The Consumer will Control the wastage of water on their own interest.

Thus the higher cost and lower cost will be vary according to their Consumption.

(iii) Distribution Pressure :-

If the distribution Pressure is very high the water Consumption will be more. Maximum water is lost unnecessarily if the tape is kept open after bathing, face washing etc.

(iv) Habits of People :-

Due to advance life style water Consumption is very high. The rate is average in middle class zone and the rate is very low in slum area (village).

(v) Industry :-

Every industry requires much water for operation and maintenance so the Presence and absence of industry in a town or city affects the rate of demand.

(vi) Quality of water :-

The good quality of water increases the rate of demand, where as the bad quality decreases the rate.

(vii) Sewerage System :-

The existance of Sewerage system in a town or city increases the rate of demand.

(viii) System of Supply :-

In a continuous system of supply the consumption of water is more, as there is a very chances of misuse and wastage of water. So the rate of demand is more. In an intermittent system of supply in which the water consump-tion is less, as water is supplied in specific period of day. There is a little chance of misuse. So the rate of demand is less.

Method of forecasting Population :-

The following are the general methods for population forecast :-

(a) Mathematical method
(b) Decreasing rate of growth method
(c) Simple graphical method
(d) Comparative graphical method
(e) water plan method.

(a) Mathematical method :-

It is of three types :-

(i) Arithmatical method
(ii) Geometrical method
(iii) Incremental increase method.

(i) Arithmetical increase method :-

In this method, the rate of increase in population is assumed as constant, so the average popul-ation is workout from the past decades, this avarage is added to the present population and the population of successive decades to get required population.

Q. The census records of a town, show the population as follows :-

Present population = 50,300
Population before one decade - 46,500
Population before two decade - 43,100
Population before three decade - 40,500

Calculate the probable population after one, two, three decades by arithmatical method.

Ans :- Increasing population between present and before past decade population.

= 50,300 - 46,500
= 3800

Increasing Population between before one decade and before two decade

= 46,500 - 43,100
= 3400

Increasing population between before two decade and before three decade.

$= 43,100 - 40,500$

$= 2600$

Total increasing $= 3800 + 3400 + 2600$

$= 9800$

Avanage increase per decade $= \frac{9800}{3}$

$= 3267$

→ After one decade population

$= 50,300 + 3267$

$= 53567$

→ After two decade Population

$= 53567 + 3267$

$= 56834$

→ After three decade Population

$= 56834 + 3267$

$= 60101$

Q.

The census record of a small town is as follows —

Year	Population
1930	9,000
1940	13,000
1950	17,500
1960	23,000

Calculate the Probable population in 1970, 1980, 1990 by arithmatical increase method.

Ans:- Increasing Population between 1940 and 1930

$= 13,000 - 9,000$

$= 4000$

Increasing Population between 1950 and 1940

$= 17,500 - 13,000$

$= 4500$

Increasing Population between 1960 and 1950

$= 23,000 - 17,500$

$= 5500$

∴ Total increasing in population $= 4000 + 4500 + 5500$

$= 14,000$

Avarage increase Per ~~dec~~ Population $= \frac{14000}{3}$

$= 4666.66$

$\simeq 4667$

→ After 1970 increase in population $= 23,000 + 4667$

$= 27,667$

→ After 1980 increase in population $= 27,667 + 4667$

$= 32,334$

→ After 1990 increase in population $= 32,334 + 4667$

$= 37001$

∴ All Population are in 37001 .

Q. The Census record of a town Show the Populati-on as follows :—

(i) Present population = 50,300

(ii) Population before one decade = 46,500

(iii) Population before two decade = 43,100

(iv) Population before three decade = 40,500

Calculate the Probable Population after one, two and three decades by geomatical method:

Ans:- Percentage increasing Population between Present and before one decade Population.

$$= \frac{50,300 - 46,500}{46,500} \times 100$$

$$= 8.17\ \%$$

Percentage increasing Population between one decade and two decade.

$$= \frac{46,500 - 43,100}{43,100} \times 100$$

$$= 7.88\ \%$$

Percentage increasing Population between two decade and three decade.

$$\frac{43100 - 40,500}{40,500} \times 100$$

$$= 6.41\ \%$$

∴ The total increasing in population = 8.17 + 7.88 + 6.41

= 22.46 %

∴ Avarage increase per decade = $\frac{22.46}{3}$

= 7.48 %

= $\frac{7.48}{100}$

= 0.074

∴ After one decade Population = 50,300 + (50,300 × 0.074)

= 54022.2 ≅ 54023

∴ After two decade Population = 54023 + (54023 × 0.074)

= 58020.70 ≅ 58020

∴ After three decade population = 58020 + (58020 × 0.074)

= 62314

∴ All population increase in 62314 .

Q

The Census record of a Small town is as follows:-

year	Population
1930	9,000
1940	13,000
1950	17,500
1960	23,000

Calculate the Probable population increase in 1970, 1980 and 1990 by geomatical increase method.

Ans:- Percentage increase in year population 1940 and 1930 $= \frac{13,000 - 9000}{9000} \times 100$

$= 44.44\%$

Percentage increase in year Population 1950 and 1940 $= \frac{17,500 - 13,000}{13,000} \times 100$

$= 34.61\%$

Percentage increase in year Population 1960 and 1950 $= \frac{23,000 - 17,500}{17,500} \times 100$

$= 31.42$

∴ Total increase in year population

$= 44.44\% + 34.61\% + 31.42$

$= 110.47$

Avarage increase in year population

$= \frac{110.47}{3}$

$= 36.82\%$

$= \frac{36.82}{100}$

$= 0.36$

∴ After 1970 increase in population

$= 23,000 + (23,000 \times 0.36)$

$= 31280$

∴ After 1980 increase in Population

$= 31280 + (31280 \times 0.36)$

$= 42540.8$

$= 42541$

∴ After 1990 increase in Population

$= 42541 + (42541 \times 0.36)$

$= 57855$

∴ All Population increase in 57855.

Gemetrical increase method :-

In this method, It is assume that the Percentage increase in Population remains Constant from the ovel Census recod, the Percentage increase is workout then the Population of successive feture decades is calculated according to the Procedure.

Date :- 23.09.2022

Incremental increase method :-

In this method, the average increase in Population is first workout as per arithmatical increase method. Then the average incremental increase method is found out then both the average are counted to get the population in feature decades.

Q. The Census records of a town as follows :- Show the Population as follows :-

(a) Present in Population = 50,300
(b) Population before one decade = 45,500
(c) Population before two decade = 43,100
(d) Population before three decade = 40,500

Calculate the probable population after one, two, three decades by incremental increase method.

Ans:- Increase in Population Present and before 1st decade Population

$= 50,300 - 46,500$

$= 3800$

Increase in Population one decade and two decade Population

$= 46,500 - 43,100$

$= 3400$

Increase in Population two decade and three decade Population

$= 43,100 - 40,500$

$= 2600$

∴ The total increase in Population

$= 3800 + 3400 + 2600$

$= 9800.$

∴ The Avarage increase in Population

$= \frac{9800}{3} = 3267$

∴ Incremental increasing in Population

$= 3800 - 3400$

$= 400$

∴ Incremental increasing in Population

$= 3400 - 2600$

$= 800$

∴ The total incremental increase in Population
= 800 + 400 = 1200.

∴ The Avarage incremental increase in Population
$= \frac{1200}{2}$
= 600.

∴ Increase in Population one decade
= 50,300 + 3267 + (1 × 600)
= 54167.

∴ Increase in Population two decade
= 54167 + 3267 + (2 × 600)
= 58634

∴ Increase in Population three decade
= 58634 + 3267 + (3 × 600)
= 63701

∴ All Increase in Population 63701.

Q. A Census records of a town, as Follows :-

Year	Population
1930	9,000
1940	13,000
1950	17,500
1960	23,000

Calculate the Probable Population in 1970, 1980, 1990 by incremental increase method.

∴ The total incremental increase in Population
= 800 + 400 = 1200.

∴ The Avarage incremental increase in Population
= $\frac{1200}{2}$
= 600.

∴ Increase in Population one decade
= 50,300 + 3267 + (1 × 600)
= 54167.

∴ Increase in Population two decade
= 54167 + 3267 + (2 × 600)
= 58634

∴ Increase in Population three decade
= 58634 + 3267 + (3 × 600)
= 63701

∴ All Increase in Population 63701.

Q. A Census records of a town, as Follows –

Year	Population
1930	9,000
1940	13,000
1950	17,500
1960	23,000

Calculate the Probable Population in 1970, 1980, 1990 by incremental increase method.

Ans :- Increase in year Population 1940 and 1930

$= 13,000 - 9,000$

$= 4000$

Increase in year Population 1950 and 1940

$= 17,500 - 13,000$

$= 4500$

Increase in year Population 1960 and 1950

$= 23,000 - 17,500$

$= 5500$

∴ The total increase in year Population

$= 4000 + 4500 + 5500$

$= 14,000$

∴ The average increase in year Population

$= \frac{14000}{3}$

$= 4667$

∴ Incremental increase in year Population one decade

$= 4500 - 4000$

$= 500$

∴ Incremental increase in year Population two decade

$= 5500 - 4500$

$= 1000$

∴ The total incremental increase in year Population

$= 1000 + 500$

$= 1500$

∴ The average in year Population

$= \frac{1500}{2} = 750$

Increase in ~~Population year~~ Population 1970

$= 23,000 + 4667 + (1 \times 750)$

$= 28417$

Increase in year Population 1980

$= 28417 + 4667 + (2 \times 750)$

$= 34584$

Increase in year Population 1990

$= 34584 + 4667 + (3 \times 750)$

$= 41501$

∴ All Population increase in 41501.

Date:- 24.09.2022

Decreasing rate of growth method :-

In this method, the average decrease in Percentage increase is calculated. This average is deducted from the Percentage increase of each successive decades accordingly. Then the Population of the successive decades is workout accordingly.

Q. The Census records of a Small town is as follows :-

year	Population
1930	9,000
1940	13,000
1950	17,500
1960	23,000

Calculate the Probable Population 1970, 1980 and 1990 by decreasing growth rate method.

Ans :- Percentage increase in year Population 1940 and 1930 $= \frac{13,000 - 9,000}{9,000} \times 100$

$= 44.44\%$

Percentage increase in year Population 1950 and 1940 $= \frac{17,500 - 13,000}{13000} \times 100$

$= 34.61\%$

Percentage increase in year Population 1960 and 1950 $= \frac{23,000 - 17,500}{17,500} \times 100$

$= 31.42\%$

∴ Decrease in year Population ——

∴ Decrease in year Population

$= 44.44 - 34.61$

$= 9.7\%$

∴ Decrease in year Population

$= 34.61 - 31.42$

$= 3.1\%$

∴ The total Decrease in year Population

$= 9.7 + 3.1$

$= 12.8\%$

∴ The average decrease in year Population

$$= \frac{12.8}{2}$$

$$= 6.4$$

Net Percentage increase in year Population 1970

$$= 31.42 - 6.4$$

$$= 25.02\ \%$$

Net Percentage increase in year Population 1980

$$= 25.02 - 6.4$$

$$= 18.62\ \%$$

Net Percentage increase in year Population 1990

$$= 18.62 - 6.4$$

$$= 12.22\ \%$$

For 1970 = 23,000 + 23000 × 0.25 = 28750

For 1980 = 28750 + 28750 × 0.25 = 33925

For 1990 = 33925 + 33925 × 0.25 = 37996

∴ All the Population 37996.

Q. The Census records of a town is as follows:-

Year	Population
2000	12,500
2010	15,000
2020	18,000
2030	21,500

Calculate the Probable Population in the year 2040, 2050 and 2060 by using decreasing rate of growth of population.

Ans:-

Percentage increase in Population 2010 and 2000

$$= \frac{15,000 - 12,500}{12,500} \times 100$$

$$= 20\%$$

Percentage increase in Population 2020 and 2010

$$= \frac{18,000 - 15,000}{15,000} \times 100$$

$$= 20\%$$

Percentage increase in Population 2030 and 2020

$$= \frac{21,5000 - 18,000}{18,000} \times 100$$

$$= 19.44\%$$

Percentage Decrease in Population = ——

Percentage Decrease in Population = 0.

Percentage Decrease in Population = 20 − 19.44

= 0.56%.

∴ The total Decrease in Population = 0.56

∴ Average in Population $\frac{0.56}{2} = 0.28$

Net increase in Population 1940.

= 19.44 − 0.28 = 19.16%

Net increase in population 1950.

= 19.16 − 0.28 = 18.88%

Net increase in Population 1960

= 18.88 − 0.28 = 18.6%

For 1940 = 21,500 + 21,500 × 0.19 = 25585

For 1950 = 25585 + 25585 × 0.19 = 30190

For 1960 = 30190 + 30190 × 0.19 = 35624

∴ All Population 35624.

Q.
The census recorded of a town show the population as follows :-

(i) Present Population = 50,300
(ii) Population before one decade = 46,500
(iii) Population before two decade = 43,100
(iv) Population before three decade = 40,500

Calculate the Probable one, two and three decade by using decreasing rate of growth method.

Ans :- Percentage increase in Population present and before one decade = $\frac{50,300 - 46,500}{46,500} \times 100$

$= 8.17\%$

Percentage increase in Population one decade and before two decade = $\frac{46,500 - 43,100}{43,100} \times 100$

$= 7.88\%$

Percentage increase in Population two decade and before three decade = $\frac{43,100 - 40,500}{40,500} \times 100$

$= 6.41\%$

Percentage decrease in Population = ——

Percentage decrease in Population

$= 8.17 - 7.88 = 0.29\%$

Percentage decrease in Population

$= 7.88 - 6.41 = 1.47\%$

∴ The total increase in Population

$$0.29 + 1.47$$

$$= 1.76\ \%$$

∴ The average increase in Population

$$= \frac{1.76}{2}$$

$$= 0.88$$

Net increase in Population one decade

$$= 8.17 - 0.88 = 7.29$$

Net increase in Population two decade

$$= 7.29 - 0.88 = 6.41$$

Net increase in Population three decade

$$= 6.41 - 0.88 = 5.53$$

For one decade = $50,300 + (50,300 \times 0.072)$

$$= 53922$$

For two decade = $53922 + (53922 \times 0.064)$

$$= 57373$$

For three decade = $57373 + (57373 \times 0.055)$

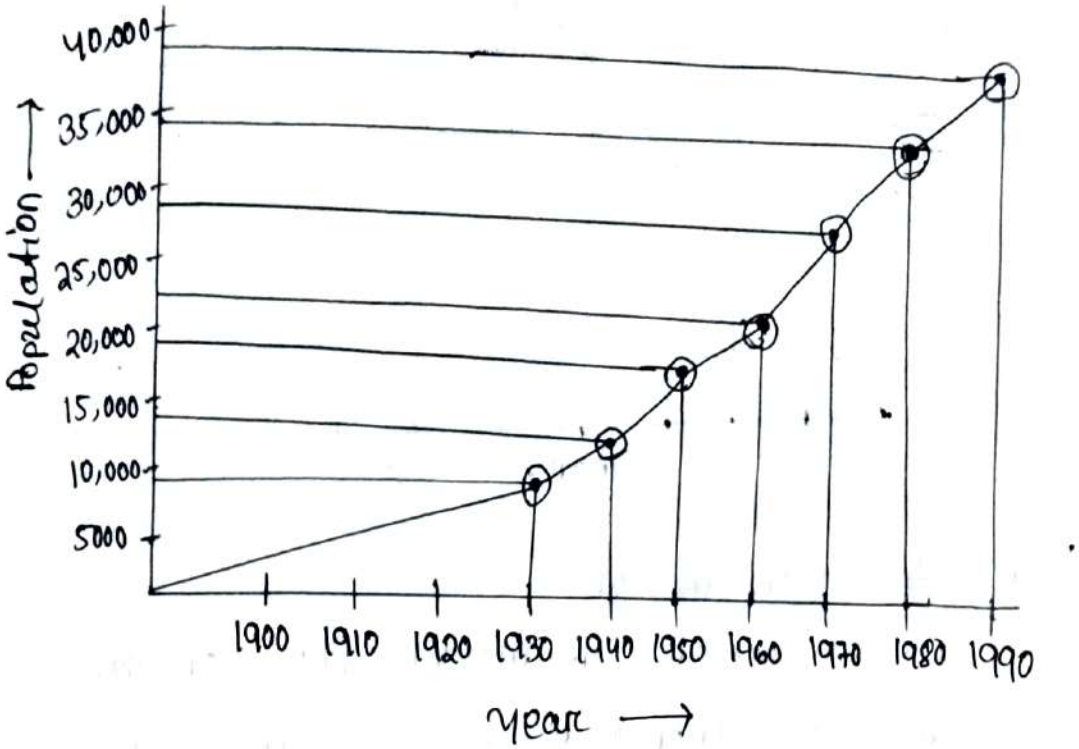
$$= 60528$$

∴ All Population 60528.

Simple graphical method :-

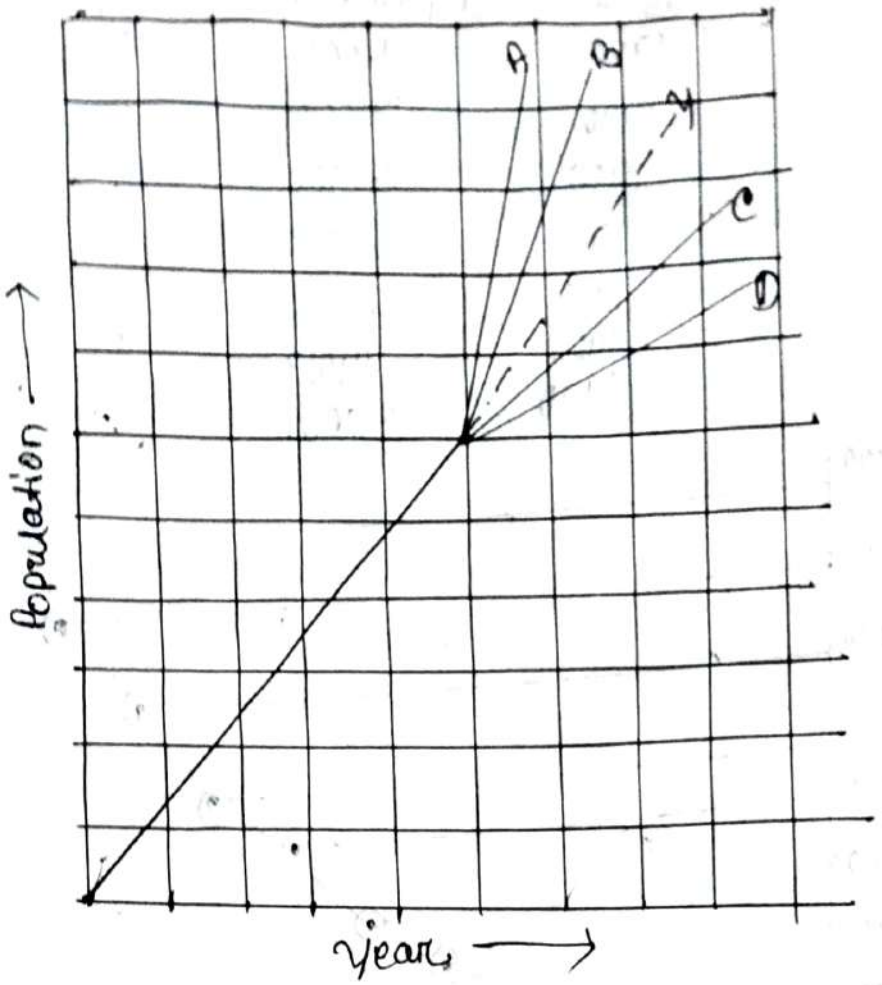
In this method we plot a graph with the Population of past decades (Population as ordinate and year as abscissa) to any suitable scale and a Curve is obtained. This Curve is extended upto the required future decades.

year	Population
1930	9,000
1940	13,000
1950	17,500
1960	23,000
1970	28727
1980	34013
1990	38061



(d) Comparative graphical method :-

In this method, from the Census records the Population growth Curves of different cities (A, B, C, D) are plotted on the graph. The Curves will indicate the trends of growth of Population in the cities. By Comparing the nature of the Curves, the Curve of the city under Consideration is drawn by a dotted line (y). This dotted line show the expected Population of the city under Consideration.



Master Plan method :-

In this method, a master plan of the city should be prepared by dividing the city into various zones such as residential, industrial and commercial zone etc. The future expansion of the city should also be regulated with the by-laws of the Corporation. The population densities of different zone are pre-determined. When the city will be fully developed, the probable population may be forecast by studying the master plan.

Impurities in water :-

The common impurities in water may be classified into three groups :-

1. Physical impurities
2. Chemical impurities
3. Bacteriological impurities

1. Physical impurities :-

(a) Turbidity :-

The turbidity of water indicates the presence of colloidal particles such as fine silt and clay. In some cases the salts of iron and manganese may impart turbidity in water. The colloidal substances and salts may be injurious to human health.

(b) Colour :-

The water gets colour from the discharge of some industries such as textile industry. Paper industry etc. Those discharges waste product which may impart colour.

(c) Taste and odour :-

The discharge of waste products from some industries and trades contain strong smelling, chemical compounds are free chlorine, hydrogen sulphide etc. Such compounds make the water very unpleasant to consume.

(d) Floating matters :-

At many places, the dumping ground for debris or garbage may be close to the river. In rainy season, garbage are carried by rain water appearing as floating matter may Pollute water by decomposing.

(e) Unpleasant Gas :-

The Presence of gases in water is indicated by the formation of foam in rivers. The foam may be formed by absorption of gases.

(f) Radioactive substances :-

The nuclear Power Plant, nuclear research Centre & some industries dealing with radio-active substances. This Property seriously affects human life & also aquatic life.

2. Chemical Impurities :-

(a) Acids :-

The waste Products of some industries such as battery factory, explosive factory contain acids. If these waste Products are directly discharge into river then it will be harmful to the aquatic life & will destroy the self-Purification Property of river water.

(b) Alkalies :-

The waste Products of some industries Contain of some alkalies. Also they have the same effect as that of acid.

(c) Inorganic Compound :-

The waste Product of some industry like ferti-, -liser industries Co.tain inorganic Compounds (chloro- -mines, Sulphide, ammonia etc.) which are toxic to the aquatic life.

(d) Organic Compound :-

The organic Compound may exist in water due to the Presence of Fats, Proteins, Carbo hydrates.

3. Bacteriological impurities :-

The development of Pathogenic bacteria, fungi, viruses etc. in water is Caused due to fermentation of dead bodies. These bacterial loads are responsible for water borne diseases.

Analysis of water :-

There are three types of test are adopted for analysis of water —

① Physical test
② Chemical test
③ Bacteriological test

① Physical Test :-

Collection on water Sample :-

Following points to be remembered during Collection of water sample.

(i) The bottle of the samples should be properly labelled by date, time of collection, type of source etc.

(ii) The bottles should be properly cleaned.

(iii) The capacity of bottle should be about 2 to 3 litres.

(iv) The samples should be tested as early as possible.

(v) If the water is collected from surfaces such as rivers, streams or lake then it should be collected from the depth of about 50 C.m.

Physical Test :-

This test is carried out for the following physical characteristics :-

(i) Colour
(ii) Taste & odour
(iii) Turbidity
(iv) Temperature

① Colour :-

We have mentioned earlier that the colour discharged from the industries impart colour to water. The colour in water is measured

by the instrument is called tintometer. The instrument consists of eyepiece, having two holes. one hole is meant for looking a glide of water to be tested. The unit of ~~standard 1 mg of Platinum - Cobalt in 1 litre of distilled water. The unit of water is.~~ standard colour is produced by dissolving 1 mg of Platinum - Cobalt in 1 litre of distilled water. The unit of water this number should be less than 10.

(ii) Taste & odour :-

The odour is generally expressed as fishy, earthy, grassy, etc. It is measured by an instrument is known as osmoscope, which consists of the water to be tested by diluting it in odour-free water. The intensity of odour is expressed as threshold number. For Potable water, the theshold number is less than 3.

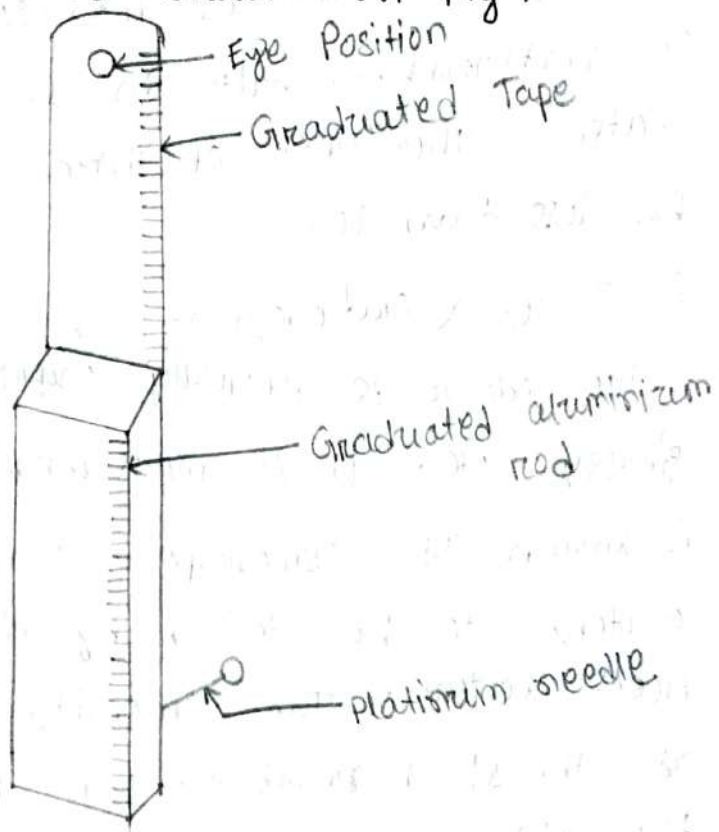
(iii) Turbidity :-

The colloidal matters like silt and clay impart turbidity to water. It is expressed as Part million (i.e. ppm). The Permissible turbidity for Potable in water should be 5 to 10 ppm. The turbidity can be measured by following methods -

(i) Turbidity rod
(ii) Jackson turbidimeter.
(iii) Baylis turbidimeter.

① Turbidity rod :-

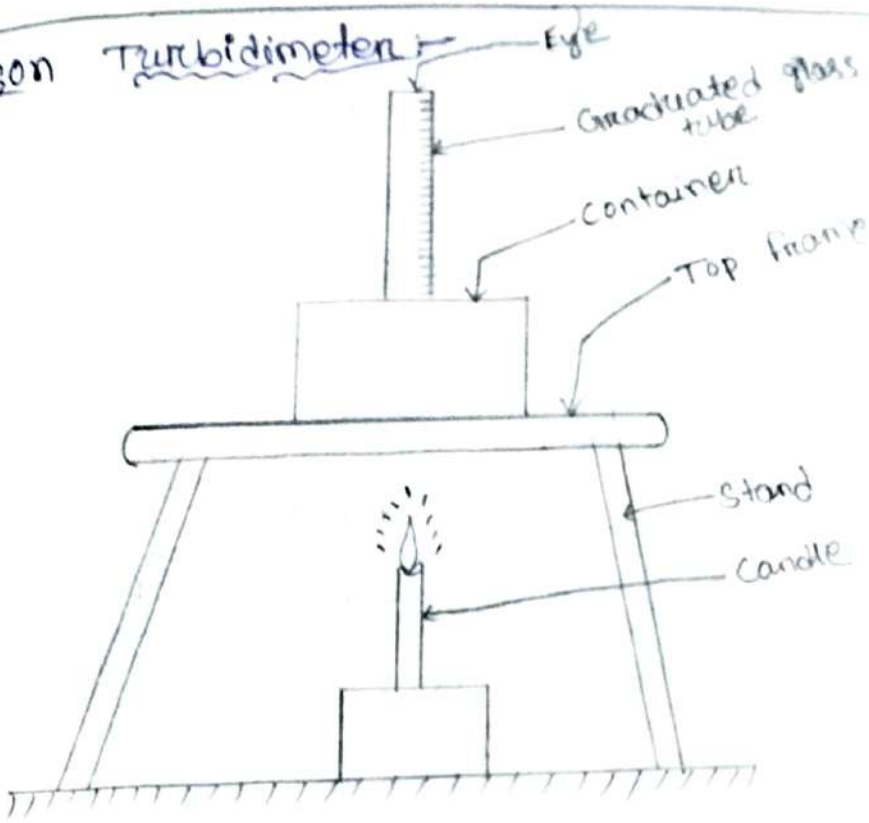
It Consist of an aluminium rod which it graduated tape is Provided on the top of the rod for making the position of eye. A hole is Provided ~~dot~~ the bottom of the rod, for inserting a Platinum needle as shown in fig.



(Turbidity rod)

For measuring the turbidity, the rod is gradually lowered in water. Then a position will come when the needle is just disappear under standard light condition. The depth of water from the position is noted from the bar. This reading gives the turbidity in PPM.

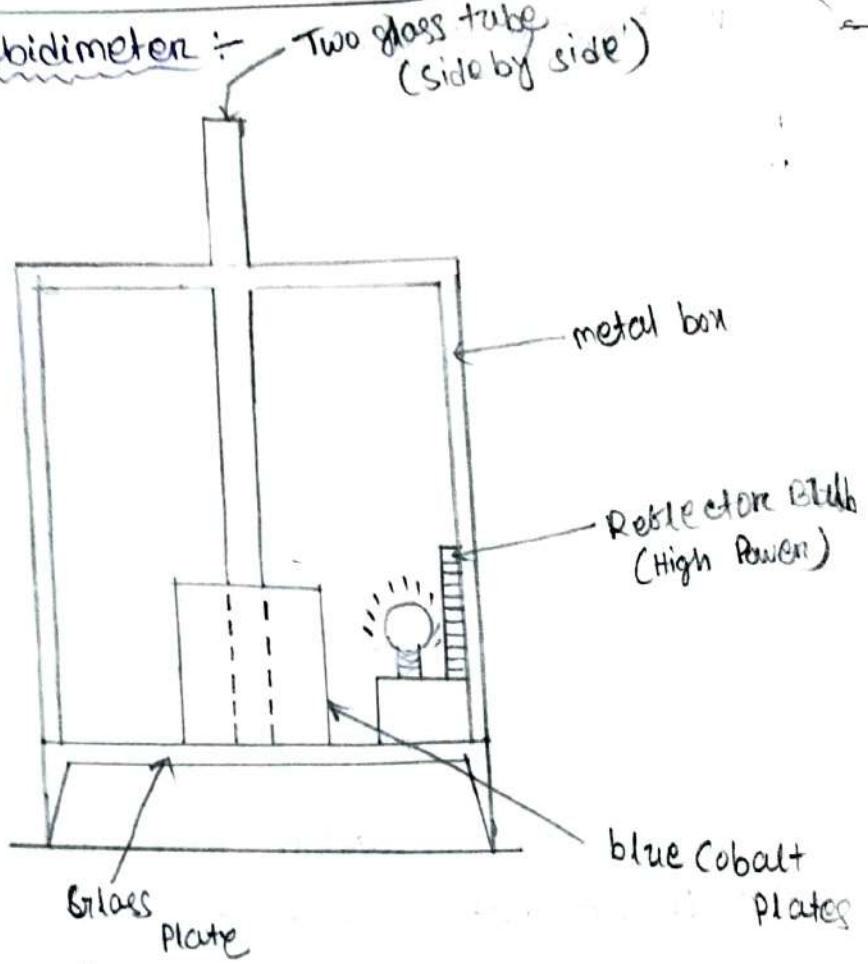
(11) Jackson Turbidimeter



(Jackson Turbidimeter)

The instrument consists of a stand made of wood or metal on which a container is provided with suitable frame. Again, the container consists of a graduated glass tube. A candle is placed below the stand. The flame of the candle is visible through the glass tube. Then the water under test is poured gradually and the image of the flame is observed. A time come when the flame disappears. Just at that moment the reading of the glass tube is noted which indicates the turbidity in ppm. This instrument is suitable for measuring the turbidity above 100 ppm.

Baylis Turbidimeter :-



(Baylis Turbidimeter)

It Consist of a metal box. On the left side of the box two glass tubes are mounted vertically. The lower ends of the tubes are Surrounded by blue Cobalt Plates. On the right side a bulb is fitted and the base and a reflector is Provided on the back. One glass tube is filled with water whose turbidity is to measured & the other glass tube is filled with Stand-and Solution of turbidity. (Known turbidity). When the bulb is lighted, the blue light

is Seen through the glass tubes from top. If the colour intensity of the glass tubes differ, the another tube with standard solution of known turbidity is inserted. In this way, the tube with Standard Solution goes on changing until a stage comes when the colour intensity from both the tubes are nearly same. The turbidity of Standard Solution is considered as the turbidity of the sample or water. This instrument is suitable for measuring the turbidity below 5 PPM.

(N) Temperature :-

It is seen that the growth rate of bacteria is rapid at high temperature. So the sample or water should be collected at a temperature should be below 15°C. The temperature is observed by a thermometer by which the atmospheric temperature is recorded. The temperature of potable water should be about 10°C - 25°C.

2. Chemical Test :-

The chemical tests are carried out to determine the following factors :-

(a) Chlorides
(b) Nitrogen & its Compound
(c) Dissolved gases
(d) PH value
(e) Hardness
(f) Iron & manganese
(g) Total Solids

(h) Sulphates
(i) Alkalimity

3. Bacteriological Test :-

Water always Contains Some bacteria which can be detected by microscope only. Again the bacteria is of two types — I. Pathogenic bacteria ; II. Non - Pathgenic.

I. Pathogenic Bacteria :-

The Pathogenic bacteria are harmful. bacteria. It Causes harmful diseases such as typhoid, Cholera, dysentry etc.

II. Non - Pathogenic bacteria :-

The non - Pathogenic bacteria are not harmful. The Combined of two bacteria is termed as B - Coli group. The Common bacteria of this group is Known as E - Coli group. Both the groups are identified by the following bacteriological test :-

(I) Total Count test
(II) B - Coli test

Water Quality Standard :-

Standard Considering physical Characteristics :-

1. Colour — The number on Cobalt Scale Should not exceed 20.

2. Taste & Odour :- The threshold number should not be more than 3.

3. Temperature :- The desirable temperature should be 10°C.

4. Turbidity :- The Permissible turbidity should be 5-10 PPM.

Standard Considering Chemical Characteristics :-

1. Chlorides :- The amount of clorides should not exceed 250 mg./l.

2. Dissolved Gases :- The amount of dissolved gases should be 5 - 10 PPM.

3. Hardness :- The hardness of water should be between 5 & 10°.

4. PH value :- The pH value should be between 7 and 8.5.

5. Nitrogen & its Compounds :-

(i) The amount of free ammonia should not exceed 0.15 PPM.

(ii) The aluminoid ammonia should not exceed 0.3PPM

(iii) The amount of nitrides should be nill.

(iv) The amount of nitrades should not exceed 45 mg/l.

6. Total Solids :- The amount of total solids should be less than 500 PPM.

Standard Considering Bacteriological characteristic :-

1. Total Counts :- The total count should not exceed 100 Per C.C.
2. B-coli Index :- The B-coli index should be Preferably less than 3. In any case, it shuld not exceed 10.

Chapter-2 Sources and Conveyance of water

Source of water -
(i) Surface Source
(ii) Underground Source

(i) Surface Source :-
The following are the different surface Source of water.
(i) River or Stream
(ii) Pond or lake
(iii) Storage reservoir or impound reservoir

(I) River or Stream
Rivers are the Principle Sources of water Supply. Some rivers are Perrnial (water avail-able in rainy season only). Perrnial should always selected for the scheme.
→ In case of non-Perrnial river, the water or barrage or dam may be constructed to form a storage reservoir.

(ii) Pond or lake :-
The natural or artificial depression where surface run-off is collected for rainy season are known as Pond or lake. The catchment area of these sources is small

and hence the quantity of water is not reliable but the quality is reliable & it requires little treatment before use. This sources is suitable for small water supply scheme.

(iii) Storage reservoir or Impound reservoir :-

An artificial lake which is formed by constructing dam across a river valley is known as storage reservoir. The function of such reservoir may be multiporpose such as irrigation, water supply, hydro electric power generation, fishery etc. The quality and quantity both are railable. So this sources is always preferred for large water supply scheme.

(II) Underground Sources :-

The following are the underground sources of water :-

(i) Infiltration well
(ii) Infiltration Gallery
(iii) Spring
(iv) well

(i) Infiltration well:-

For tapping water from the Sandy river beds, the infiltration wells are sunk in series in Sandy river beds. These are constructed with brick masonary with open joint. The water percolates through that joint & gets collected in the wells. The top of the well are covered with RCC slab having manhole of inspection well gets collected in a jack well is pumped out and stored in storage reservoir. The quality of water is good & it requires no treatment. The quantity of water from this source suitable for small water supply schemes.

(ii) Infiltration Gallery:-

For tapping water, for Sandy river beds Some horizontal tunnels are constructed in the beds. The walls of the tunnels are Constructed with brick work & its top is Covered with RCC Slab having manhole at some interval. The Perforated pipe lines are connected to the tunnel through which water gets Collected inside the tunnel, this tunnel is known as infiltration gallery. The water inside the gallery flows towards a well is known as Sump well. Finally the water from the Sump well is Pumped out & Stored in a storage reservoir. The Quality of water is so good & it requires no treatment. This Sources is Suitable for Small water Supply Schemes.

(iii) Spring :- when underground water reappears at the ground Surface Percolation or by Under ground Pressure, then it is known as Spring. The water of the Spring may Contain Some types of salts and minerals. So, it should be treated before use. This Sources is Suitable for water Supply in hilly towns. There are three types of Springs :—

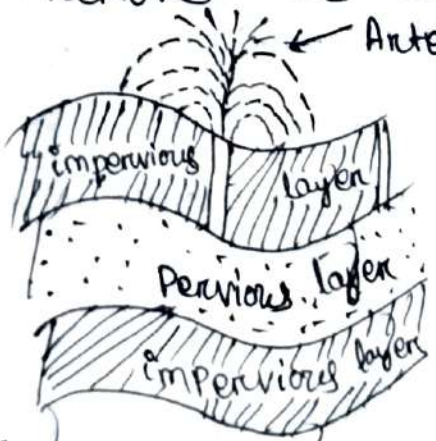
(I) Artesion Spring
(II) Gravity Spring
(III) Surface Spring

→ Artesion Spring :-

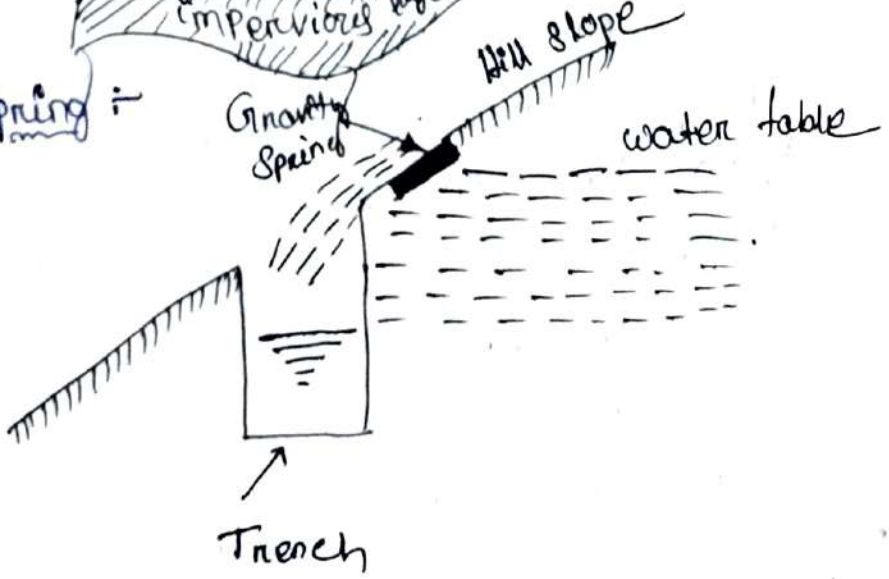
→ When a pervious layer is sandwiched between two impervious layers in the form of a valley then the spring is known as artesion spring, which comes out with some pressure.

→ Some artesion spring discharge hot water, such springs are known as hot spring.

→ The water of the hot spring is suitable for bathing to remove the ~~disease~~ disease.

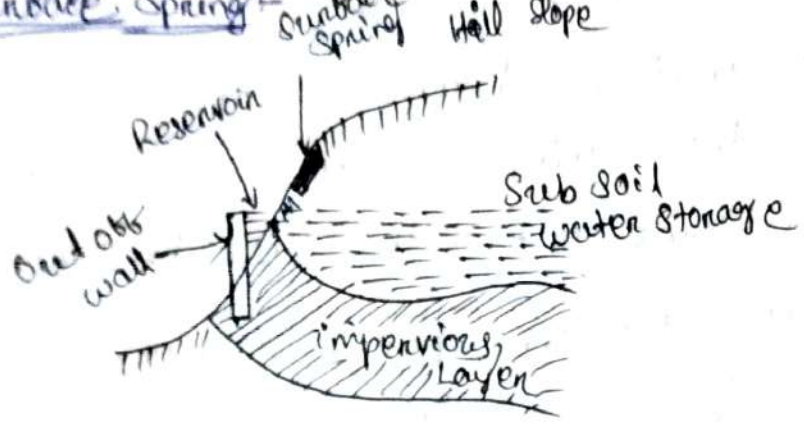


(II) Gravity Spring :-



The gravity Spring comes into existance water the water table rises along the hill slope and the water finds a path on the slope through which it rushes out by gravity.

(iii) Surface Spring :-



When Sub-Soil water forms a storage due to the Presence of Impervious layer on the form of a valley, then the Surface Spring comes into existance. A Cut-off wall is Constructed to form a reservoir from where water supplied to the Consumer.

(b) Well :-

As artificial hole made into the ground for tapping under ground water is known as well. Again the well is of two types :-

(i) Open well

(ii) Tube well

(i) Open well :-

The open well draws water from the topmost Pervious layer. The diameter of this well

varies from 1m to 2 m. and depth varies from 20 to 30 m. Depending under the nature of soil & water table. This well may be constructed by earthen - ware rings RCC ring or brick work.

(ii) Tube well :-

The tube well drows water from the deeper most Perviors layer. The diameter & depth of this well varies from 37 mm to 150 mm. & 100m to 200 m respectively, depending upon the nature of soil & suitable water bearing strata. The tube well is constructed by sinking, G.I. Pipe & it is considered as the best source of water for any water supply scheme. As the water can be drown by direct Pumping system.

Aquifier :-

The Permeable formation of soil or the earth's crust is known as aquifier. It is also known as water bearing strata. It is about three types :-

1. Unconfined aquifier
2. Confined aquifier
3. Peached aquifier

① Unconfined aquifer :-

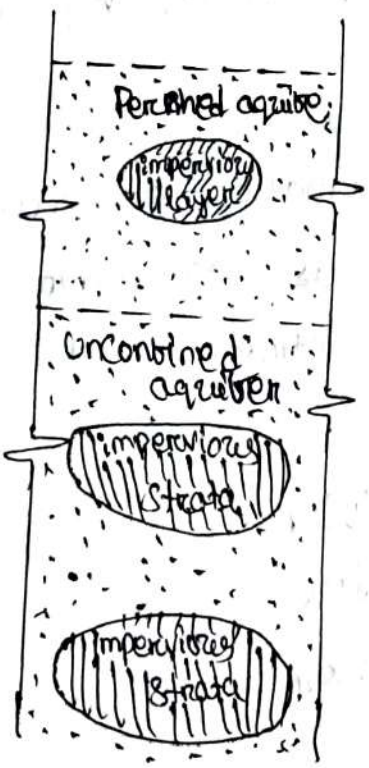
It is the topmost aquifer, in which water table exists on the surface of saturation. The surface water enters into this aquifer through the surface soil.

② Confined aquifer :-

The aquifer which is sandwiched between two impervious layer or strata is known as confined aquifer.

③ Perched aquifer :-

This is also an unconfined aquifer, which is separated from the main water table by a shallow & curved impervious strata. This water table in this aquifer is known as perched water table.



(i) **Yield of a well :-**

The yield of a well is defined as the rate of pumping of water from the well without causing its failure.

(ii) **Cone of depression :-**

When water is pumped out from the well the original water table is depressed & forms a curved surface in the form of an inverted cone. This cone is known as cone of depression.

Determination of yield of a well :-

From darcy's law,

$$Q = K \cdot A \cdot i \qquad i = \frac{H}{L}$$

$$= K \cdot A \cdot \frac{H}{L} \qquad \left(\frac{K}{L} = C\right)$$

$$= C \cdot A \cdot H$$

where, Q = discharge

K = co-efficient of permeability

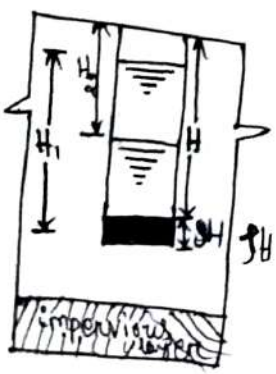
A = Cross - Sectional area of permeable through which water enters the well

i = Hydraulic gradient

H = Depression head

L = Length of flow path

C = Percolation intensity co-efficient.



where, H_1 = Depression head when Pumping was stopped.

H_2 = Depression head after a Certain Period.

T = Time taken by the water level to rise from H_1 to H_2

H = Depression head at time 'T'

To find out the Specific yield and Specific Capacity, there is a Formula :-

$$\frac{K}{A} = \frac{2.303}{T} \log_{10} \left[\frac{H_1}{H_2}\right]$$

where, $\frac{K}{A}$ = Specific yield of well per unit Area, it is expressed as = $m^3/hr/m^2$

Again,

$$K = \frac{2.303}{T} A \log_{10} \left[\frac{H_1}{H_2}\right]$$

where, K = Specific Capacity of well in $m^3/hr/$unit head

$\therefore$ Q.K.H

Q. Calculate the Specific Capacity of an open ~~initial~~ well From the Following data :-

Initial depression head = 5m.

Final depression head = 2m.

Time of recuperation = 2 hour

Diameter of well = 3m.

Calculate also the Specific yield Under the head 3m.

Sol^n :- Given data,

$H = 3m$

$H_1 = 5m$.

$H_2 = 2m$.

dia $= 3m$.

$T = 2 hr$

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

$= \frac{\pi}{4} \times (3)^2 = 7.06$

Specific Capacity $(K) = \frac{2.303}{T} A \log_{10} \left[\frac{H_1}{H_2}\right]$

$= \frac{2.303}{2} \times 7.06 \times \log_{10} \left[\frac{5}{2}\right]$

$= 3.238 \ m^3/hr$ / Unit head

Specific yield $= \frac{K}{A} = \frac{3.238}{7.06} = 0.46$

Specific yield under the head 3m.

$= Q = K \cdot H = 3.238 \times 3 = 9.71 \ m^3/hr.$

$= 9710 \ Lit/hr$

Q. Find the diameter of an open well to give the discharge of 3 Lit/sec. The depression head is 3m & the Specific yield is $1 \ m^3/hr$.

Sol^n :- $Q = 3 Lit/sec$

$= \frac{3 \times 60 \times 60}{1000} = 10.8 \ m^3/hr$

$H = 3m$.

$\frac{K}{A} = 1 m^3/hr$

$Q = K \cdot H$

$\Rightarrow Q = \frac{K}{A} \cdot A \cdot H$

$\Rightarrow 10.8 = 1 \times \frac{\pi}{4} d^2 \times 3$

$\Rightarrow d2 = 4.58$

$\Rightarrow d = 2.14\,m$

Determination of yield of a tube well:-

For Uncontined aquiten

$$Q = \frac{1.36 \times K \times S \times (S+2h)}{\log_{10}\left(\frac{R}{r}\right)}$$

where, Q = discharge of well

K = co-ebbient of permeability

S = draw down

h = height of maxm draw down from water to and the top of impervious layer

R = radius of circle of influence

r = radius of well

For Contined aquiten,

$$Q = \frac{2.72 \times T \times S}{\log_{10}\left(\frac{R}{r}\right)}$$

where, T = a Point on draw down Curve

Q. A tube well fully Penetrates on uncontined aquiten Calculate the discharge of well from the following data:-

(i) Dia of well = 15 c.m

(ii) Draw down = 4 m

(iii) Length of Strainer below draw down = 10 m.

(iv) co-efficient of Permeability = 0.05 cm/sec

(v) radis of circle of influence = 200 m.

Soln :- Given data,

$d = 15\ cm \Rightarrow r = \frac{15}{2} = 7.5\ cm = 0.075\ m.$

$S = 4\ m.$

$h = 10\ m.$

$K = 0.05\ cm/sec = 5 \times 10^{-4}\ m/sec.$

$R = 200\ m$

$$\therefore Q = \frac{1.36 \times 5 \times 10^{-4} \times 4 \times (4 + 2 \times 10)}{\log_{10}\left(\frac{200}{0.075}\right)} = 0.019\ m^3/sec.$$

Q. A tube well Penetrates a Confined aquifer Completely. Determine the diameter of the tube well From the following data :-

(i) Required yield = 100 lit./sec.

(ii) Radius of circle of influence = 200 m.

(iii) Thickness of Confined aquifer = 30 m.

(iv) Draw down = 5 m.

(v) co-efficient of Permeability = 60 m/day

Soln :- Given data,

$K = 60\ m/day$

$= \frac{60}{24 \times 60 \times 60} = 6.94 \times 10^{-4}\ m/sec.$

$Q = 100\ lit/sec = \frac{100}{1000} = 0.10\ m^3/sec.$

$T = K \cdot b$

$= 6.94 \times 10^{-4} \times 30 = 0.02082$

$R = 200\ m.$

$$Q = \frac{2.72 \times T \times S}{\log_{10}\left(\frac{R}{r}\right)}$$

$$\Rightarrow 0.10 = \frac{2.72 \times 0.02082 \times 5}{\log_{10}\left(\frac{200}{r}\right)}$$

$$\log_{10}\left(\frac{200}{r}\right) = \frac{0.283152}{0.10} = 2.83$$

$$\Rightarrow \frac{200}{r} = 10^{2.83}$$

$$\Rightarrow r = \frac{200}{10^{2.83}} = 0.29 \Rightarrow d = 0.29 \times 2 = 0.58m$$

Intakes :-

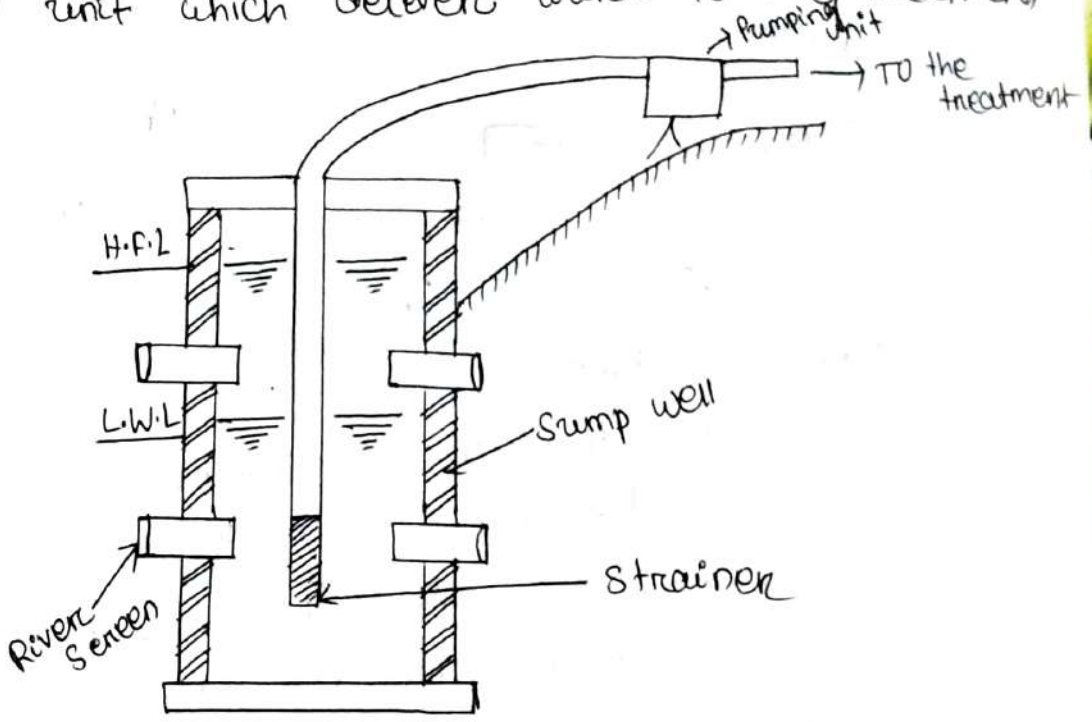
Intake works may be various types depending upon the available sources of surface water. Generally the intakes works are of 4 types :-

(i) River intakes
(ii) Lake intakes
(iii) Reservoir intakes
(iv) Canal intakes

(I) River intakes :-

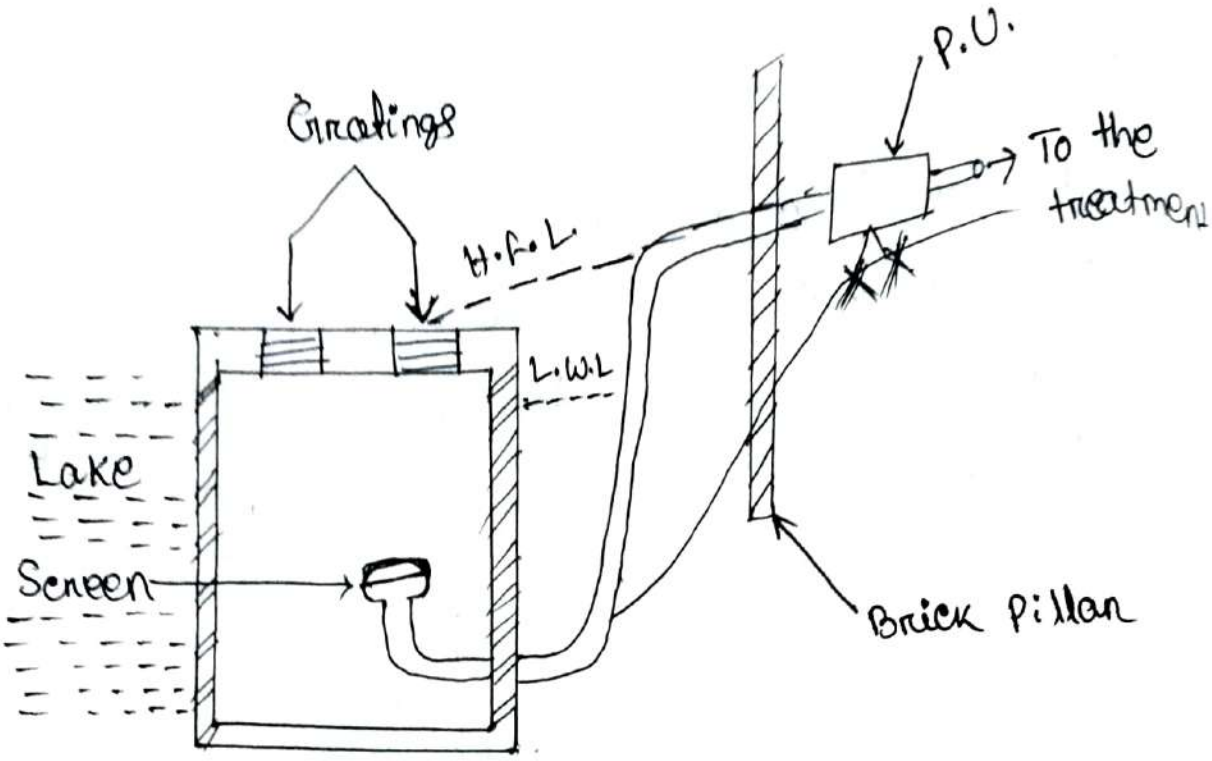
A circular or rectangular sump well is constructed with masonary work in the bank of the river. In a such a way that, the water can enter the well in both the conditions such as H.F.L & L.W.L. The water enters to the sump well through the pipes installed at different levels

Screens are Provided at the end of the Pipes to eliminate the Suspended matters. A main Suction pipe having Strainer in the bottom is inserted to Sump well. The main pipe is Connected to the Pumping unit which delever water to the treatment Plant.



(II) Lake Intake :-

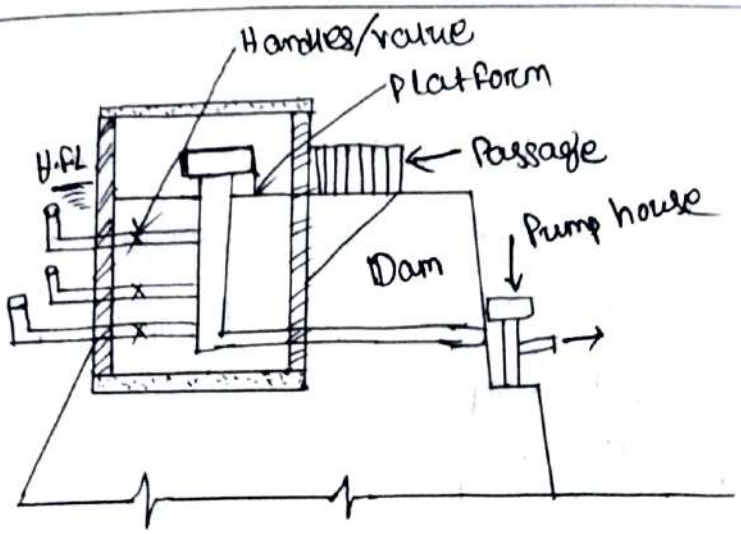
A Submergible rectangular chamber is Constructed at the bed of the lake from where water can be available throughout the year. The top cover of the chamber Consist of Several holes having gratings to Prevent the entry of bridges, weeds, aquatic lives etc, into the ~~Cham~~ chambers. A bell mouth pipe is Connected to the Pumping unit through the Suction pipe. The Pump house draws the water from the chamber & deliver to the treatment plant.



3. Reservoir intake :-

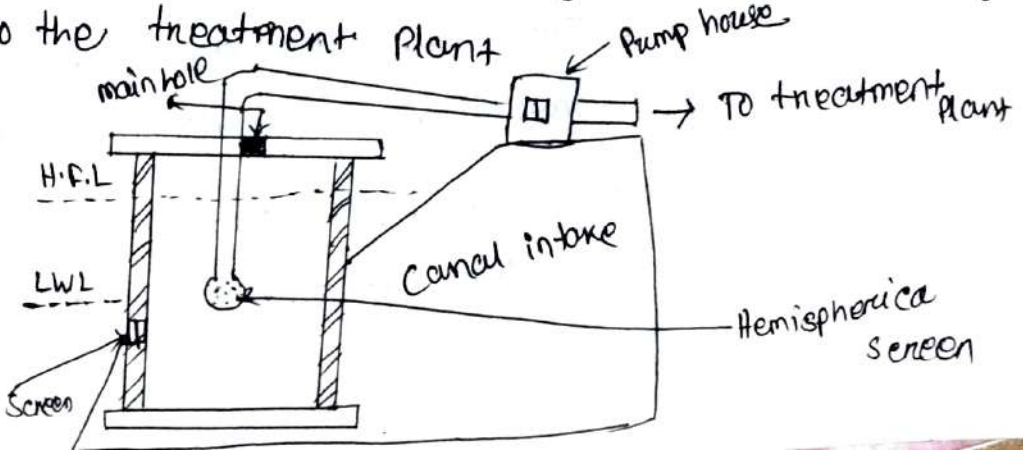
In an inundation river becomes the only near by source of water for a town, then ~~wire~~ weir or low dam may be constructed across the river to form a reservoir. The dam may be earthen or gravity type which depends on the sight condition. An intake well is constructed on the body of weir can be tapped throughout the year.

Intake pipe with screen at its ends are fitted in different level to a vertical pipe which is provided inside the well. The vertical pipe is again connected with pumping unit. and the pumping unit draws water from the reservoir to the treatments plant directly.



4. Canal Intake :-

If a Canal becomes the sources of water for a town, then an intake well is Constructed by the bank of the Canal. The well may be circular or rectangular and it is Constructed with masonary well. An inlet pipe is inserted into the well for drowing the water. On the Canal side the well consist of an opening with Screen. The intake pipe is extended below the lowest water level in the Canal and it carries hemispherical Screen at its end. A man hole is Provided on the well cap for inspection of work. The intake pipe is Connected to the Pumping unit for sending water to the treatment plant



Pumps for Conveyance :-

The mechanism by which the water is lifted from underground source to some height or to some place is called Pump. There are 4 types of Pumps :-

(1) Centrifugal Pump
(2) Reciprocating Pump
(3) Rotary Pump
(4) Air Lift Pump

Pipes for Conveyance :-

The following are pipes that are generally used for the conveyance water for water supply scheme :-

(1) Asbestos pipe
(2) Cast-iron pipe
(3) Cement Concrete pipe
(4) G.I. Pipe
(5) Lead pipe
(6) Steel pipe
(7) Wrought iron pipe
(8) Copper pipe
(9) Plastic pipe

Pipe joints :-

The Pipes are manufacture in small length varying from 2m. to 5m. But at time of laying, the pipes are joints together. The followings are the different types of pipe joints :-

(1) For Cast & Wrought iron - Bell & Spiget joint
(2) For Steel Pipes - Riveted & welded joints

(3) For RCC & AC pipes – Collar joint
(4) For temporary work – Flanged & threaded joint.
(5) For temperature change – Expansion joint
(6) For places where settlement is suspected – flexible joint.

Chapter-3 Treatment of water

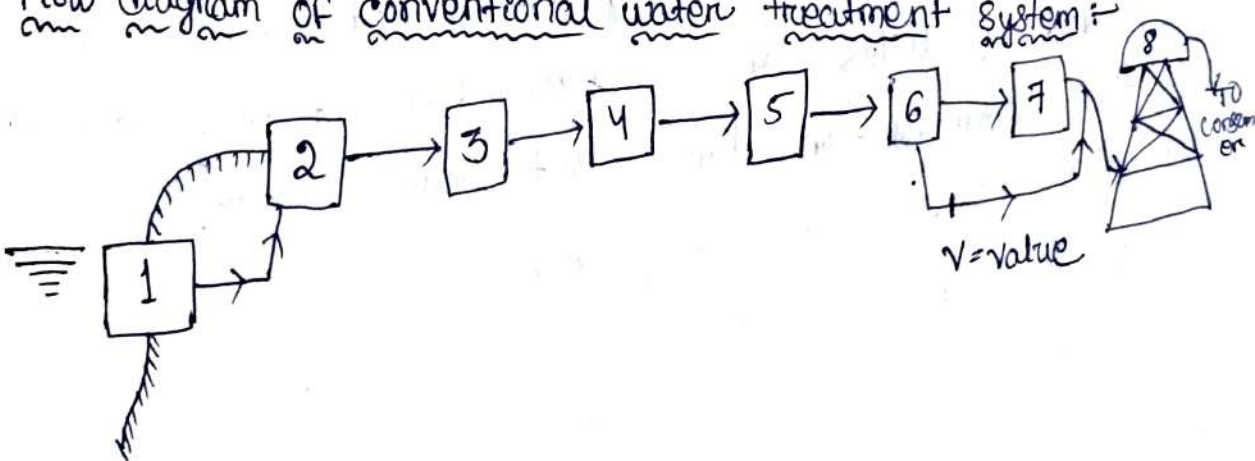
Object of water treatment :-

→ The water from the surface sources may have some characteristic which are unsuitable for human consu-mption, industrial use, Commercial use etc.

→ So the object of the treatment of water is to remove those impurities, like turbidi, colour, acid, bacteria etc. to make the water suitable for domestic, industrial and commercial uses.

→ Underground water may be free from impurities, but sometimes it may possess the property of hardness which should be removed.

Flow diagram of conventional water treatment system :-



(1) Intake point
(2) Pumping unit
(3) Plain Sedimentation tank
(4) Coagulation tank
(5) Filtration tank
(6) Chlorination tank
(7) water softening tank
(8) Overhead reservoir

Functions of each Units :-

1. Intake point :-

The function of this unit is to collect water in the intake well. So that the water can be supplied through out the year.

2. Pumping Unit :-

The function of this unit is to draw water from the intake well and to supply the same to the treatment plant.

3. Plain Sedimentation Tank :-

The function of this unit is to remove the heavier suspended particles in water. In this tank the water is detained for some period or allow to flow at a very low velocity. So that the heavier suspended particles are settle down at the bottom of the sedimentation tank. But some lighter particles still remains in suspension.

4. Coagulation Tank :-

The function of this unit is to remove the lighter

Suspended Particles by application of Some Coagulation in this tank recommended Coagulant is mixed with the water and water is allowed to flow at a very low velocity through the Coagulation tank. The coagulation make the lighter particles to gain suitable size and ultimately Settle down at the bottom of the tank. But Some finer Colloidal Particles still remain in suspension.

(5) Filtration Tank :-

The fuction of this unit is to remove the finer colloidal particle and Some bacteria by filtering media of sand and gravel but Some bacteria will still remain in water.

(6) Chlorination Tank :-

The function of this unit is to destroy the bacteria by application of Chlorin.

(7) Water Softening Tank :-

The function of this unit is to remove the hardness of water to make it fit for Commercial Purpose. This unit is not always necessary.

(8) Over head Tank :-

The function of this unit is to store the purified water after the treatment is Complete. The water from the reservoir is Supplied to the Consumer by gravity.

Sedimentation Theory :-

→ The particles which do not change their shape size and weight while setting down in a fluid are known as discrete particle.

→ The suspended impurities in water consist of discrete particle such as inorganic solids, having specific gravity about 2.65 and organic solids having specific gravity 1.04.

→ The particle having specific gravity more than 1.20 readily settled down at the bottom of the tank due to the force of gravity. This phenomenon of settlement is known as hydraulic subsidence. This process of settlement depends upon the following factors —

(1) Velocity of flow
(2) Size and shape of particles
(3) Viscosity of water.

Theory of Coagulation :-

The theory of coagulation can be explained by floc formation and electric charge.

Flock formation :-

When some chemicals (coagulants) are mixed with water throughly, a thick precipitate is

formed which is known as flock. The flock has got the property of attracting the suspended impurities in water and settledown towards the bottom of the tank.

Electric charge :-

It is observed that ion of flock possess the electric charge and the colloidal particles possess -ve electric charge. So the flock attracts the colloidal particles while it travels towards the bottom of the tank.

Floccculation :-

The phenomenon of the formation of flock is termed as floccculation. The efficiency of floccculation depends upon the following factors :-

(i) Dose of Coagulants :-

It should be ascertained by laboratory test for the sample of water.

(ii) Mixing :-

The mixing of Coagulants should be perfectly done for the quick formation of flock.

(iii) PH value :-

The PH value of water should be determined in laboratory to select the type of Coagulant.

Sedimentation Tank :-

There are 3 types of used to treatment plant and they are -

① Rectangular Tank
② Circular Tank
③ Hopper bottom Tank

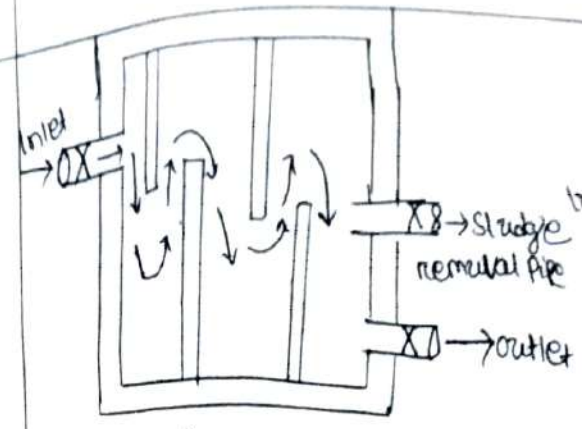
① Rectangular Tank :-

In this type of tank, its Capacity depends upon the ~~value~~ volume of water to be treated. The length depends upon the velocity of flow and detaintion Period. The detention Period may vary from 4-6 hours. The width of the tank varies from 10m - 12m. and the depth of the tank varies from 2m - 4m.

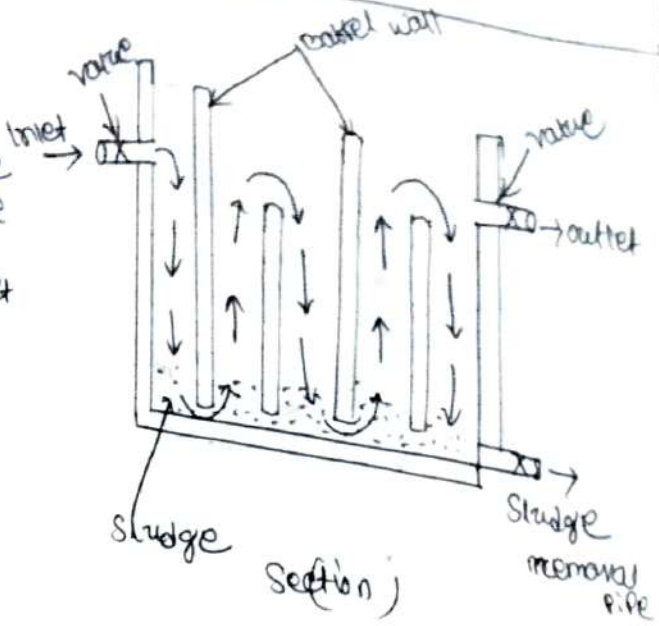
→ There are some baffle walls Provided to reduce the velocity of flow. Due to low velocity of flow the heavier Particles are settledown at the bottom of the tank as sludge.

→ At some interval the sludge is clean through the sludge removal pipe by if the sludge become stop it is agitated gently be taken at the time of ~~remov~~ removal.

→ The Compairatively clean water is taken to the next unit through the outlet pipe.



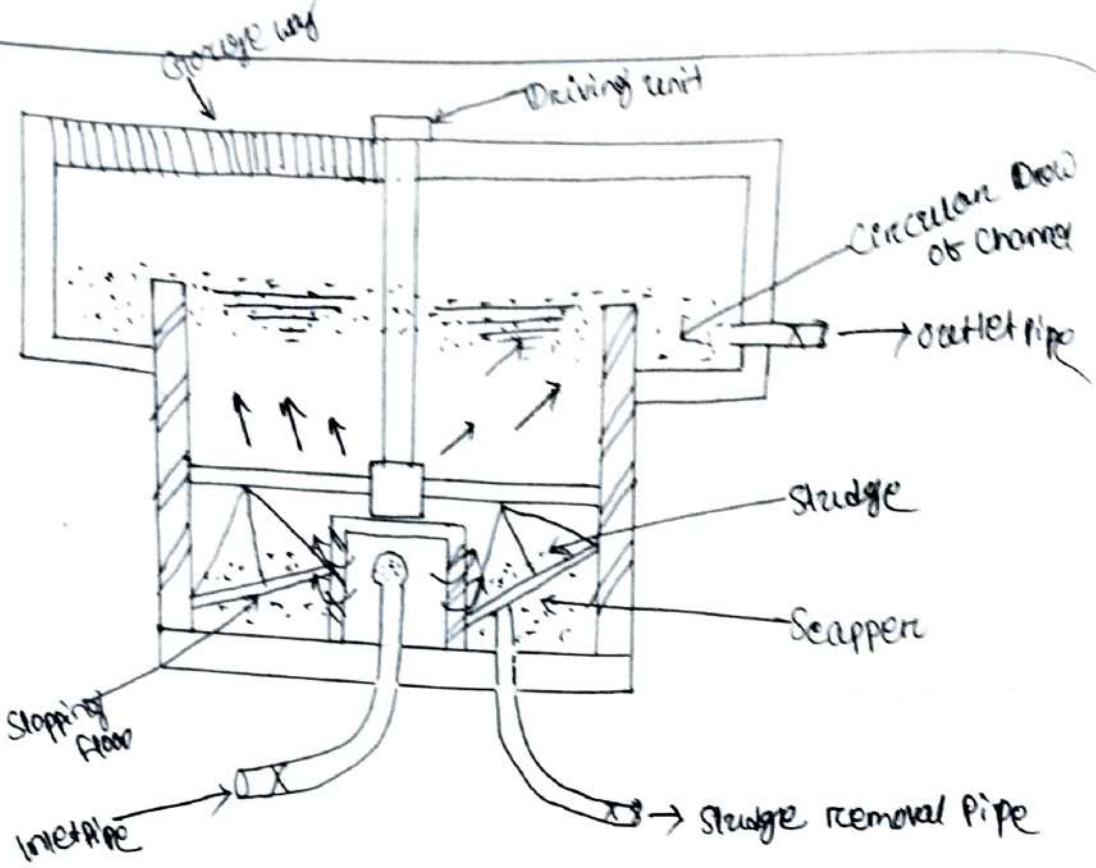
(plan)



Section)

Circular Tank :-

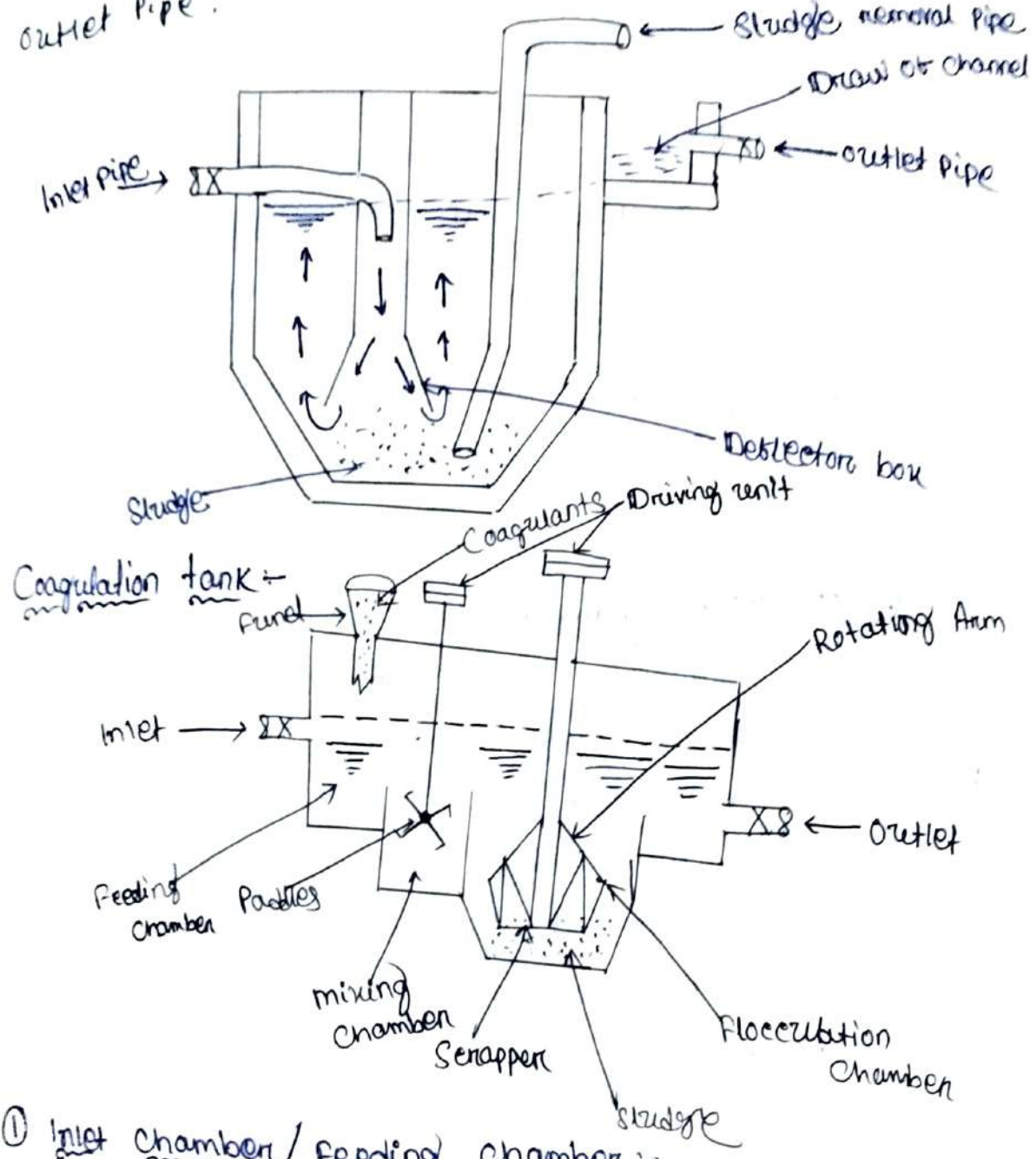
The circular sedimentation tank may have radial or Spiral flow. The tank with radial flow is Commonly adopted. In this tank the water is allowed to enter through the pipe which is provided at its Centre. The water flows upward gently through the openings the water is collected at the circular draw off Canal from where it is taken to the next unit through the outlet pipe the sediment or Sludge are settledown at the bottom of the tank. A driving unit is provided for rotating an arm which Consist of Scrapers. The circular motion of the scraper help the sludge to discharge through the sludge removal pipe.



(3) Hopper bottom tank:-

In this tank the water is allowed to enter through a deflector box which is provided at the Centre. The water flows downwards inside the box and then it rises in upward direction through the opening between the box and the wall of the tank. When the water rises in upward direction, the particles having specific gravity more than 1 can not follow the path and ultimately settle down at the bottom of the tank. The sludge is pumped out through the sludge outlet pipe. The clean water is collected at the draw off channel provided at the side of the tank from

where it is taken to the next unit through the outlet pipe.



① Inlet Chamber / Feeding chamber :-

The water is allow to enter the coagulation tank through the inlet chamber. In this chamber the feeding of coagulants is dull by a suitable method.

② Feeding device :-

The selected coagulant is added to water by a feeding device. The device consists of a

Conical Container which is filled with Coagulant A Stop Cock is Provided at the bottom of the Container to Control the dose of Coagulants.

③ Mixing device :-

There are various types of mixing devices. A Suitable type is adopted for mixing operation. Generally the device consist of Paddle which are rotated by a driving unit. The Peddles go on rotating Continuously and thus the Coagulants mixed thoroughly with water.

④ Flucculation Chamber :-

In this Chamber, the mixture of water and Coagulants is detained for Some Period or it is allow to flow at a very low velocity so that the flock is formed. The flock goes on settledown by annexting the suspended particles and the sludge is deposited at the bottom of the coagulation Chamber.

⑤ Sludge removal :-

At the time of removal the sludge is agitated by Scrapers with rotating arms which are operated by driving unit. The sludge is taken off through the sludge removal pipe by opening the valves.

⑥ Collection of Clean water :-

The clean water from the top is Collected in a draw-off Chamber from where it is taken to the next Unit through the outlet pipe.

Different types of Coagulants :-

There are various types of chemicals as used for the Coagulation -

1. Aluminimum Sulphate ($AL_2(SO_4)_3 18H_2O$)
2. Chlorinated Copperas
3. Ferrous Sulphate & lime ($Fe_3(SO_4)_3$ (CaO)
4. Magnesium Carbonate ($MgCO_3$)
5. Sodium aluminate ($NaAlO_2$)

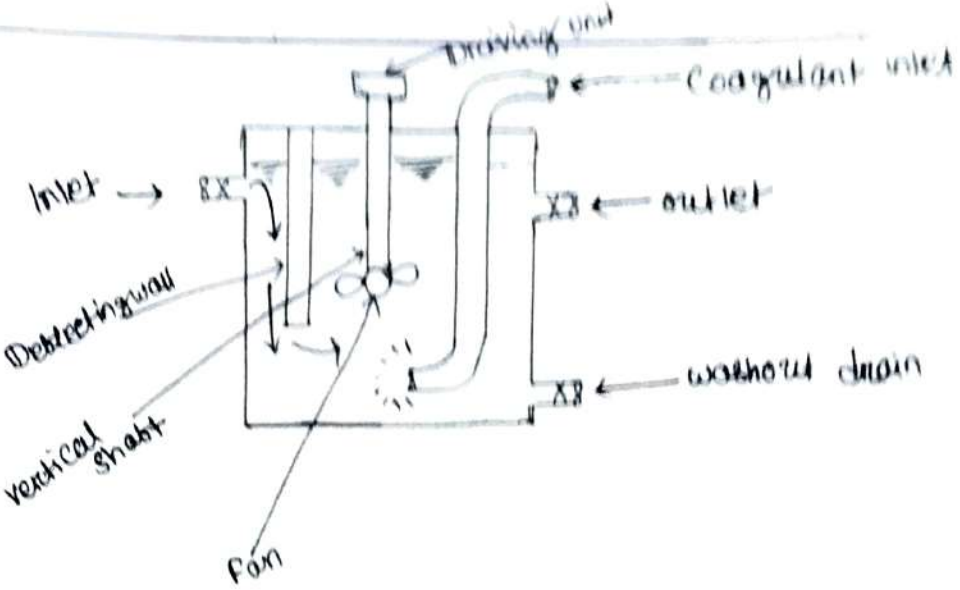
Mixing devices :-

The quick formation of flow depends on proper mixing of Coagulant with the water. The following are the mixing devices, are generally employed :-

1. Flash mixer
2. Deflector plate mixer
3. Flocculator

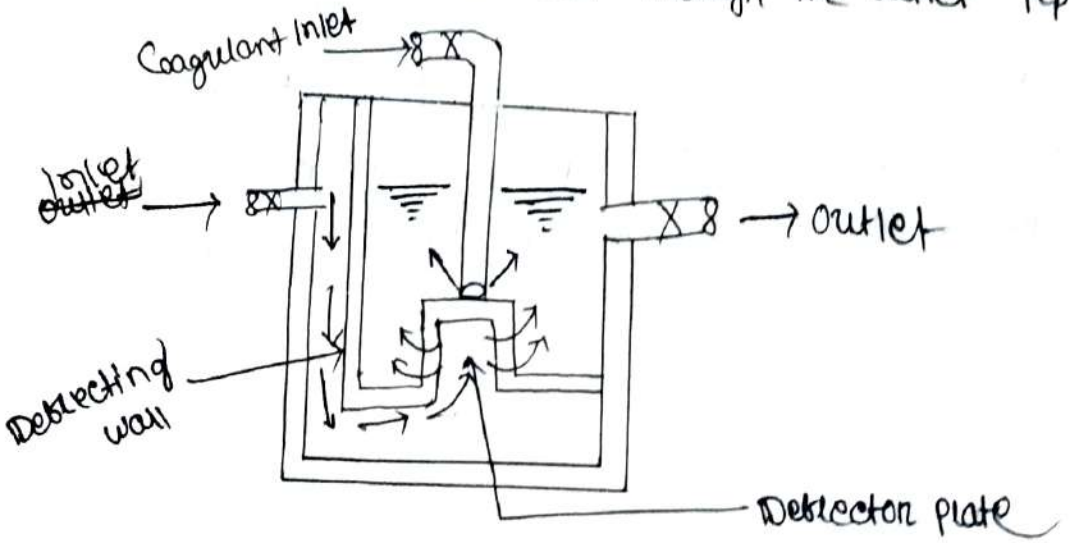
1. Flash mixer :-

The flash mixer consist of a fan which is rotated by an electric motor through a vertical shaft. The inlet pipe releases the Coagulant Solution just below the fan. Again the raw water is deflected by a deflecting wall so, that it may come in contact with Coagulant Solution. The rotating fan mixer Solution with the water thoroughly. The mixed water rises upward & finally comes out through the outlet pipe. A washout drain is provided at the bottom of mixer for cleaning when required.



Deflector Plate mixer :-

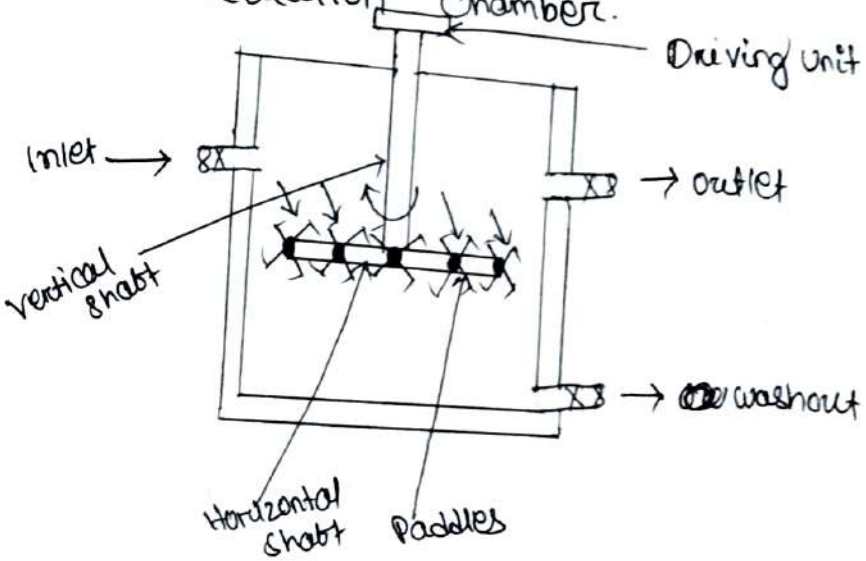
In this device a deflector plate is provided for the raw water, the inlet pipe discharges the solution just above the deflector plate, the raw water while entering the mixer is deflected by the deflecting wall and rises upward through the hole provided below the deflector plate, the water comes in contact with the coagulant solution just above the deflector plate. The water is thoroughly mixed with coagulant solution by the agitation of deflector plate finally the water passed out through the outlet pipe.



③ Flucculator :-

This device consist of a vertical shaft which is geared with a horizontal shaft. The horizontal shaft against consist of the several paddles. When the vertical shaft is rotated by the driving unit, the horizontal shaft also goes on rotating with the rotation of the horizontal shaft, the paddles go on revolving at a very slow speed at about 2-3 Rpm (Rotating Per

This unit is adopted for stirring the mixture of raw water and coagulant solution very gently, so that the formation of flock may occur very quickly. The flucculator is generally provided with in the flucculation chamber.



Types of chemical used as coagulant :-

There are various type of chemical are used as coagulant such as :- ① Aluminium — ($Al_2(SO_4)_3, 18H_2O$)

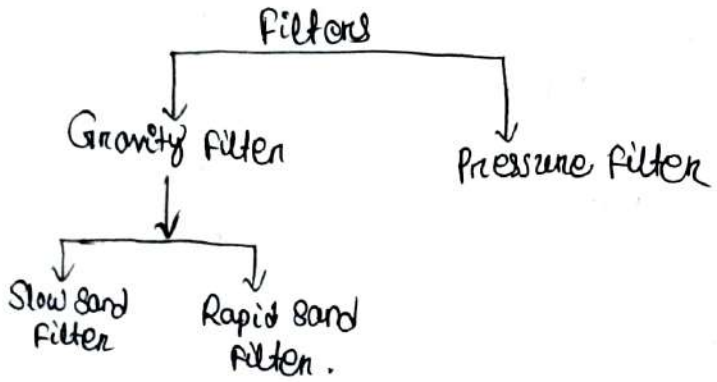
② Chlorinated coppers — ($Fe_2(SO_4)_3$, $FeCl_3$)

③

Filteration Unit :-

The process of filtration consist in allow in water to pass through the filtering media such as sand and gravel. In this unit the colloidal impurities and some of bacteria are remove.

Classification of filters :-



Gravity filter :-

→ In this type of filter, the water percolates under the force of gravity.

Slow Sand filter :-

In this filter the water is allowed to pass slowly through the layer of sand and sand used is of finer quality (fine sand).

Rapid Sand filter :-

In this filter the rate of filteration is increased by increasing the size of sand grain (coarse sand) and the water is allowed to pass under a greater filtration head.

Pressure Filter :-

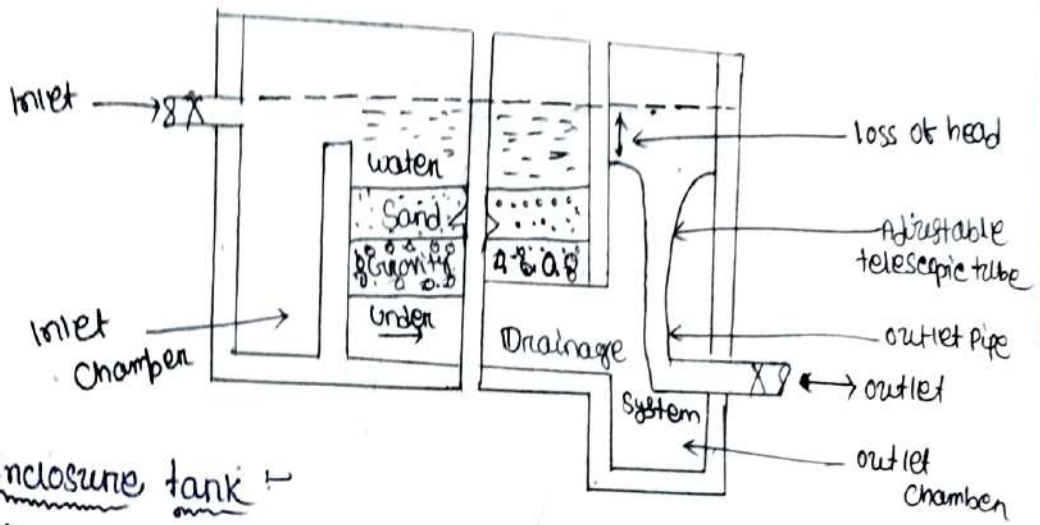
In this filter the water is allowed to pass under a pressure greater than atmospheric pressure through a closed cylinder. Here the force of gravity has no function.

Slow Sand Filter :-

Theory :-

The theory of slow sand filter is based on the principle that if the water is allowed to percolate slowly through the filtering media, then the biological, chemical & physical characteristic of water are improved. As the filteration takes much time it is not suitable for large scale. It is suitable for drinking water only for small towns.

Constructional Feature :-



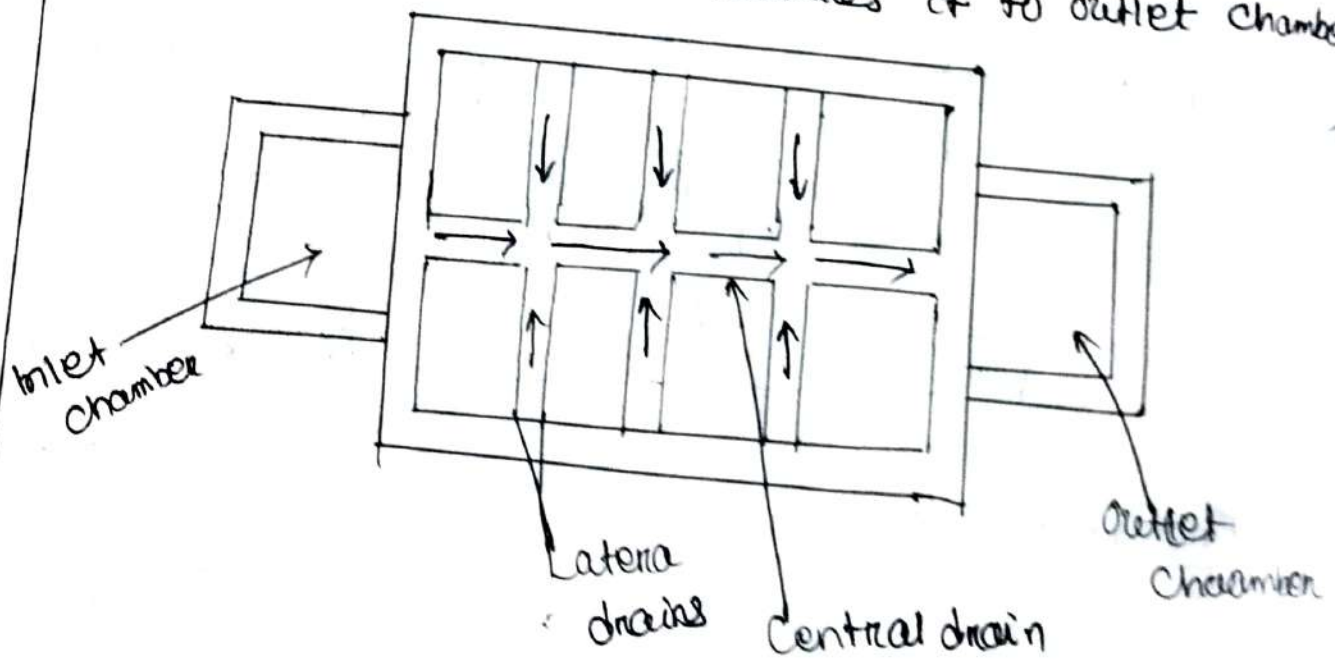
(a) Enclosure tank :-

It is a rectangular water tight tank constructed in bricks masonary, the inside surface is plastered with rich cement mortar (1:3) accompany with water proof compound. The bed slop is 1 in 100 towards

The Center the depth of the tank varies from 2m. m. The Surface area generally varies from 100 m² 2000 m².

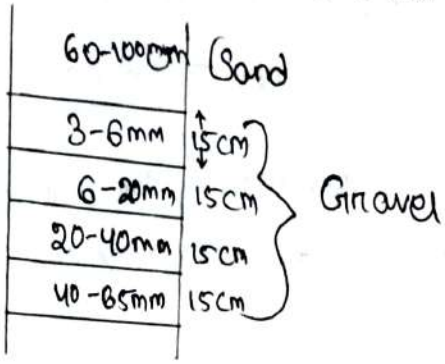
(b) Under drainage system :-

* It Consist of Central drain and lateral drain and lateral drains. The Central drain is a large diameter pipe which extends from the inlet pipe to outlet pipe. The lateral drain Consist of Perforated pipe of Smaller diameter. The lateral drains are Connected to the Central drains From both the sides.
* The filtered water is first Collected in lateral drains and then it closed towards.
* The Central drain carries it to outlet chamber



(C) Base material:-

The clean gravels of different size are used as base materials. It is placed over the drainage system in four layers. Each layer is of 15 cm thickness. The bottom layer is made of bigger size gravel size 20-40 mm. above that the layer is made of gravel size 6-20 mm and on the top most layer, the smaller size gravel i.e. 3-6 mm are provided.



(D) Filter media of Sand:-

The fine Sand of effective size of 0.20 to 0.35 mm and Uniformity Coefficient. 2 to 2.75 is generally used as the filtering media. The depth of the Sand layer varies from 60 to 100 cm.

E) Appurtences:-

Following are the appurtenances provided -

① A vertical air pipe is passed through the filter media for proper functioning of filter and removing mud clay.

② A device for measuring lose of head.

③ An adjustable telescopic tube to maintain constant discharge.

Working of the Filter :-

→ The water from the sedimentation tank enters to Slow Sand ~~bed without Causing~~ ~~filter~~ filter through a inlet pipe this water is uniformly distributed over the Sand bed without Causing any disturbances. The water Passes through the filtering media as an average rate of 100 to 200 $l/m^2/hr$.

→ The difference between the water above the Sand bed and the outlet chamber is called loss of head.

→ ~~what~~ water Percolates through the filtering media gets collected at the under drainage System and then goes to the outlet chamber.

→ During filtering of the filtering media gets closed due to impurities which Stay in the Pores, the resident to the Passage of water increases and also the loss of head increases.

→ After a Certain limit, when working of filter is Stopped then 2-3 Cm tank from the top of the bed is Scrapped and replaced with clean Sand.

→ The Scrap Sand is washed with water dried and Stored for return to the filter at the time of next working.

Efficiency :-

→ Turbidity :- It can remove turbidity to the extent of 50-60 ppm (Parts per million)

→ Colour :-

It can remove colour to the extent of about 25%

→ Bacteria :-

It can remove bacteria to the extent of about 95%.

Rapid Sand Filter :-

Theory :-

→ It is observed that the rate of filtration is more in coarse sand than that in fine sand. So the theory of rapid sand filter is based on the principle of increasing the rate of filtration by providing coarse sand as filter media.

→ The filtration head is also increased to increase the pressure head and the rate of filtration.

Constructional Features :-

(a) Enclosure tank :-

It consists of a water tight tank constructed with brick masonary. The inside surface is plastered with rich cement mortar (1:3 with water proof compound and finished with neat polish. The depth varies from 2-4m. The surface area depends upon volume of water to be filtered. Generally it is 30-60 m².

Under drainage System :-

The under drainage System Consist of a Central drain and Perforated lateral drains. The lateral drains are Connected to the Central drains from the both sides and they are placed at a 30 cm. c/c distance.

Base material :-

Clean gravels and different sizes are used as base material. These gravels are placed on the under drainage system in 4 layers each layer having 15cm thick. The bottom layer is made of bigger size gravel. That is 20-40 mm two intermediate layer are provided in first layer gravel size is 12-20 mm and 2nd layer is 6-12 mm. The top layer is made of smaller size gravel of about 3-6mm.

Filter media of Sand :-

The Coarse Sand of effective size of 0.35 - 0.65 mm and the Uniformity Co-efficient is 0.20 - 0.80 is generally used as the filtering media. The depth of Sand layer varies from 60-100 cm.

Appurtenaces :-

① Air Compression :-

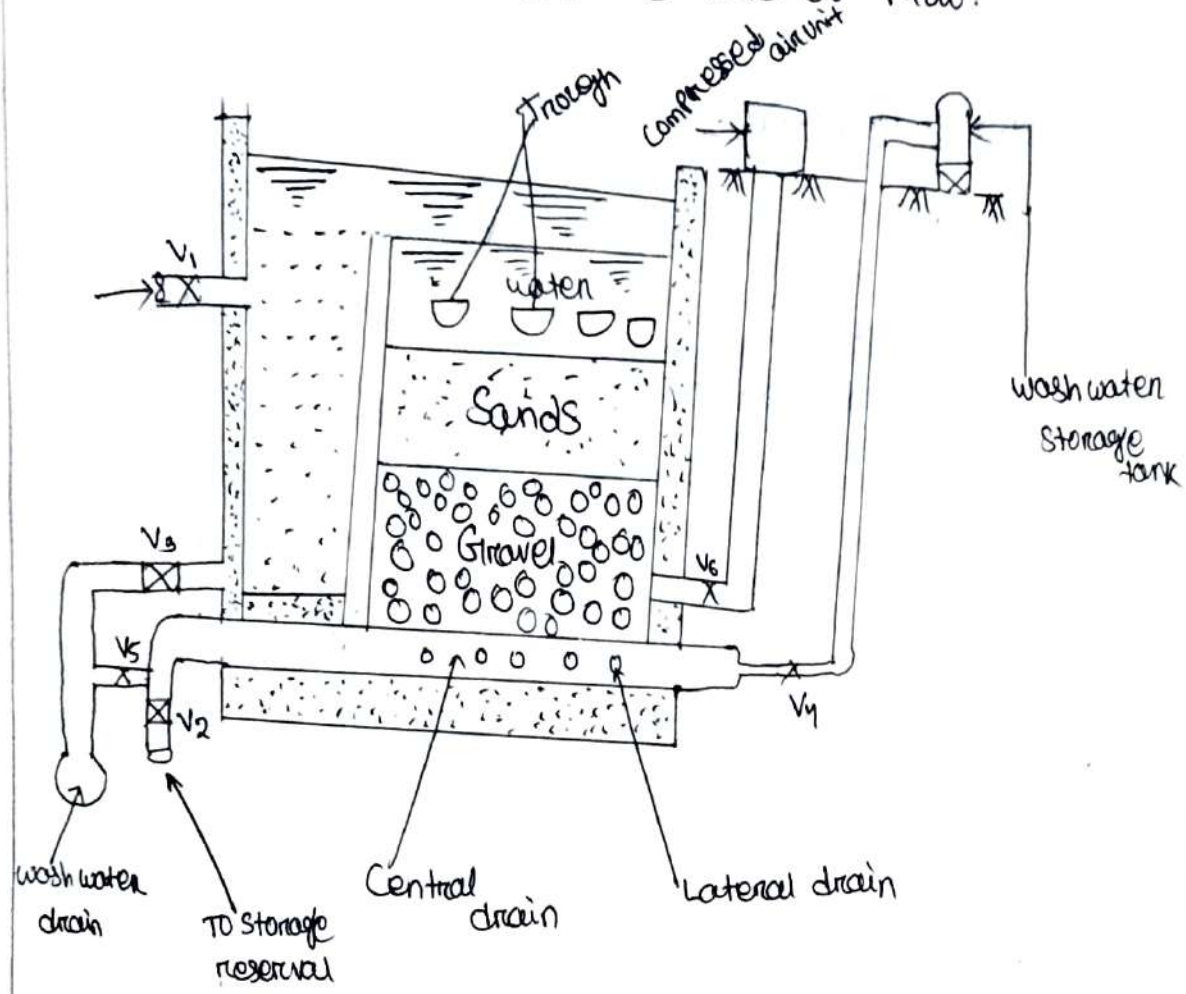
It is provided for Sending the Compressed air through the under drainage system at the times of washing the filter.

2. Trough :-

These are provided on the top of the Sand layer for Carrying dirty water at the time of washing the filter.

Rate Control :-

This is provided to control the rate of flow.



Working :-

In normal Condition, the values V_1 & V_2 are kept open and other values are kept closed. The water from the Coagulation tank enters the inlet chamber through the inlet pipe. Then the water uniformly spreads

over the filter media. The filtered water is collected in the central drain through the lateral drain. Finally the water is taken to the storage tank. When loss of head exceeds some limit, then function of filter is stopped. It requires washing to resume normal working condition.

Washing of Filter :-

a) During washing period the value V_1 & V_2 are kept closed.

b) The values V_4 and V_6 are opend. The wash water and compressed air are forced through the under drainage system.

c) After some time, the value V_6 is closed and value V_3 is opened so that the dirty water can be removed through the wash water drain.

d) When washing is over, the values V_3 & V_4 are closed. But V_1 and V_5 are kept open for some time.

e) Finally, the value V_5 is closed, and V_1 remains open now, value V_2 is opened to start the normal work.

Rate of filtration :-

the rate of filtration is very high. Generally the rate of filtration varies from 4000 - 6000 litres/hr/m² of surface of filter

Efficiency :-

(i) Turbidity :- It can remove turbidity to the extent of 30-45 ppm.

(ii) Colour :- It is highly efficient in removing the colour.

(iii) Bacteria :- It is less efficient in removing the bacteria.

Pressure filter :-

Theory :-

→ The theory is based on the fact that if water is sent under pressure through the filtering media, then the rate of filtration is highly increased. So, water passes under pressure greater than atmospheric pressure.

→ This pressure can be developed by pumping and it may vary from 0.3 - 0.7 N/mm².

Construction :-

→ It is a closed cylinder made of steel sheets by riveting. The diameter of cylinder varies from 2m - 4m and length varies from 4m - 8m.

→ Two manholes are provided on top for inspection.

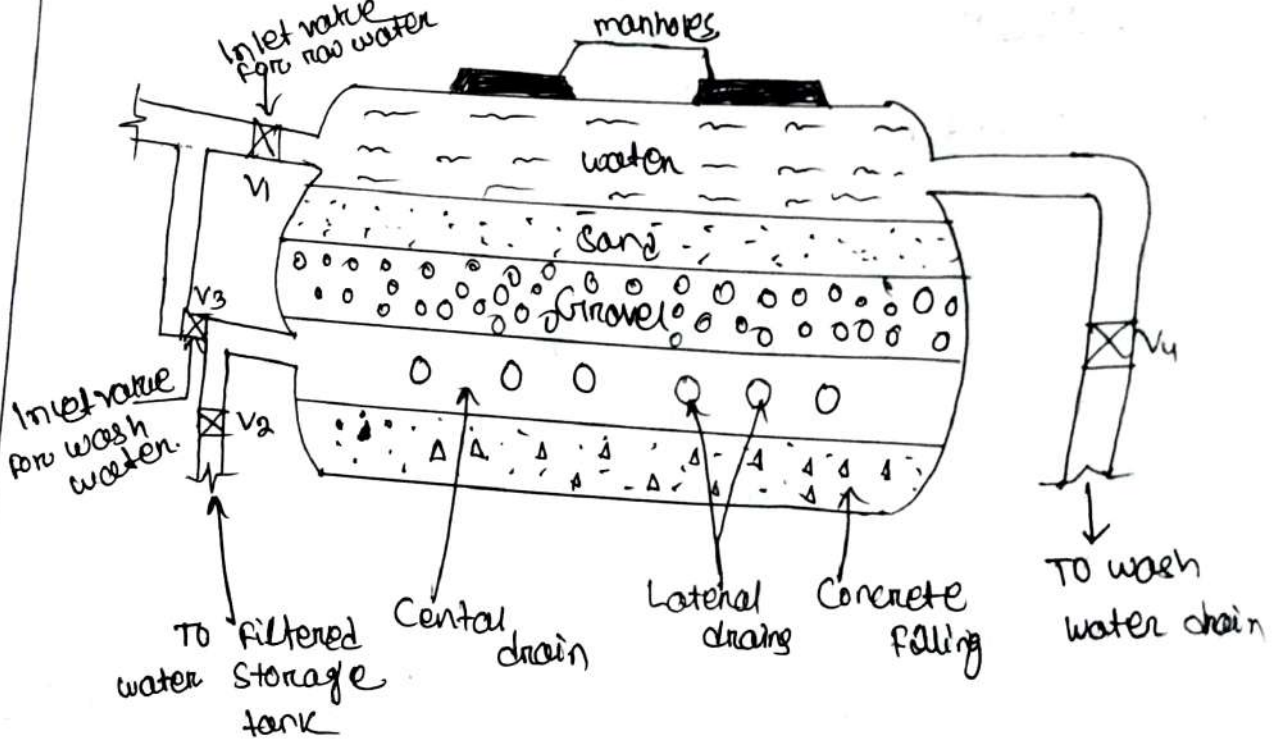
→ It consist of inlet pipe, an outlet pipe, an inlet

for wash water and compressed air and a wash water drain.

→ The gravels and coarse sand are placed over the underdrainage system which consists of a central drain and lateral drains.

→ The quality and size of sand and gravel are kept similar to the of rapid sand filter.

→ Pressure filter may be horizontal or vertical



Working :-

In normal condition, the valve V_1 and V_2 are kept open and the other valves are kept closed. The water enters the chamber through the inlet pipe on the top and passes through the filtering media under pressure. The filter water is discharged through the outlet pipe and stored in a storage tank

Cleaning :-

→ When the rate of filtration is decreased due to the deposition of impurities on the top surface of filter media, it requires cleaning.

→ During cleaning, the valves V_1 and V_2 are closed and the valves V_3 and V_4 are opened.

→ The wash water and Compressed air are sent through the base materials in an upward direction. The Compressed air agitates the sand grains and the wash water washes the impurities in sand grains.

→ The dirty water is exhausted through the wash water drains.

Rate of Filtration :-

The rate of filtration is very high. It is about 6000 - 15,000 lits/hr/m^2 of surface area of filter.

Efficiency :-

The Pressure filter is less efficient than rapid sand filter in removing turbidity, colour and bacterial load.

→ It is not suitable for Public water Supply Projects. It is suitable for industrial plants, Private State, Small colonies etc.

Comparison betn Slow Sand Filter and Rapid Sand Filter.

Slow Sand Filter	Rapid Sand Filter
* Area :- Requires large area for installation. (100-2000 m²)	* Area :- Requires small area for installation. (30-60 m²)
* Quality of Sand :- Fine Sand having effective size 0.20-0.35 mm, Uniformity co-efficient 2-2.75.	* Quality of Sand :- Coarse Sand having effective size 0.35-0.65 mm, Uniformity 1.20-1.80
* Base material :- Gravel size varies from 3-65 mm (i) Upper layer - 3-6 mm (ii) 2nd layer - 6-20 mm (iii) 3rd layer - 20-40 mm (iv) 4th layer - 40-65 mm	* Base material :- Gravel varies from 3-40 mm. (i) Upper layer - 3-6 mm (ii) 2nd layer - 6-12 mm (iii) 3rd layer - 12-20 mm (iv) 4th layer - 20-40 mm
* Method of Cleaning :- Scraping top layer of Sand to a thickness of about 25 mm.	* Method of Cleaning :- Back washing by water and Compressed air.
* Period of Cleaning :- 1-3 months.	* Period of Cleaning :- 2-3 days
* Super vision :- Skild Super vision not required.	* Super vision :- Skild Super vision is required

* Rate of filtration :- 100-200 lit/hr/m^2 of surface area of filter.	* Rate of filtration :- 3000-6000 lit/hr/m^2 of surface area of filter.
* Efficiency :- It is highly efficiency is removing bacteria.	* Efficiency :- It is slowly efficient is removing bacteria.
* Economy :- It is not economical.	* Economy :- It is economical.
* Suitability :- It is suitable for town.	* Suitability :- It is suitable for large city.

Disinfection of water :-

→ The process of destroying harmful bacteria from water and making it safe for drinking is known as disinfection of water.

→ The substance used for this purpose is known as disinfectants.

→ The process of destroying all the bacteria (either harmful or harmless) is known as sterilization. But in water supply scheme, we require only the removal of harmful bacteria (i.e. pathogenic bacteria) which may cause water-borne diseases like cholera, dysentry, typhoid etc.

Necessity of disinfection :-

→ After filtration, the water is found to some pathogenic bacteria, which are responsible for water borne diseases. Disinfection is necessary to destroy all such bacteria.

→ In distribution system, the water may be contaminated by the leakage of pipe line or in some other may so disinfection is required upto the point of consumption.

→ Disinfection is necessary to protect the citizens from health hazard and to assure a healthy atmosphere to all.

Method of disinfection :-

following are the methods of disinfection :-

(i) Disinfection by boiling
(ii) Disinfection by ultra-violet rays
(iii) Disinfection by iodine and bromine
(iv) Disinfection by excess lime
(v) Disinfection by ozone
(vi) Disinfection by potassium permanganate.
(vii) Disinfection by silver
(viii) Disinfection by chlorine.

(i) Disinfection by boiling :-

→ when water is boiled to boiling temperature (in 100°C) the bacteria is completely removed.

It should be boiled atleast for 10-15 mins.

→ Boiling also removes some of the disolved salts. It is the most efficient for disinfection. But this method is not suitable an large scale. It is suitable for domestic purpose. This water should be cooled down to a comfortable temperature before drinking.

(ii) Disinfection by ultra-violet rays :-

When mercury is enclosed in quartz bulbs and electric current is passed through it, the ultra violet rays are emitted. These arays are very powerful in killing all types of bacteria. In this method the water is allow to flow around the bulbs several times. The depth of flow should n't exceed 10-15 cm. This method doesn't impart any taste and colour to water. It is a costly method and suitable for small scale under water supply installations like factories, institution, training camps etc.

(iii) Disinfection by Iodine and bromine :-

The Iodine and bromine also have the property of killing bacteria. So, Sometimes they are used for the disinfection. The does of iodine and bromine should be 8-10 ppm. These chemicals are available in the form of small pallets. In this method the water

is stored in suitable container and required number of pallet are dropped in the container and left for 5 mins. It becomes safe for drinking

(iv) Disinfection by excess lime :-

Normally, lime is added to water to remove some of the dissolved salt. But when excess lime is added to water, it is found to act as disinfection. The excess lime increase the PH-value of water (i.e increases alkalinity) ~~of water is~~ which is destroyable to bacteria because the bacteria cannot resist alkalinity of water. It is found that the PH-value ~~has~~ having 9-10 can remove bacteria to the extent of 99 percent. But, after treatment the residual lime should be removed by the method of recarbonation.

(v) Disinfection by ozone :-

In atmosphere, the molecule of oxygen contain two atoms (O_2). But it changes to three atoms when electric current under high voltage is passed through a stream of air in a chamber containing water. The triatomic oxygen is known as ozone (O_3). The ozone easily breaks into

oxygen (O_2) and nascent atom (O). The third atom is very powerful in killing bacteria. The does of ozone varies from ~~5 to mins~~ to 2-5 ppm and Contact Period varies from 5-10 mins. It after treat-ment some residual ozone is present in water, it is automatically removed. It is a costly method and much care should be taken to avoid any accident due to electrical fault.

(VI) Disinfection by Potassium Permanaganate :-

Potassium Permanaganate is a powerful oxidising agent. It oxides the organic mattens present in water and hence the bacteria are killed. But this is not suitable in large scale for public water supply schemes. But this is mostly used for disinfecting the water of wells in village area, swimming pools, ponds etc. The does of this chemical is about 2-3 ppm and the Contact Period is generally 2-3 hours.

(VII) Disinfection by Silver :-

Silver is found very effective in killing bacteria. Silver foils are spread over the filter media and water is passed through it. The water absorbs some portion of silver which kill bacteria.

The dose of silver ~~strict~~ varies from 0.5-1 ppm. As silver is costly, it is not suitable for public water supply schemes. It is suitable for domestic use only.

(viii) Disinfection by Chlorine :-

Chlorine has got the wonderful power of destroying bacteria. It is the best among all the other disinfectants used for the disinfection of water. It kills bacteria very fast and its effect lasts for such a long time, that it even acts in the distribution system. It is cheap and reliable. If some residual chlorine exists in water, it does not cause any harm to consumers and it can be removed by break point chlorination.

Application of chlorine :-

Chlorine may be applied in water in any of the following forms :-

1. Chlorine
2. Chloramines
3. Bleaching Powder
4. Chlorine dioxide

① Chlorine

Chlorine may be applied in to ways.

→ Gaseous Form or liquid Form

→ In liquied way chlorine gas is Converted to liquid by appling a Pressure of 7 kg/cm² 11 kg/cm², in a Cylindrical vassel for this Purpose. Then the liquid chlorine is added to water by a device which is known as chlorinator

→ In gaseous way, chlorine gas is dissolved in water and Sodium is mixed with water according to the does as Certained in laboratory test.

→ The use of free chlorine is favoured universally for the following advantages.

* Chlorine is the most Powerful for destroying the bacteria absolutely.
* The Process of application is easy.
* It Can be Stored easyly.
* The optimum does Can be easily found out by break Point chlorination.

② Chloramines -

The free chlorine is not stable in water to make it stable, Some amount of ammonia is mixed with water along with chlorine. As a result of the Chemical reactions Some Compounds are formed which are known as chloramines

The following Chloramines are formed -

(i) Mono-Chloramine (NH_2Cl) - It is effective for PH value above 7.

(ii) Dichloramine ($NHCl_2$) - It is effective for PH - value bet^n 5 and 7.

(iii) Nitrogen trichloride (NCl_3) - It is effective for PH - value 4.

→ Ammonia may be mixed with water in gaseous or Solution form. The following are the advantages of adding ammonia with chlorine.

(i) It makes Chlorine Stable in water.

(ii) It reduces the amount of Chlorine necessary for the treatement.

(iii) It becomes more powerful in killing bacteria.

3. Bleaching Powder :-

Bleaching Powder is also known as Calcium hypochlorite [$Ca(OCl)_2$]. When it is mixed with water, hypochlorite ions (OCl^-) are formed. These ions again combine with hydrogen ions (H^+) present in water and thus, hypochlorous acid ($HOCl$) is formed. This phenomenon is known as hypo-chlorination.

$$Ca(OCl)_2 \rightleftharpoons OCl^- + H^+ = HOCl$$

→ Both hypochlorous acid and hypochlorite ions are responsible for the disinfection of bacteria

→ The bleaching powder is available in white powder form which contains usually 35% of chlorine. It should be stored carefully.

→ Before application, the bleaching powder is dissolved in water and a solution is prepared. Generally the does of bleaching powder is about 2 to 4 ppm.

→ Bleaching powder is not recommended for public water supply. It is suitable for disinfecting the water of swimming pools, ponds etc.

4. Chlorine dioxide :-

Sometimes, the chlorine dioxide (ClO_2) is used for removal of bacteria. It is produce by passing chlorine gas through Sodium chlorite in a closed container. It can remove taste and odour. It may be used for small installation like housing estate, factories etc.

Forms of Chlorination :-

The following are the different forms of chlorination :-

(i) Plain Chlorination

(ii) Pre - chlorination

(iii) Post Chlorination
(iv) Double Chlorination
(v) Break Point Chlorination
(vi) Super Chlorination
(vii) Dechlorination

(i) Plain Chlorination :-
It is the simple process in which the chlorin is added to the water. The process is known as plain-chlorination.

(ii) Pre-Chlorination :-
In rainy season, when the raw water is suspected to be highly contaminates, then a dose of chlorine is added to the raw water before it enters the sedimentation tank. This application of chlorine is known as Pre-Chlorination. That means it is an advance dose of chlorine before the actual period of chlorination. The idea of pre-chlorination is as follows :-

(i) It reduces bacteria load before it enters the treatment plant.

(ii) It checks the formation of angle in sedimentation tank.

(iii) Post-Chlorination :-
Sometimes the dose of chlorine is applied after treatment if required. It is known as post-chlorination.

(iv) Double chlorination:-

when first dose of chlorine is not sufficient to remove bacteria then we again apply the second dose of chlorine. To remove that bacteria is known as double chlorination.

(v) Break Point chlorination:-

→ The break point chlorination is a method of determining the chlorine demand of raw water.

→ There is no chlorine demand in pure water. If chlorine is added to such water, the chlorine will come as residual chlorine which is represented by a straight line R_1.

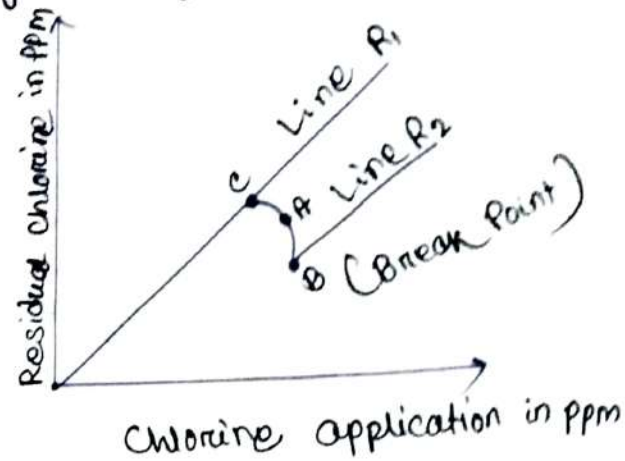
→ when chlorine is added to contaminated water it will kill the bacteria and oxidise the organic matters.

→ In the beginning the chlorine goes on killing bacteria and then it starts mixing up to a certain point which is shown by point (A). If the dose of chlorine goes on increasing. It will start emitting bad smell. That means chlorine is oxidising the organic matters and killing the bacteria during that ~~period~~ period.

→ But after sometimes the bed smell suddenly disappears. This critical point is known as break point, which is indicated by B. If further chlorine is added it will come as residual chlorine, which

is shown by line P_2.

→ So, the actual dose of chlorine should be determined by Carefully finding the break point formation.



(vi) Super - Chlorination :-

The Process of application of chlorine beyond the formation of break point, is termed as Super - Chlorination. This treatment is necessary when is a Spread of water - borne disease.

(vii) De - Chlorination :-

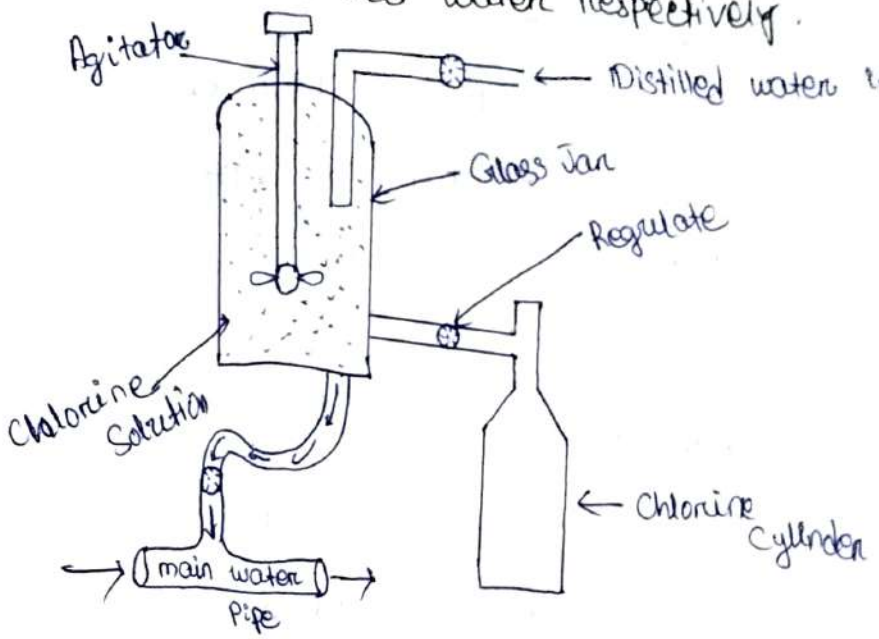
But in the treatment much residual chlorine in water may appear which is unpleasant to Consumers. To neutralise the residual chlorine to an allowable limit, dechlorination should be done.

Mixing device of Chlorine :-

Chlorine is mixed with water with a device which is known as Chlorinator. A simple type is described below.

→ It Consists of a glass Jar Containing distilled water in which the Chlorine is fed from the Chlorine Cylinder. An agitator is Provided inside the jar as shown in fig. It agitates distilled water to form a uniform Chlorine Solution. This Solution is fed to the water in the main pipe through injector pipes.

→ To Control the dose of Chlorine a regular is Provided in the injector pipe. one regulator is Provided in Chlorine inlet pipe and the other is Provided in distilled water pipe to regulate/Control the flow of Chlorine and distilled water respectively.



Water Softening :-

water softening may be defined as the removal or reduction of hardness from water.

Definition of hardness :-

The hardness of water is defined as the quality of water which is due to the Presence of bicarbonates of Calcium

and magnesium; Sulphates, chlorides and nitrates of Calcium and magnesium. Such water is termed as hard water.

Types of Hardness :-

Hardness may be of two types :-

a) Temporary hardness :-

The Presence of bicarbonates of Calcium and magnesium in water is known as temporary hardness. It is also known as Carbonate hardness.

b) Permanent hardness :-

The Presence of Sulphate chlorides and nitrates of Calcium and magnesium in water is known as Permanent hardness. It is also known as non-Carbonate hardness.

Effects of hardness :-

The following are the effects of hardness —

a) It makes the food tasteless.

b) The vegetable, meat, etc, takes much time to be boiled Property (i.e. Soft).

c) It increases the fuel Cost for Cooking.

d) It Consumes more Soap and so it is uneconomical in washing of clothes.

(e) The working of dying system is highly affected as it causes the change of colour shades in fabrics.

(f) It reduces the life of fabrics.

(g) It forms scales on boilers which is reduce the life of steam engines.

(h) It leads to corrosion and incrussation of pipes.

Necessity of water softning :-

The softening of water is necessary for the following reasons :

(a) To improve the taste of food.

(b) To reduce the consumption of soap in washing of clothes.

(c) To reduce the formation of scales in boilers.

(d) To increase the ~~effect on colour~~ life of fabrics.

(e) To neutralise the effect on colour in dying system.

(f) To reduce the corrosive effect on pipe.

Removal of Temporary hardness :-

The temporary hardness may be removed by the following methods :-

(a) By boiling (b) By adding lime

(a) By boiling :-

When the water is boiling for a long time, the chemical reactions take place as given below :-

$$Mg(HCO_3)_2 \longrightarrow MgCO_3 + CO_2 + H_2O$$

$$Ca(HCO_3)_2 \longrightarrow CaCO_3 + CO_2 + H_2O$$

After boiling, the magnesium and calcium carbonates are formed which are insoluble in water and they settle down at the bottom of the tank when the water is cooled gradually.

The process is not suitable for large scale. This is applicable in domestic purpose only.

(b) By adding lime :-

When lime is added to water having temporary hardness, the following chemical reactions takes place.

$$Mg(HCO_3)_2 + Ca(OH)_2 \longrightarrow CaCO_3 + Mg(OH)_2 + H_2O$$

$$Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3 + 2H_2O$$

After reaction, the calcium carbonate and magnesium hydroxide are formed. These are insoluble in water and they settle down at the bottom of the tank.

Removal of Permanent hardness :-

The permanent hardness can be removal by the following three processes :

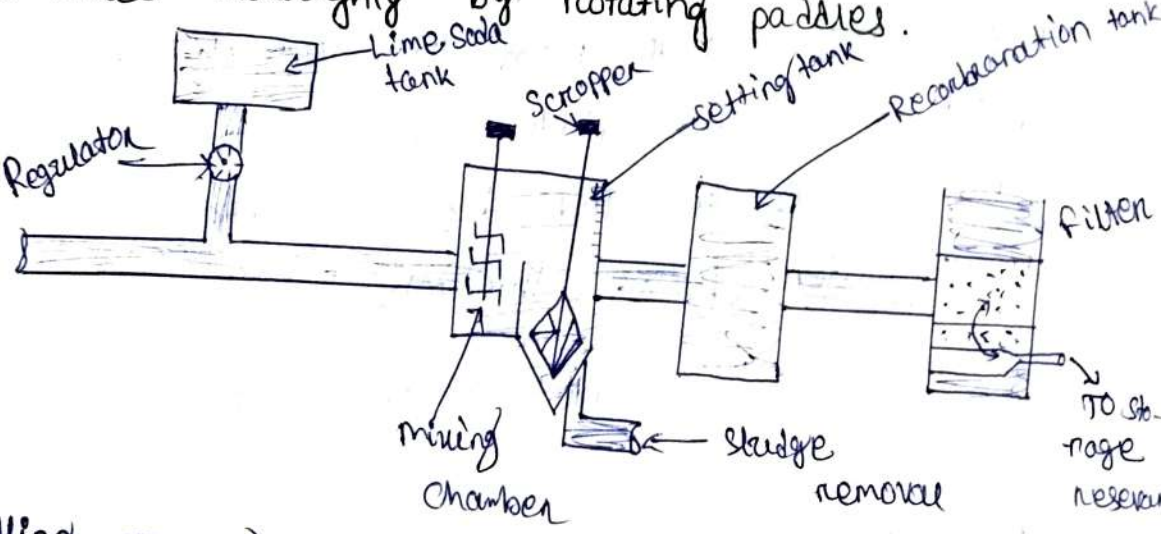
* Lime - Soda Process.
* Zeolite process
* Demineralisation Process.

* Lime Soda Process :-

Fig 11.1 shows the lime-soda process which involves the following unit :-

(i) Feeding and ~~maximum~~ mixing Unit :-

The lime and soda are mixed in an appropriate Proportio and a solution is made. The solution is stored in a lime-soda tank. It is then fed to the raw water inlet pipe by suitable device. A regulator is provided to control the dose of lime-soda. The solution flows to the mixing tank where the water and lime-soda are mixed thoroughly by rotating paddles.



(ii) Settling Tank :-

This tank is similar to the coagulation tank. Here, the water is detained for some specific period. The sludge is collected at the bottom of the tank which is taken-off through the sludge removal pipe at a regular interval. The water from the top is taken to recarbonation plant.

(iii) Recarbonation Tank :-

The calcium carbonate formed in this process should be removed from water. Otherwise, this will disturb the function of the filtration unit. It is removed by carbon dioxide. The carbon dioxide (CO_2) reacts with calcium carbonate ($CaCO_3$) and thus calcium hydroxide [$Ca(HCO_3)_2$] is formed.

(iv) Filtration Unit :-

The filter may be rapid sand filter or pressure filter. The water from the recarbonation tank is spead over the filter media. The suspended fine particles are arrested by the filter media and clear water passes through the under drainage system. The filtered water is taken to the storage reservoir.

Advantages :-

(i) The PH-value of water is increased which reduces the corrosion of distribution pipes.

(ii) The alkalinity of water is increased which destroys path-genic bacteria.

(iii) It removes iron and managanese to some extent

(iv) It reduces the other mineral contents.

(v) It reduces the quantity of coagulant required for coagulation.

Disadvantages :-

(i) It is difficult to dispose of the large volume of sludge.

(ii) The calcium carbonate formed in this process is not completely insoluble. It is slightly soluble in water. So, this process can not remove the hardness completely.

(iii) If recarbonation is not done, a ~~large~~ layer of calci carbonate will be deposited on the filter media. This layer disturbs the process of filtration.

* Zeolite Process :-

→ The zedite is a compound of aluminimum, silica and soda. These chemicals posess the property of inter changing base. Hence, the zeolite process is also known as base exchange process. The zeolite may be obtained from nature or it may be artificially prepared.

** The natural zedite is green in colour so, it is also known as green in colour can remove the hardness of 7,000 – 10,000 gm/m³ of zeolite.

⇒ The artificial zeolite is known as permutit. It a synthetic hydrated silicate of aluminium and sod The raw materials from which it is manufactured ar felspar, ~~Kaolin~~ kaolin clay and soda. It is white in colour. It can remove the hardness of 35,000 to 40,000 gm/m^3 of permutit.

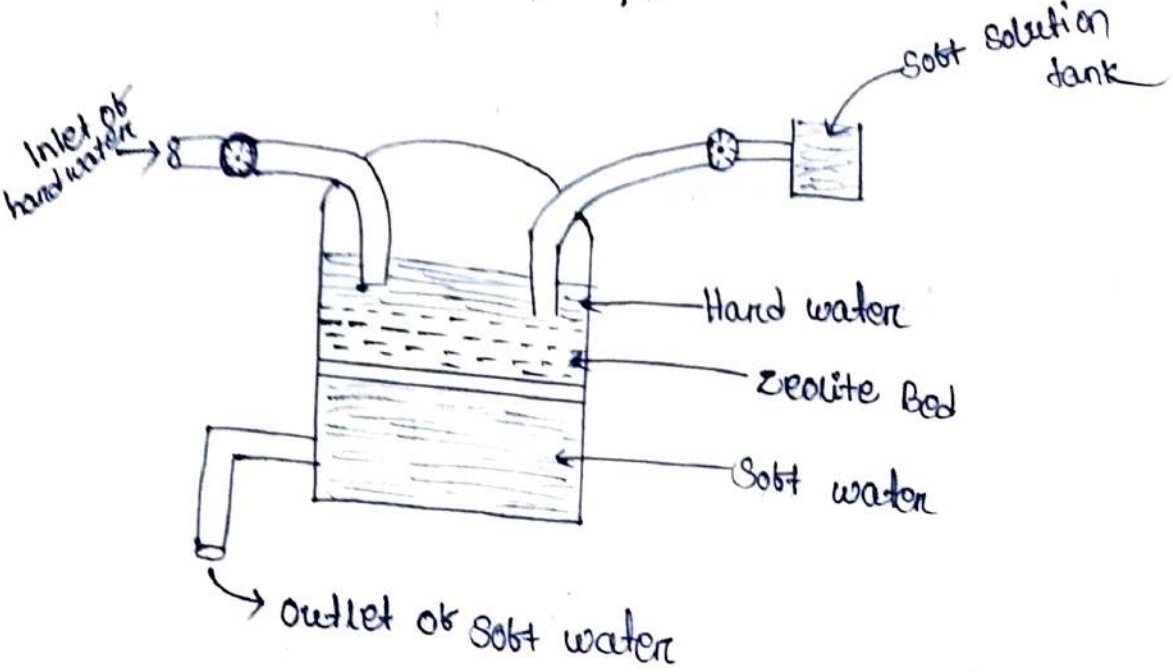
⇒ The sodium present in zeolite may be exhausted after some period then it is regenerated by adding a solution of salt in the bed of zeolite.

⇒ It is a filter of cylindrical shape in which zeoli bed of thickness 90-180 cm is provided directly over the under drainage system in this filter, these is no necessity of gravel and sand layer.

⇒ The hard water is allowed to enter the filter on the top in passes through the zeolite bed and the soft water is collected below the under drainage from where it is taken to the storage reservoir.

⇒ The zeolite plant may be gravity filter type o pressure filter type. After softening a considerable amount of hard water, the sodium content

in zeolite may be exhausted. It is regenerated by passing a solution of 10% Common Salt through the zeolite bed. The rate of flow through the zeolite is generally 100-300 Lit/min/m^2 of surface area.



Advantages :-

(i) The treatment Unit is Compact.

(ii) No Sludge is Formed in this Process.

(iii) It produces zero hardness of water.

(iv) The desired degree of hardness can be prepared by adding this soft water to any hard water in to a Proper Proportion.

(v) It is automatic and economical.

(vi) It eliminates the deposition of calcium carbonate in distribution System.

Disadvantage :-

(i) It is not suitable for turbid water.

(ii) It is unsuitable for water containing iron and manganese.

(iii) Much time is lost at the time of regeneration of exhasted Sodium.

(3) Demineralisation :-

In this process, hard water is passed through the bed of carbonaceous matter containing hydrogen ion (H) as base. Here, the hydrogen ions are exchanged for metallic ions. So this process is also termed as de-ionisation process. when hard water is allowed to pass through the resineous bed. The chemical reactions take place the chemical reactions take place. Thus, the filtered water contains carbonic acid, sulphuric acid and hydrochloric acid and which are removed by mixing required proportion of alkaline water to the treated water.

⇒ After some time, the hydrogen ions of the substance are exharusted. These are regenerated by passing a solution of sulphuric acid or hydrochloric acid through the bed of resin. This method is suitable for preparing soft water for industrial purpose.

Chapter-4 Distribution System

Introduction :-

The distribution system plays an important role in the water supply scheme. Distribution should be done in such a way so that the water can be supplied evenly to the consumers and it can reach at every corner of various zones. The location of fire hydrant, air relief valve, Pressure relief valve etc. should be so oriented that any accidental situation may be easily overcome. The following points should be kept in mind while designing the distribution system :-

(a) The methods of distribution such as gravity method, Pumping method and dual method should be carefully decided according to the conditions of intake point and the distribution area.

(b) The layout of distribution such as dead end method grid iron method, Circular method and radial method should be decided according to the nature of supply zones.

(c) The distribution pipe lines should not be taken below the sewer line.

(d) The joints of pipe lines should be perfectly done and tested before filling up the trenches to ensure any leakage of the joints.

(e) The pipes should be anti-corrosive and strong enough to bear the loads of vehicles passing over the pipe lines.

(f) Inspection chambers should be provided at specific points.

(g) Each zone should be separated by sluice valves (i.e. gate valves) so that the repair works in any zone may not ~~distri~~ disturb the other zones.

(h) The diameters of main line, branch lines, distribu-tory lines should be carefully designed so that ample supply of water to the consumers can be assured.

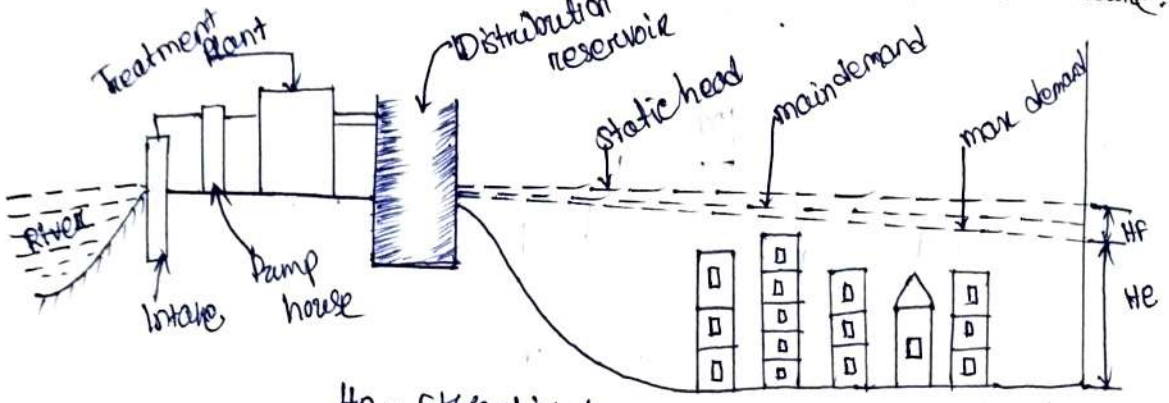
Methods of distribution :-

The methods of distribution depends on the topography of the town or city. The following are the different methods of distribution:

1. Gravity System :-

In this system, the water flows under the force of gravity from the distribution reservoir to the distribution area. This system is suitable when the source of water treatment plant and the distribution reservoir are situated ~~wate~~ at a high level than the distribution area. As shown in fig 13.1. the treated

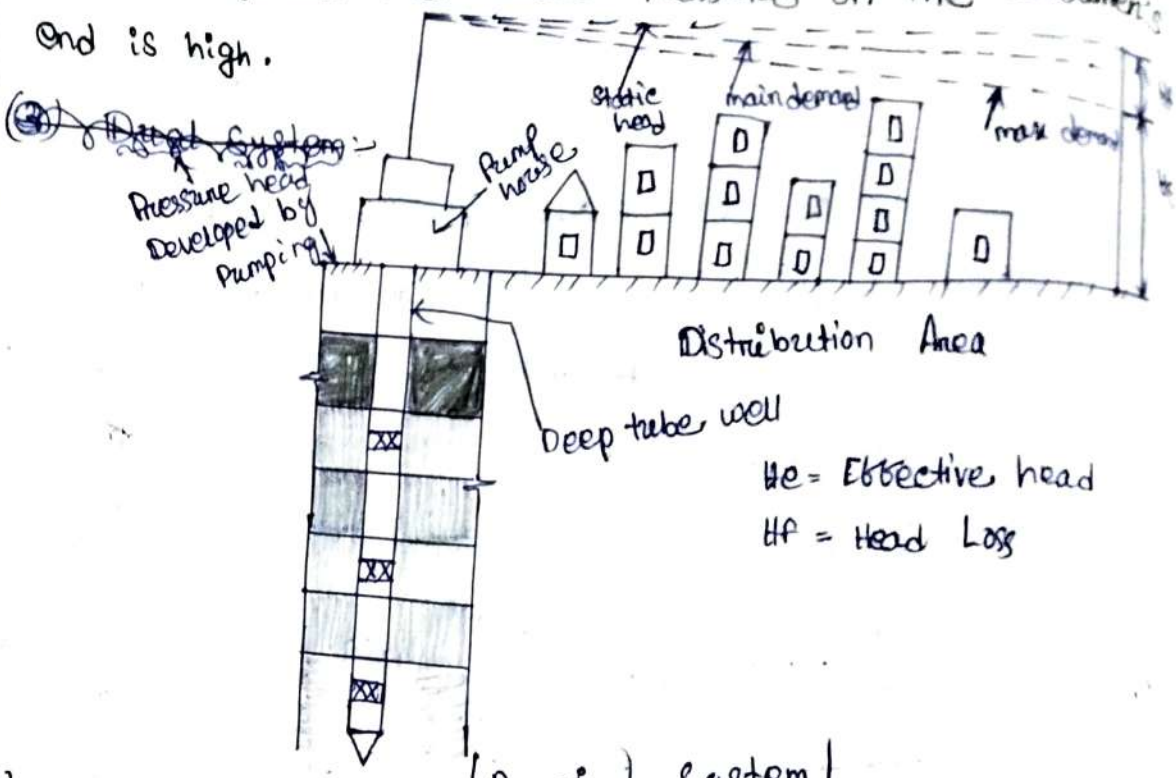
water is stored in the distribution reservoir, from where it is supplied to the consumers. It is the most reliable system, as there is no possibi-lity of break of water supply due to any mechanical or electrical failure. But here, much pressure head may not be developed and hence the water may not rise to a considerable height at the consumers end. In case of fire demand, the booster pumps may be installed to develop high pressure.



2. Pumping System :-

As shown in fig. 13.2, in this system, the water is lifted from the deep tube well by submersible pump or bowl assembly and is directly supplied to the consumers. Here, the treatment plant is not necessary. This system is adopted when suitable surface source is not available near the town or city. But this system is solely dependent on the mecha-nical power. So, in case of any failure of the

mechanism, the supply of water is highly disturbed. In this system, the water pressure on the consumer's end is high.

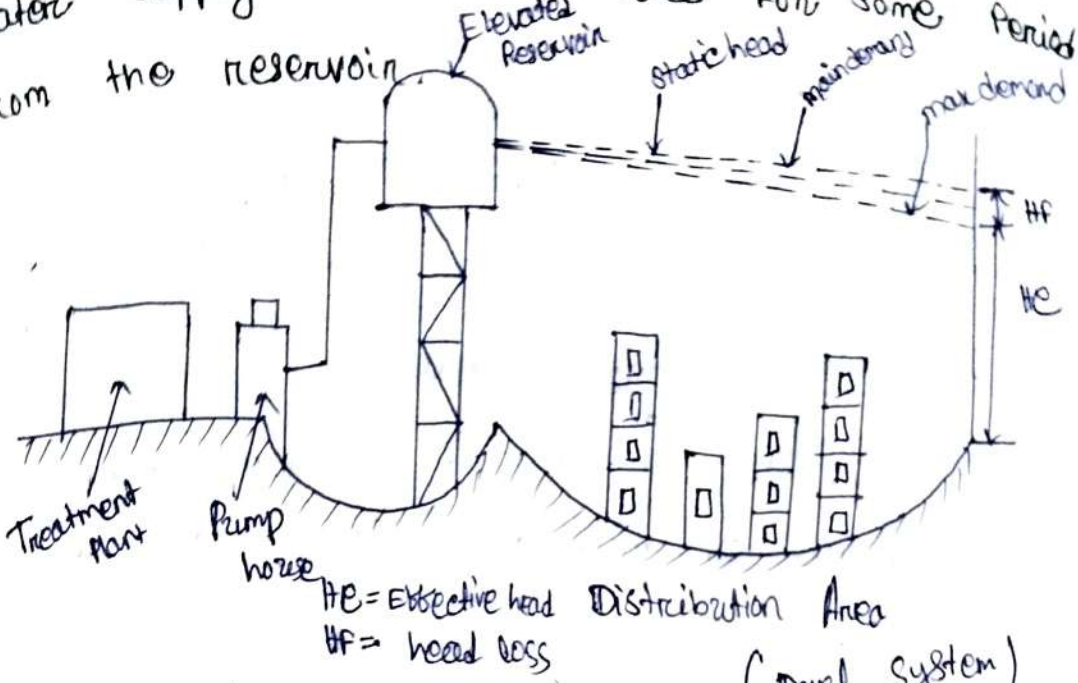


(3) Dual System :- (Pumping System)

Fig 13.3 shows the dual system of distribution in which, the pumping and gravity both systems are utilised simultaneously when required. Normally, the pumps are operated at a constant speed to meet the average demand of water. So, during the period of low demand, the excess water is stored in an elevated reservoir. During the period of peak demand, the water is supplied by pumping and from the elevated reservoir simultaneously.

~~The~~ This system is fairly reliable, because in

case of any failure of pumping mechanism, the water supply can be continued for some period from the reservoir.



13.3 System of water supply :- (Dual System)

Depending upon the duration of supply, the water supply system may be divided into the following two groups:

① Continuous Supply System :-

In this system, water is supplied to the consumers through out the 24 hours of the day. This system is suitable when plenty of water is available from the source and the cost of water treatme is considerably low. But in this system a considerabl amount of water may be wasted due to the lack of civic sense of consumers or any leakag

in pipe line or any damage in taps Provided along the streets. However, this is an ideal System, because the Consumers do not face any water Problem during the day and water for fire-fighting may be available at any time.

2. Intermittent Supply System :-

In this System, water is supplied during some fixed period of the day. The number of times and the duration of supply depend on the water supply authority. Generally, water is supplied three times in a day, such as 5 a.m. to 7 a.m. 9 a.m. to 11 a.m. and 5 P.m to 7 P.m. But this System is not ideal, because the Consumers may face inconvenience due to the unavailability of water at the time of extreme necessity Again at the time of sudden outbreak of fire, the fire-brigade vehicles may not get water for fire-fighting.

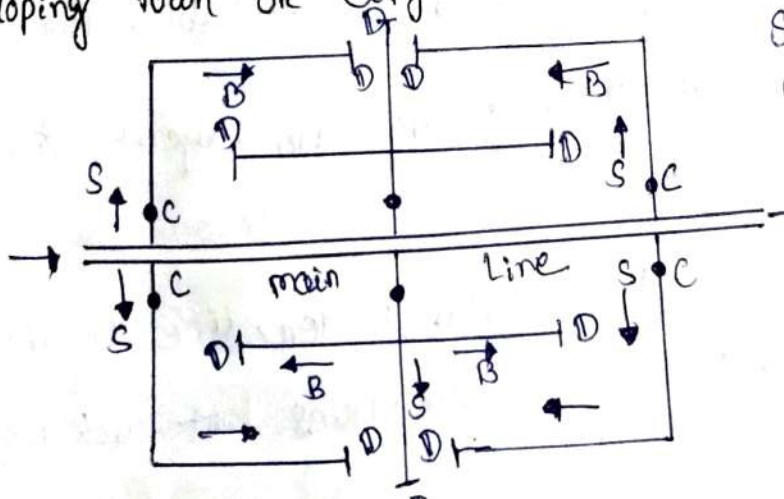
Layout of distribution pipes :-

The following are the four methods of the layout of distribution pipes :

1. Dead-end method :-

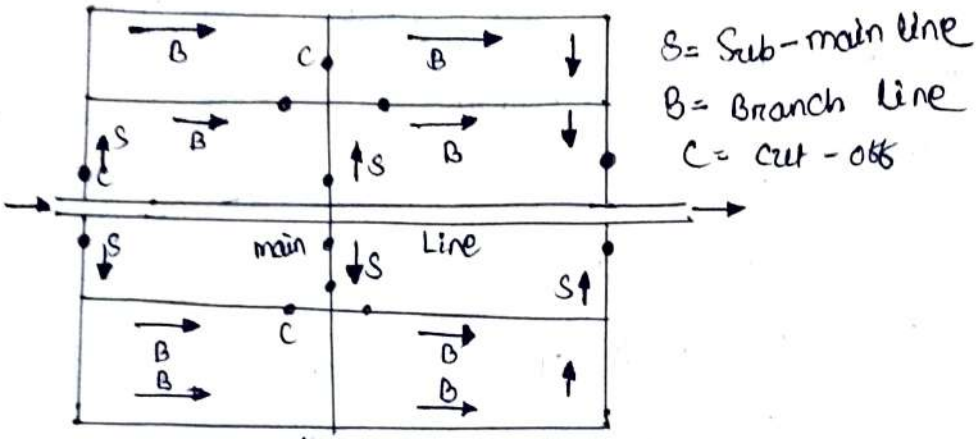
Figure 13.4 shows the dead-end method of layout of water distribution pipes. In this system, a main line is taken from the ~~main line~~ reservoir along the main road. The sub-mains are taken suitably from the main line. Cut-off valves are provided at the entry of sub-mains. From the sub-mains, the branch lines are taken from which service connections are given to the consumers through the ferrule. The ends of the sub-mains and branch lines are stopped by scour valves which are known as dead-ends. For washing the pipe lines, the dead-ends (i.e. ~~S~~ Scour valves) are opened periodically and the stagnant water is allowed to flow out.

Due to the dead-ends, there is no free circulation of water and the water remains stagnant within the pipe line. This system is suitable for irregular developing town or city.



2. Grid-iron method :-

Figure 13.5 shows the grid-iron method. It is also known as interlaced system or reticulation system. In this system, the main line, the Sub-main lines, and the branch lines are interconnected. So, there is free circulation of water through the pipe lines.



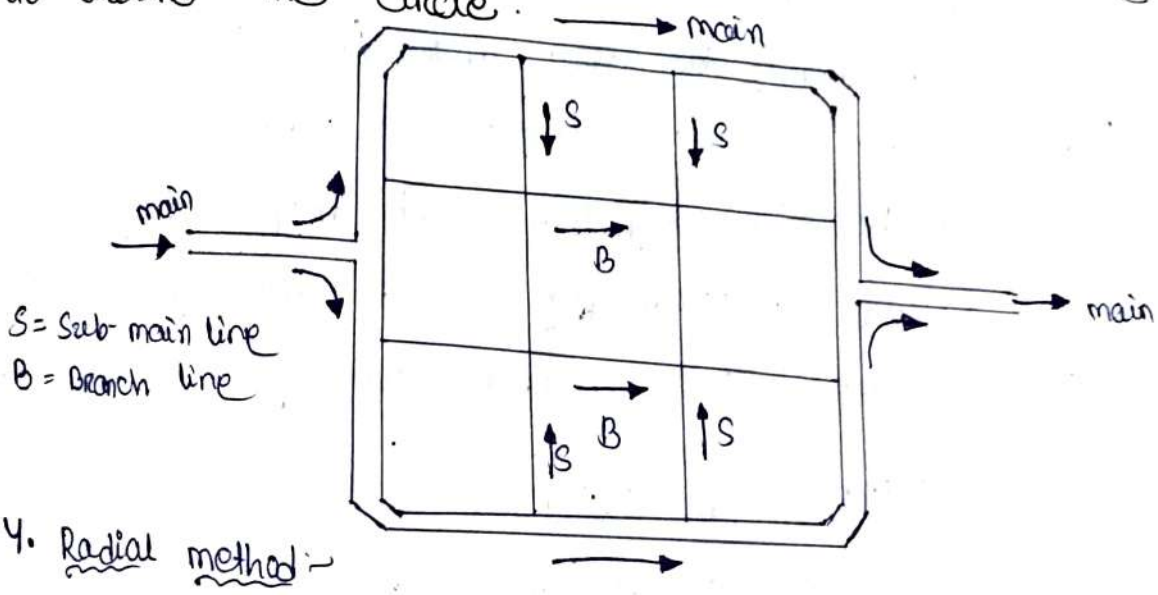
(Fig- 13.5)

Cut-off valves are provided at each junction point so that the repair works may be conducted at a particular area without disturbing the whole area. In case of fire, plenty of water is available at any zone and at any time. But in this system the length of pipe lines is too great, and hence it is very costly. This system is suitable for town or city having ~~rect~~ rectangular layout of roads.

3. Circular method :-

In this system, the main water line is divided into two parts : In two directions left and right. As

shown in Fig 13.6 in inlet side, the left and right water mains travel in opposite directions along the periphery of the area and they meet again on the outlet side. This system is also known as ring system. Here, every point gets water supply from both directions and for fire-fighting the water may be available from all the direction. This system is suitable for well planned town or city where the locality can be divided into square or circular blocks and the main water line can be laid around the sides of the square or around the circle.



4. Radial method :-

As shown in Fig 13.7, in radial method, the town or city is divided into various circular or square zones and distribution reservoirs are placed at the centre of each zone. The distributor lines are laid radially from the reservoir towards the periphery of each zone. This system is suitable when the town or city be oriented with radial roads and streets.

this system, the water from the main reservoir is allowed to flow through the main ~~reservoir~~ pipe and sub main pipe and get collected at the distribution reservoir of each zone. Then the water is supplied to consumers through the distribution lines.

Wastage of water :-

The wastage of water has a great impact on the water supply scheme. If the wastage exceeds the permissible limit, then the supply of water to the consumers decreases and they have to suffer for that. So, the causes of wastage should always be investigated and proper steps should be taken accordingly. The following are some of the reasons of water wastage.

(a) Carelessness of Consumers :-

(i) A tap in the bathroom or basin or kitchen or any other place may be kept open unnecessarily.

(ii) A damaged tap may not be replaced in time.

(iii) The small reservoir in bathroom or in any other place may be allowed to overflow unnecessarily.

(iv) The street taps may be kept open or damaged and the water flows out unnecessarily.

(b) Leakage in pipe Line :-

(i) There may be leakage of water through the pipe joints.

(ii) There may be leakage through the pipe line which was damaged at the time of excavation trenches for telephone line, drainage line, Sewer line etc.

Valves & Pipe fitting :-

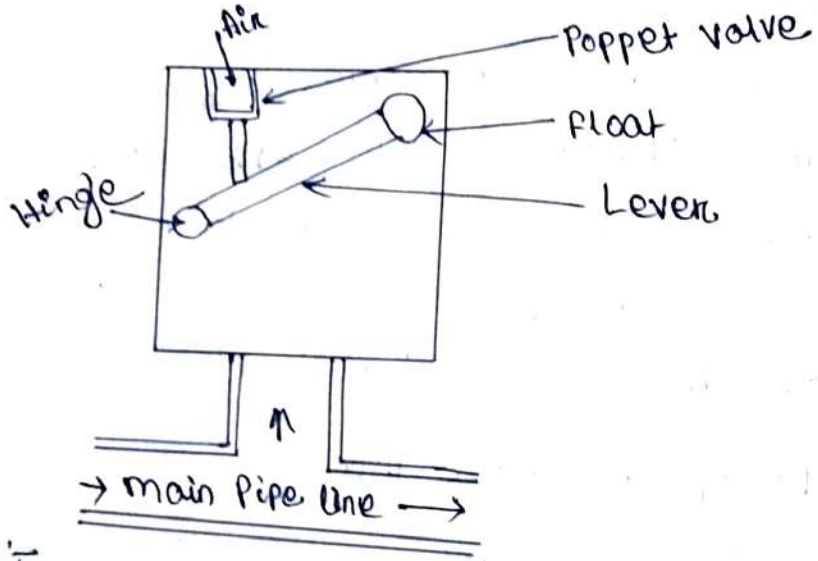
Introduction :-

In water works, the various types of pipe apparatus such as values, Sluices Sockets, elbows etc. are needed to Control the flow of water, to release the excessive Pressure in the pipe line, to eliminate the accumulation of air in the Summits of the pipe line. Again in house plumping various types of pipe fitting such as taps, Sockets, elbows nipples. Stop Cocks, gate valves, check valves, tees, etc are requirmet the following are the important appurtences in pipe lines.

1. Air valves
2. Reflux valves (check valves)
3. Relief valves (gate valves)
4. Scour valves
5. Fire hydrants
6. water meters.

1. Air valves :-

Air valves are also known as air relief valves. The water flowing through the pipe line always carries some air with it. This air tends to accumulate at the summits of the pipe line. Due to the accumulation of air, a back ward pressure is created which causes a blockage to the flow of water. Thus the discharge through the pipe is suddenly decreased and ultimately it may be stopped. So, the air relief valve is provided at the summit to release the air pressure. The air valve consists of a cast-iron chamber in which a float, lever and a poppet valve at provided as shown in fig.



Function :-

⇒ In normal condition the chamber remains full the float reaches the roof and the popet valves remains in closed position.

⇒ As the air goes on accumulating on the top of the chamber a pressure goes on developing.

⇒ This process cause the water level to go down and hence the float book down wards which pulls the river down. Thus the popet valves is open and air is allowed to escept.

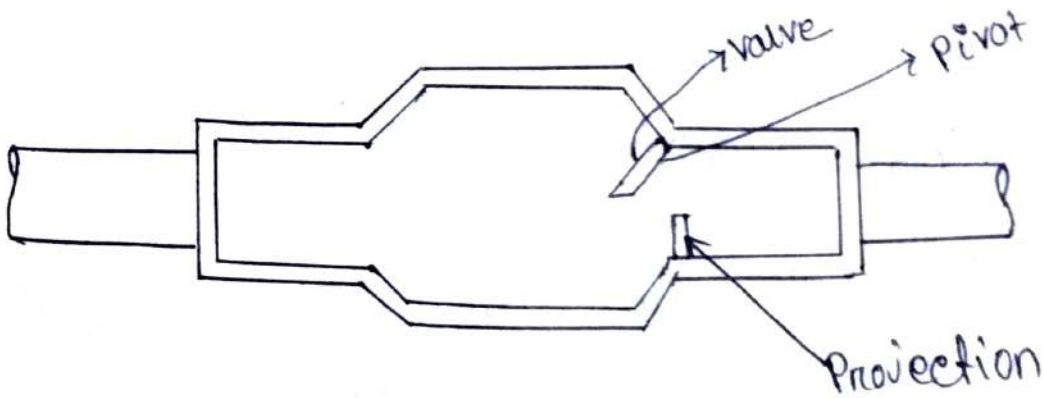
⇒ when the air is released Completly. The water level rises again the normal working Condition revies.

(2) Re-flux valve / Check valves -

⇒ It is also known as check valves or known return valves. This passes some automatic device which allowed to flow in one direction only. These are made of brass or gun metal.

⇒ A valves is pivoted at one end and it can restan a Provection and the other and the value is provided in the pipe line which drows water from the Pump.

⇒ when the pump is operated, the valve is open & the water flows through the pipe as indicated by arrow. But when the pump is suddenly stop or it face due to Power failure the valve is automatically closed and the water is prevented from returning to the pump.

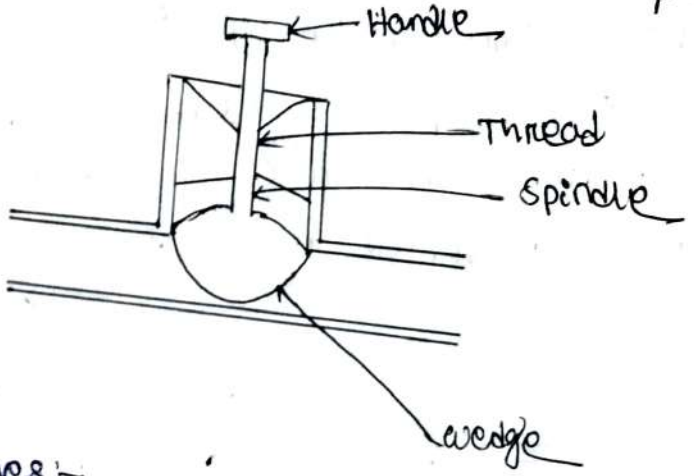


* Sluice valve :-

⇒ It is also know as get valve or shorter valve. This valves are provide to stop the flow of water through the pipe and and assential to devide the main line into several sections. In branch line or some specific points on the distribution system, these valves are provide to perform the repair watch without disturbing the water supply in other section.

⇒ It Consist of spindle. which carries away at the bottom and at handle at the top, the spindle is threaded and can be move of an down. when the spindle is rotated antic lock wise the ways is lifted of & the water flows through the pipe.

⇒ when the spindles roted clock wise the ways is libted the water flow of water is stop.



* Scour valves :-

The scour valves are also known as washout valve These are similar to the sluice valve bret the function is different the scour valves is provided

at the ded end of the pipe line. the function of the valves is to remove the sand silt etc from the pipe line. The valves is opened by turning by spidle the miedly water is allowed to flow out when the washing is Complete, the valves is closed by turning the spendle.

(5) fire hydrantes :-

⇒ fire hydrantes is a out let provided in the main water line. for tapping water in case of fire when fire accour in some places. The fire briged vehicle run to the spot and connect the home pipe to the ~~sport by~~ sport by removing the cap. Then the valves open by turning the han -dle, after finishing the work the cap is replace and the valve is closed the hydrants are provided on the main line at important points. The location of the fire hydrant should be marketed on a map by the fire briged authority. The hydrants may be of two types.

1. post hydrants.
2. flush hydrants.

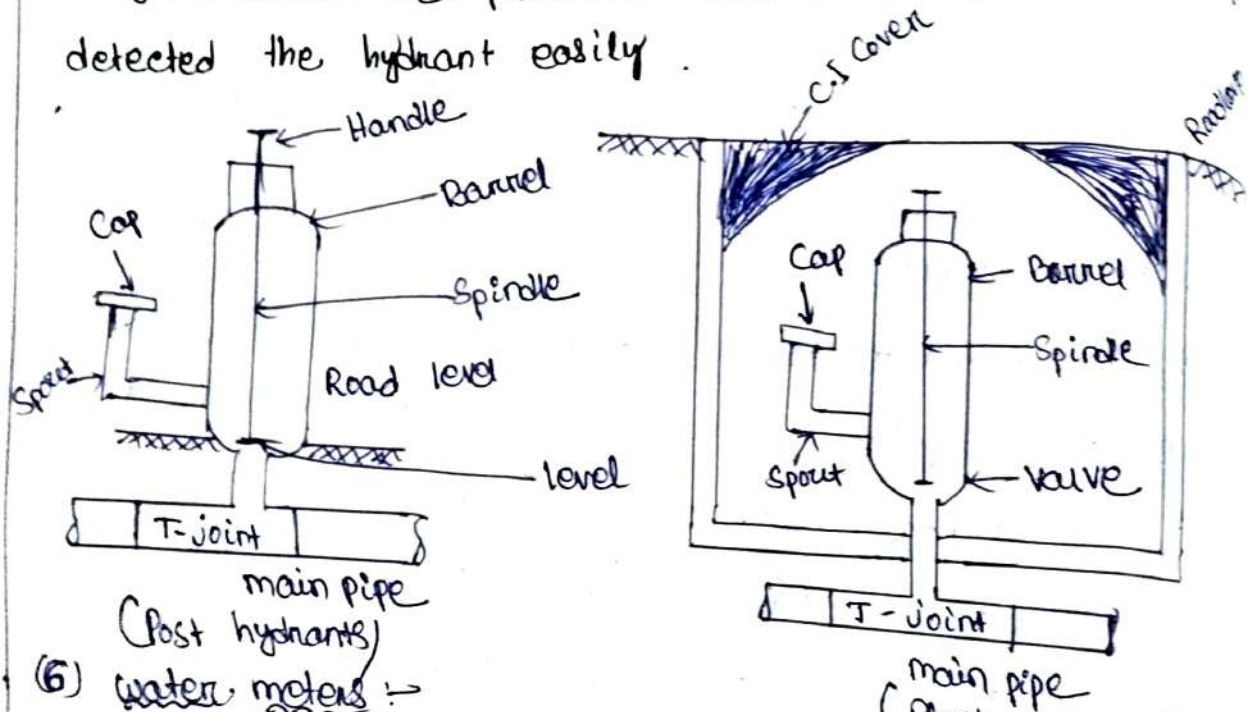
1. post hydrants :-

The post hydrants is project above the road level. This type of hydrant is prominate & can be located easily but it is liable to be damage by the ~~mission~~ miscreants.

2. flush hydrants :-

The flush hydrants is provided below the road level it is Projected by cast iron box or brick masonary a cost

iron Cover is placed to the box. It is difficult to locate the position of the fire hydrant easily however Some Single should be provided. Above the ground level to detected the hydrant easily.



(Post hydrants)

(6) water meters :-

The device by which the quantity of water flowing through a particular points is measured is known as water meter it helps directly to Compute the value of water used by a Consumer from the reading on the meter. The waterce is charged according to the volume of water Consume. The meter may be of two type :-

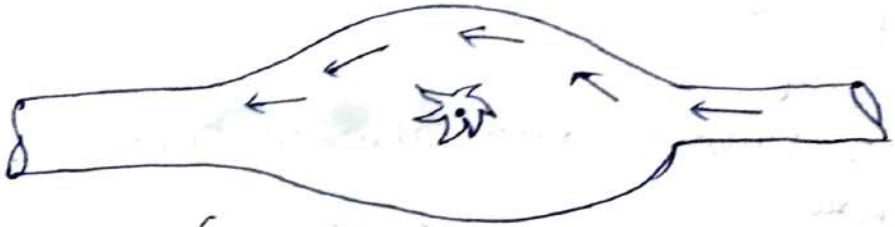
① Displacement type
② velocity type

1. Displacement type :-

This type of meter records the no of time a Container of known volume is filled or emptyed to the flowing water from the reading the volume of water Can be workedout.

2. Velocity type –

This type of meter gives a reading on the dial according to the velocity of flow of water the volume of wate can be workedout from the manufacture tunes rotting table.



(Rotary type meter)

Introduction :-

The method of fitting the accessories in water supply system in a building is known as plumping:

The following accessories are required for the plumping work:

1. Stop Cock
2. Bib Cock
3. Check valve or gate valve or Sluice valve
4. Sockets
5. Nipple (short and long)
6. Union
7. Elbow
8. Tee
9. wash basin
10. Sink
11. Shower
12. Bathtub (if necessary)
13. G.I. pipes – 12 mm ϕ, 19 mm ϕ, 25 mm ϕ, etc.

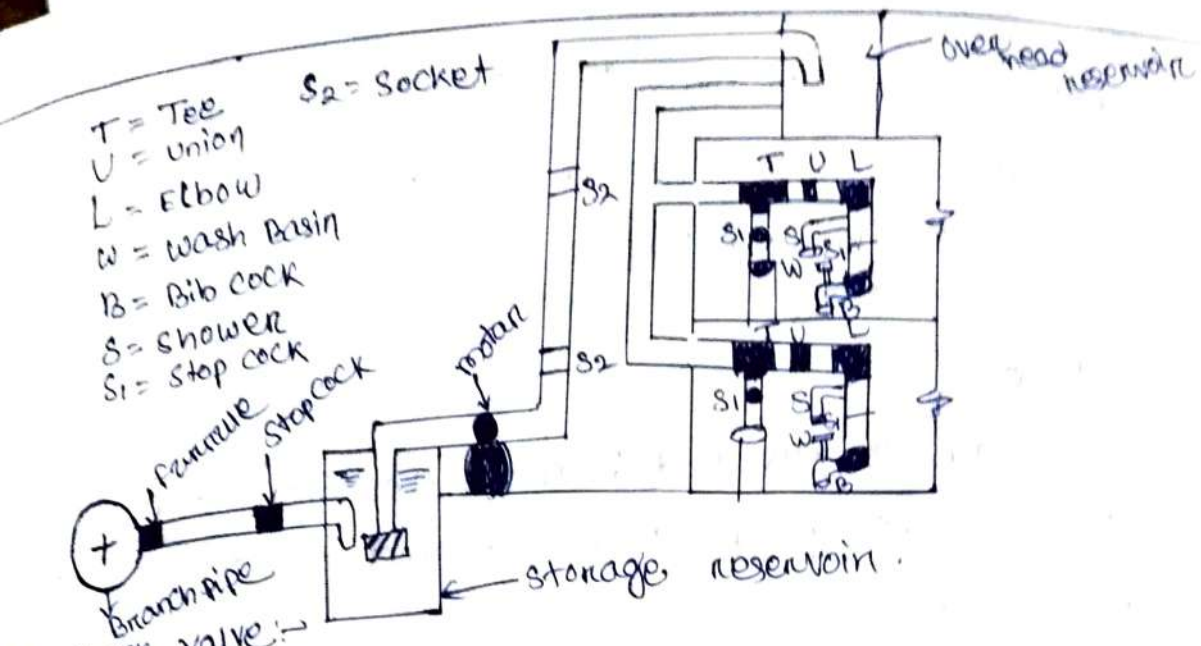
Positions and Functions of different Accessories –

1. Stop cock :-

It may be made of steel or brass and is fitted to the pipe line leading to wash basin, sink, shower, bathtub, etc. to stop the flow of water when necessary.

2. Bib cock :-

It may be made of steel, brass or plastic. It is provided to the wash basins, sinks, bathrooms and at places where it is necessary for tapping water for washing hands and faces, utensils, clothes etc.



③ Check valve :-

It may be made of steel or brass. It is provided to the pipe line to check the flow of water. It is also known as gate valve or sluice valve. The non-return check valve is provided on the vertical pipe line leading to the overhead tank to check the back flow of water.

④ Socket :-

It is made of galvanised iron pipe of different diameters. Sockets may be of two types - plain socket and reducing socket.

The plain socket is used to connect two pipe of same diameters. The reducing socket is used to connect two pipes of different diameters.

⑤ Nipple :-

It is made of galvanised iron pipe of different diameters. Nipples may be of two types - short and long. The length of short nipple is 25 mm and is used for fixing bib cocks or at some other necessary points. The length of long nipple may be 150 mm, 225 mm, 300 mm etc. and of different diameters. It is used for short extension of pipe line when necessary.

(6) Union :-

It may be made of brass or Cast iron. It is used to connect two pipes of same diameter so that the pipe line may be opened easily for the purpose of washing or for carrying out repair works.

(7) Elbow :-

It is made of galvanised iron in the shape of 'L'. It is used at the point where two pipes are to be joined at right angles.

(8) Tee :-

It is made of galvanised iron in the shape of 'T'. It is used at the point where a vertical pipe line is to be taken from a horizontal pipe line.

(9) Wash Basin :-

It is made of porcelain in various shapes and sizes. It is fixed with the wall at a suitable place in a building for washing hand, face, etc.

(10) Sink :-

It may be made of Concrete or porcelain or P.V.C. in the shape of rectangular trough and fitted with the wall of kitchen.

(11) Shower :-

It may be made of steel or plastic in different types. It is provided in the bathroom for bathing.

(12) Bath tub :-

It is installed in the bathroom for bathing by immersing the whole body in water. It is an essential fitting in houses abroad, also popular in rich urban societies, specially in the metropolitan cities.

(13) G.I. Pipe :-

It is made of galvalised iron of different diameters (12mm, 19mm, 25mm .....). The length of the pipe varies from 6m to 7m.

Purpose of Sanitation :-

The waste Product like garbage, Sewage, Sullage, etc. are Produced everyday in towns and cities. The garbage is Produced in domestic area, markets, Public places, streets, etc. ~~of the garbage~~ and the liquid waste is Produced and From latrines, Urinals, stables, bathrooms, etc. If the garbage is not collected and disposed of regularly, then it will on accumulating in the dust-bins. This will Cause Insanitary conditions by Producing bad Small, Fly nuisance bacteria, etc. The source of water may also be polluted which may Cause water-borne diseases. Again, if the Sewage and Sludge are not disposed of Properly, they will also Cause insanitary condition.

Under these circumstances, it is most necessary to establish the sanitation systems in towns or cities.

Principles of sanitation :-

~~The following a~~

The following are the principles of sanitation:

(a) The waste matters like garbage and sewage should be removed as early as possible after its formation.

(b) The waste matters after collection should be treated within four hours and the effluent should be disposed of immediately.

(c) The floors and furnitures in a house should be cleaned regularly.

(d) The buildings should be made damp-proof.

(e) Water supply should be regular and sufficient so that the flushing of the lavatories may be done properly.

Definition of different terms :-

1. **Refuse :-**

The rejected materials which are collected in dust-bins and the foul discharges which are carried by underground drains are termed as refuse. Refuse may be of two types:

(a) **Dry refuse :-**

It includes grass, leaves, paper pieces, sweepings decayed fruits and vegetables, cloth pieces, waste cotton, rejected plasters from hospitals, etc.

(b) Wet Refuse :-
It includes the discharge from latrines, urinals, bathrooms, kitchens and stables.

2. Garbage :-
The dry refuse is also termed as garbage. It includes the sweepings from markets, public places, and streets. The rejected materials from residential area such as vegetable peel, paper pieces, ash, decayed fruits and vegetables, etc. are also included in garbage.

3. Sewage :-
The liquid waste from a community is termed as sewage. It mainly includes the discharges from latrines, urinals and stables. The discharges from bathrooms, and the storm water (i.e. rain water) are also included is sewage. The human excreta is termed as night soil. The sewage may be of the following types:

(a) Sanitary Sewage :-
The foul discharges from the residential area are known as Sanitary Sewage. It includes mainly the discharge from latrines and urinals.

(b) Industrial Sewage :-
The discharges from the industries (i.e. industrial waste) are known as industrial sewage.

(c) Combined Sewage :-
The combination of Sanitary sewage and storm water is known as Combined sewage.

(d) Fresh Sewage :-

The sewage which is produced at the moment is termed as Fresh sewage.

(e) Raw Sewage :-

The sewage which is not yet treated is termed as raw sewage.

(f) Septic Sewage :-

The sewage which is undergoing treatment process is termed as septic sewage. After the completion of the process of decomposition, it is termed as stale sewage.

(g) Weak Sewage :-

The sewage which is diluted with water and contains less amount of suspended matters is termed as weak sewage.

4. Dry weather flow (D.W.F.) :-

The flow of sewage during the dry season of the year is termed as dry weather flow.

5. Wet weather flow (W.W.F.) :-

The flow of sewage during the rainy season of the year is termed as wet weather flow.

6. Storm water :-

The surface run-off during the rainfall at any place is termed as storm water.

7. Sullage :-

The discharge from the bathroom and kitchens is termed as sullage. It is not a foul discharge, and it does

not cause bad smell.

(8) Sewer :-

The Underground Conduits or drains which Carry the Sewage are known as Storm water.

(a) Main Sewer :-

The Sewer which carrise the whole Sewage Coming from the branch lines is termed as main Sewer.

b) Branch Sewer :-

The Sewer which Carries the Sewage from the lateral Sewers and delivers the same to the main sewer is termed as branch Sewer.

(c) Combined Sewer :-

The Sewer which Carries the domestic Sewage and storm water is termed as Combined Sewer.

(d) Intercepting Sewere :-

The Sewer which carries the discharges from a number of main Sewers and delivers the same to the point of treatment as known as intercepting Sewer.

(e) Lateral Sewer :-

The Sewer which obtains the Sewage directly from the residential buildings is known as lateral Sewer.

(f) Relief Sewer :-

The Sewer which Carries the excess discharge from an existing Sewer is termed as Relief Sewer.

(g) Sewerage :-

The network of collecting and conveying Sewage by water Carriage system through the Underground Sewers is known as Sewarage.

(10) Manhole :-

The opening or hole through which a man can enter the sewer line or other closed structure for inspection and cleaning is termed as manhole.

(11) Soil pipe :-

The pipe which carries the discharges from the urinals, water closets, etc. is known as soil pipe.

(12) Vent pipe :-

The pipe which is installed for the purpose of escaping the foul gases from the septic tanks, digesting tanks etc, is known as vent pipe.

(13) Anti-Siphonage pipe :-

The pipe which is installed with water closet to preserve the water seal in the trap is known as anti-siphonage pipe. This pipe maintains the ventilation properly and it prevents the siphonic action in the water seal of the trap.

(14) Waste pipe :-

The pipe which carries the discharge from the bath-rooms, kitchen sinks, etc, is termed as waste pipe.

FEATURES OF SANITARY WORKS :-

The features of the sanitary works are as follows :-

1. Collection
2. Conveyance
3. Treatment
4. Disposal

① Collection :-

The dry refuse (i.e. garbage) and liquid refuse (i.e. Sewage or night soil) should be collected in a planned way to Protect the town from insanitary conditions. The following steps should be taken for the collection work:

(a) Market is the main source of garbage. The refuse like decayed vegetable and fruits, ash, mud, fish scales, etc. should be collected by labourers and dumped in a particular place for removal.

(b) The swept refuse from Public places should be dumped in dust-bins.

(c) The refuse from the domestic houses should be thrown in road side dust-bins.

(d) The refuse from hospitals should be collected in some Particular place.

(e) If a town is under Conservancy system the night soil should be removed by the sweepers from the latrines of individual houses before dawn and collected in covered bullock carts or trailors.

(f) In water carriage system, the collection of Sewage does not arise as it is conveyed through the network of pipe lines.

2. Conveyance :-

After collection of the garbage and night soil, they should be removed to the dumping ground by suitable conveyance. Generally the trucks or trailors are employed for the conveyance of those refuse. The night soil carts or trailors should move to the trenching ground early in the morning.

3. Treatment:-

In Conservancy System, the night soil is left for natural treatment by Sunshine. The garbage is separeted in two groups Combustible and non-Combustible. The Combustible garbage is burent to ashes and non-Combustible garbage is laid in low-lying areas.

In water carriage system, the Sewage is Carried to the treatment plant by Underground Sewer line for nece-ssary treatment.

4. Disposal

There are various methods of Sewage disposal and Sludge disposal. The effluent is discharge into the river and the sludge is digested to Convert it to manure.

System of Sanitation

Introduction :-

The System of Sanitation involves the collection and disposal work of the solid waste (garbage) and liquid waste (Sewage) in a systematic way so that the town or city may remain neat and clean and no insanitary condition may arise. Again, the purpose of well planned sanitations is to protect the People from infectious diseases. The refuse should be removed quickly from the town area so that the bad odours, fly nuisance and ugly environment may not arise. The following are the methods of collection and disposal of refuse :-

1. Conservancy System
2. Water Carriage System

The Conservancy System is an old system and is employed in underveloped towns. But, in modern developed cities the water carriage system is always adopted. Again, the water Carriage System may be of three types :-

(a) Separate System
(b) Combined System
(c) Partially Separate System.

We shall study all the above topics in the followings sections.

CONSERVANCY SYSTEM :-

In this system the garbage, Sewage and Storm water are collected and disposed of separately by the following ways:

(a) Garbage :-

The garbage is removed by the wheeled baskets from road side dust-bins, markets, cinema halls, hospitals, etc and collect-ed in heavy vehicles like Straillers or Strucks. And then it is conveyed to the dumping ground which should be far away from the town. At the dumping ground, the garbage

is Separated in two categories - flammable and inflammable The flammable garbage should be burnt and the inflammable garbage should be dumped in ditches or low-lying areas.

(b) Sewage (i.e. Night Soil) :-

The night soil which is collected in pans at the service latrines of individual houses is removed by the sweepers every day before dawn. The contents of the pans are collected in closed tankers which are drawn by tractors. When the tankers are filled up, they are taken to the night soil trenching ground which should be far away from the town area. The tankers discharge its contents to the night soil pits which are excavated in zig zag manner. Here, the night soil is left for natural treatment by sunshine. It takes too much time for complete decomposition and too much area for disposal.

(c) Storm water and Sullage :-

The storm water and sullage are allowed to flow through the open drains and finally allowed to discharge into the river or stream. They do not require any treatment before disposal to natural watercourse.

Disadvantages :-

The following are the disadvantages of conservancy system:

(i) The compact design of building is not possible, because the lavatory must be constructed separately and away

from the main building.

(iii) The decomposition of night soil starts after five hours from the time of production. But the night soil is normally removed after twenty four hours. So, it creates bad odour any fly nuisance around the building.

(iv) The night soil trenching ground requires large area for disposal.

(v) This system extremely depends on the mercy of sweepers. If the sweepers go on strike for any reason, then the public health will be in dangen.

(v) The movement of the night soil vehicles through the main roads or residential area is highly undesirable.

(vi) In rainy season or in floods, the night soil trenching ground may be submerged and it may cause water pollution and may load to epidemic.

(vii) Initially it seems to be cheap but the, maintenance cost is very high. The conservancy system has no advantages.

WATER CARRIAGE SYSTEM :-

The system in which water is used as a medium for conveying the sewage to the treatment plant and final disposal is known as water carriage system. Plenty of water is required to run this system satisfactorily. Here, the use of human power for collection and disposal of sewage is completely eliminated. The following works are involved in water carriage system.

① Storm water :-

The Storm water may be Carried Separately or may be Carried along with Sewage through the underground Conduits or Sewers

② Sewage and Sullage :-

The Sewage and Sullage are Carried by water through the underground Sewers. Plenty of water is required for Flushing the Lavatories and Urinals for easy Conveyance. The quantity of water should be Such that the dilution ratio between Solid matters and water becomes very high and the mixture behaves like water. If the water Supply remains Suspended for a Considerable time due to electrical or mechanical failure, then this System is highly affected. Due to lack of water, the Sewer line may be Choked or Some other troubles may arise.

The installation of water Carriage System is very costly, but still it is a Scientific and hygienic method of Sewage disposal. So, this System is always recommended for modern towns or cities.

Advantages :-

The following are the advantages of this System:

(i) This System Permits Compact design of building by accommodating the Lavatories in a Suitable part of it.

(ii) This is hygienic in nature, as the Sewage is Carried by underground Sewers.

(iii) Less area is required for treatment works.

(iv) The water Supplied to the Consumers as per demand

(i.e. per Capita demand) is sufficient for flushing and carrying the sewage. No extra water is required for the sewerage system.

(v) It does not depend on the manual labours expect in the case of cleaning of sewers when required.

(vi) There is no chance of any nuisance on the streets.

(vii) The self-cleaning velocity is effective in cleaning the sewers.

(viii) The sludge obtained from sewage treatment plant may be used as manure after proper digestion.

Disadvantages :-

The following are the disadvantages of this system:

(i) The system is very costly.

(ii) In rainy season, the large volume of sewage flows to the treatment plant which may exceed the normal capacity of the plant.

(iii) In case of any break of water supply, the system is highly affected.

COMPARISON BETWEEN CONSERVANCY SYSTEM AND WATER CARRIAGE SYSTEM :-

Table 3.1 lists down the difference between Conservancy and water Carriage system.

Sl no	Conservancy System	water Carriage System
1.	Compact design of building is not possible.	① Compact design of building is possible.
2.	Collection and disposal works are done above the ground	② Collection and disposal works are carried out by underground sewers.
3.	It is non-hygienic	③ It is hygienic.
4.	It requires no water for conveyance.	④ It requires large amount of water for conveyance.
5.	The sewage is disposed of without treatment.	⑤ The sewage is disposed of after treatment.
⑥	Underground sources of water may be polluted.	⑥ There is no risk of pollution of underground water.
7.	Large number of labours are required for running the system.	⑦ Less number of labours are required for running the system.
8.	It depends on the mercy of sweepers.	⑧ It does not depend on the mercy of sweepers.
9.	No skilled labours are required for the maintenance of this system.	⑨ Highly skilled labours are required for the maintenance of this system.
10.	Initial cost is low but maintenance cost is high.	⑩ Initial cost is high, but maintenance cost is low.
11.	This system is applicable for undeveloped towns.	⑪ This system is applicable for developed cities.
12.	Large area is required for treatment and disposal.	⑫ Less area is required for treatment and disposal.

SYSTEMS OF SEWERAGE :-

The three systems of sewerage have been discussed below-

① Separate system :-

This system consists of two sewer lines. one is meant for carrying the sewage to the treatment plant and the other is meant for carrying the storm water. The storm water is directly discharged into the river. After sewage treatment the effluent is also discharged into the river through separate sewer line.

The following are the advantages of this system :-

(i) The storm water can be discharged into river directly without treatment.

(ii) It reduces the load on the treatment plant.

(iii) There is no chance of pollution of river water, as the storm water is not foul in nature.

(iv) If due to change of grade or other inconvenience the sewage is required to pumped, it will impart less load to pumping unit.

The following are the disadvantages of this system:

(i) As two sets of sewer lines are required, it becomes costly.

(ii) The sewer line carrying the storm water remains idle in dry period. So, it may be clogged by garbage in that period.

2. Combined System :-

This system consists of a single sewer line of large diam-eter through which the sewage and storm water are allowed to flow and are carried to the treatment plant.

The following are the advantages of this system :-

(i) The storm water dilutes the sewage and hence its strength is reduced.

(ii) The self-cleansing velocity is easily achieved.

(iii) Due to larger diameter of sewer, it can be easily cleaned.

(iv) As the single sewer line serves the double function, it becomes economical.

The following are the disadvantages of this system :-

(i) The treatment plant is unnecessarily loaded with the combined volume of sewage and storm water. It may exceed the normal capacity of the plant.

(ii) During a heavy storm, the combined sewer may be overflown and it may create trouble for the people at large.

(iii) It creates unnecessary pollution of storm water.

3. Partially Separate System :-

This system consists of two sewer lines - one is of large diameter for carrying sewage and the other is of smaller diameter for carrying storm water only.

When it rains, the storm water, at the beginning, is allowed to flow with the sewage through the larger sewer line. When the rain continues for a long time or it rains heavily, then the excess storm water is diverted to the smaller sewer line to discharge in the river directly. Thus, the load on the treatment plant is controlled and kept within the permissible capacity of the plant.

The following are the advantages of this system :-

(i) It reduces the load on the treatment plant and the excess storm water may be safely discharged in the river.

(ii) It helps to maintain the self cleansing velocity in the larger sewer as the storm water is allowed partly.

(iii) The storm water from individual houses may be safely disposed of to the larger sewer.

The following are disadvantages of this system:

(i) The smaller sewer remains idle in dry season.

(ii) If the diversion of storm water is not done at proper time, then it may create unnecessary trouble both in the treatment plant and in the streets.

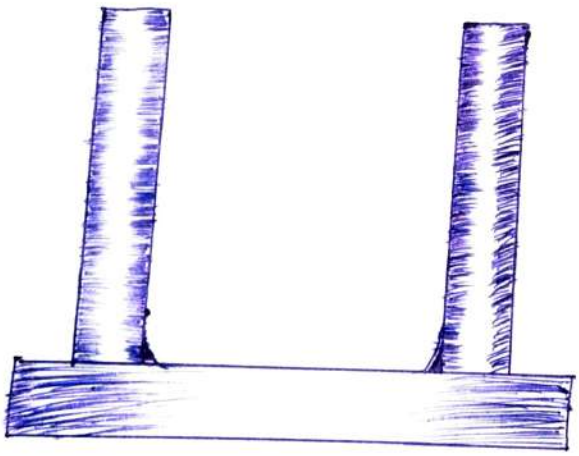
SECTION OF SURFACE DRAINS :-

The following sections are adopted for the Construction of surface drains:

1. Rectangular Section
2. Semi- Circular Section
3. U- Shaped Section
4. V- Shaped Section

1. Rectangular Section :-

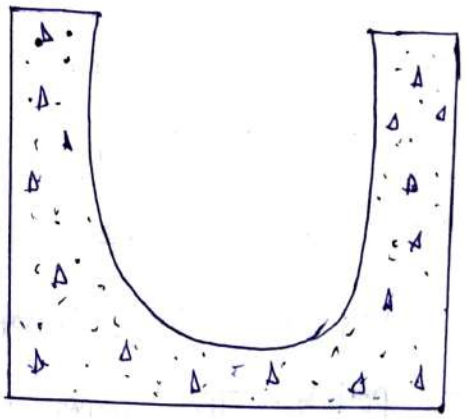
In this type, two vertical walls are con- structed on a Concrete foundation. The thickness of the walls depends on the size of the drain. Again, the depth and width of the drain depends on its required Carrying Capacity. The inner surface is plastered with rich Cement mortar (1:3) and finished with neat Cement polish. The bottom edges are rounded - off for Smooth running of the Sewage as shown in fig. 5.7. This Section is suitable for Carrying high discharge.



2. Semi- Circular Section :-

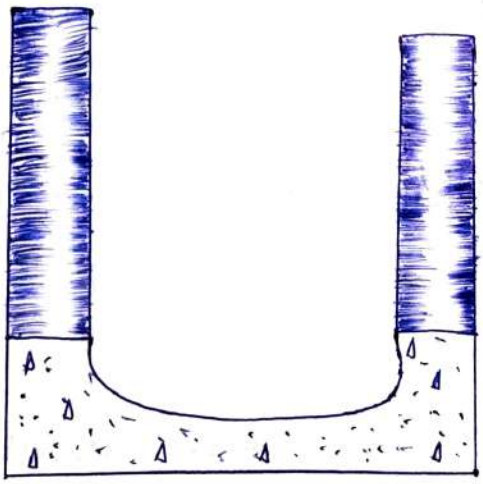
figure 5.8 shows the Semi- Circular Section. It is Construct- -ed by Casting plain cement Concrete (1:3:6) in the

shape of Semi-circle. The inner surface is finished with neat cement polish over a rich cement plaster (1:3). The radius (r) of the drain depends on the carrying capacity. These are suitable for low discharge.



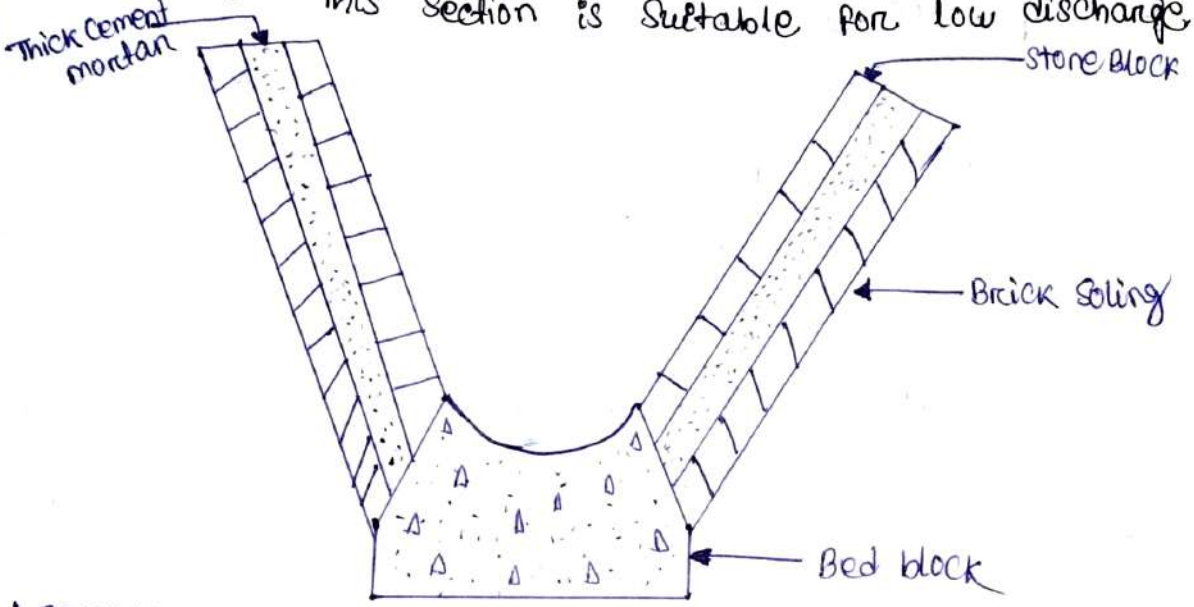
3. U-shaped section:-

In this type of drain, the bottom surface is made curved and it is constructed with plain cement concrete (1:3:6). The two sides are constructed with brick work. As shown in Fig 5.9, the sides are vertical and the bottom is curved. So, it resembles the letter 'U'. This is practically a combination of rectangular and semi-circular section. The inner surface is finished with neat cement polish. This is suitable for medium discharge.



4. V- Shaped Section :-

In this type of drain, the bed block is constructed with Plain Cement Concrete. The sides are made sloping and the brick soling is done according to the slope. Then thick Cement mortar (1:6) is laid and levelled Properly to form a bed. on this Prepared bed, Concrete blocks of size 50 cm x 50 cm are set with rich Cement mortar (1:3) as shown in fig 5.10. The inner surface is finished with neat cement polish. The shape of this drain resembles letter 'V'. This section is suitable for low discharge.



LAYING OF SEWER

The Laying of the Sewer Consists of the following steps:

1. Marking of the Alignment :-

The alignment (i.e Centre line) of the Sewer is marked along the road with a theodolite and inver tape. The Centre line may be marked according to the following two methods:

(a) By reference line

(b) By sight rail

(a) By reference line :-

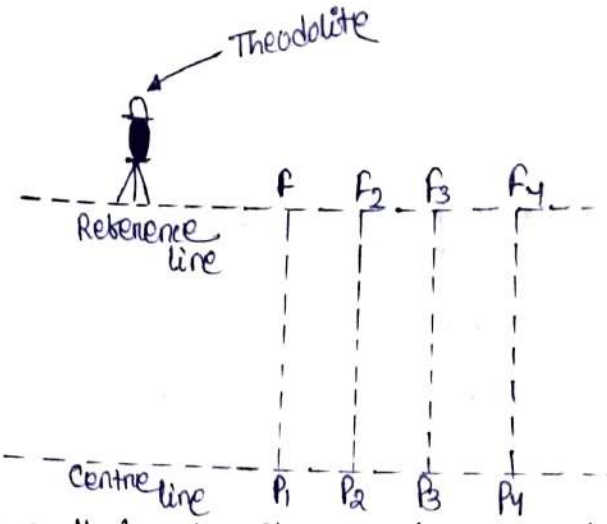


Figure 5.11 explains the method of reference line. In this method of reference line is marked along any side of the busy roads by theodolite and inver tape. The points $F_1 F_2$ ---- are on the reference line. The starting point (P_1) of the Centre line is marked with a peg. Then the distance F_1P_1 is measured by inver tape. Now the other points P_2, P_3, P_4 ---- etc are marked pegs by taking as $F_1P_1 = F_2P_2 = F_3P_3$ ---- etc. Thus the points P_1, P_2, P_3 etc. will represent the Centre line of the sewer. this Centre line may be checked by the theodolite.

(b) By Sight Rail :-

As shown in fig 5.12. in this method, two vertical post are driven at suitable distance apart. Then by ranging through a theodolite the Centre line is marked with nail on a sight rail which is fixed on the vertical posts. The sight rail should be fixed in such a way so that its upper edge just coincides with the line

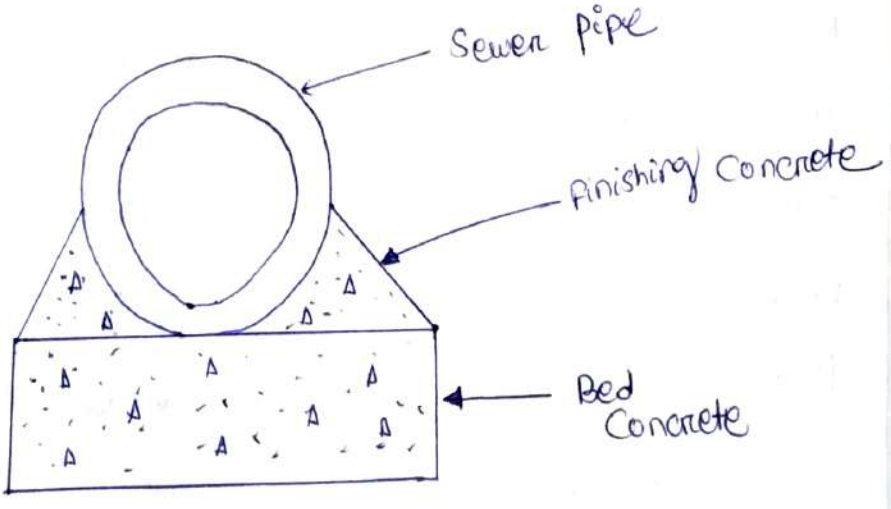
of sight. The centre line of the sewer is transferred to the ground by plumb bob with respect to the nail.

4. Dewatering of Trench :-

Due to percolation of subsoil water or sudden rainfall, the trench may be filled up with water. So, the dewatering of the trench should be done by pumping before the laying of sewer pipes or construction of sewers.

5. Laying and Joining of pipes :-

The bed of the sewer lines is prepared by plain cement concrete (1:3:6). The thickness of concrete varies from 15-20 cm. After proper curing, the pipes are laid along the trench very carefully to avoid cracking or breaking of pipes. Then the operation of joining is performed according to the recommended joint as per the type of pipe material. After completion of joining both sides of the pipe are finished with concrete, as shown in fig 5.14.

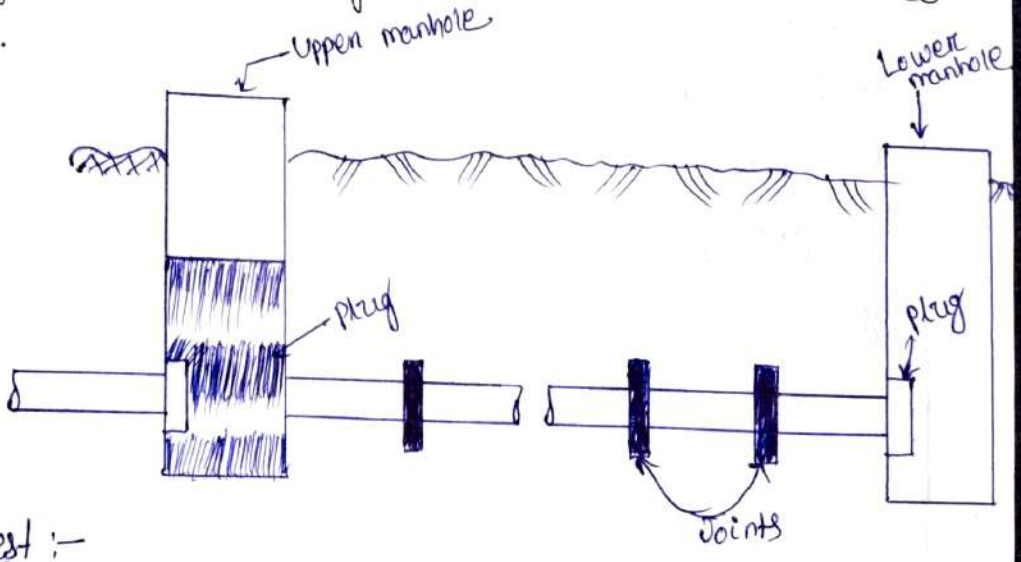


6. Testing of Leakage :-

The leakage in the pipe joints or any point in the pipe line is tested by the following two methods:

(a) By water test :-

This test is carried out between two manholes. In the lower manhole, the end of the sewer is plugged and in the upper manhole, the other end is kept open. The pipe end of previous section is kept plugged. It has been shown in fig. 5.15. Then the water is allowed to flow in the sewer line from the upper manhole until the sewer is completely filled up. The depth of water in the upper manhole is raised up to 1m above the sewer. The water is allowed to stay in the sewer for a week. Then the sewer line is inspected to detect the leakage by observing any sweating. If the leakage is detected, it is rectified immediately.



(b) By Air test :-

Figure 5.16 explains the procedure of air test. This test is carried out for large diameter sewer. The pipe

ends of both the manholes are plugged. An air Compressor is connected to the plug of upper manhole and Pressure gauge is attached with the plug of lower manhole. The Pressure exerted by the Compressed air is recorded in the Pressure gauge. It is left for few hours. If the Pressure drops below the Permissible limit, then it is an indication of Leakage. The exact Point of leakage is found out by applying Soap solution which will show bubbles at the point of leakage. If leakage is detected, it should be removed immediately.

7. Back filling :-

After the Completion of testing and removal of leakage (if any) the trenches are filled up with the excavated earth. The earth filling is done in stages. At first, the earth is laid to a thickness of 15 cm above the Sewer and it is watered and rammed gently. Then, further layer of earth of thickness 15 cm is laid and rammed properly. Then the back filling is stopped for about 7 days. Finally, the trench is filled up Completely with a Projection of about 15 cm above the ground level.

Quantity of Sewage :-

write a short note on Domestic and Industrial Sewages
Distinguish between Domestic and Industrial Sewages.
write a note on Sanitary Sewage.

Ans :- The total Sewage from the domestic and Industries are termed as Sanitary Sewage. The following are the bifurcation of Sanitary Sewage,

* Domestic Sewage :- The Sewage, collected from water closets, Urinals, Lavatory basins of homes, offices and institu-tion. It is highly foul in its nature because of night Soil. (excremental matter). This Sewage contains large number of pathogenic bacteria. Domestic Sewage require great care while handling and disposal.

* Industrial Sewage :- The Sewage, collected from Industrial and Commercial establishment is termed as industrial Sewage. The quality and the foul Smell depends upon the nature of the industry. Sometimes it needs treatment before dis-posal into the Public Sewers.

The wastes from manufacturing Process are also Called as trade effluents or trade waste. Ex :- Wastes From Slaughter - houses, mills, Laundries, chemical plants.

VARIATION OF FLOW OF SEWAGE

The flow of Sewage is directly related to the flow of water Supply. As water supply varies from hour to hour day to day, month to month and Season to Season, the flow

of Sewage also varies accordingly. In designing the Section of Sewer, the maximum rate of flow is required. The maximum flow occurs early in the morning, i.e. 05-00 hrs. to 07-00 hrs, at noon 12-00 hrs to 14-00 hrs, at evening 18-00 hrs to 20-00 hrs. However, the peak flow of Sewage should be ascertained by different observations.

Empirical Formulae for the design of Sewers :-

1. Mean velocity by Chezy's Formula.

Velocity, $V = C\sqrt{mi}$ m/sec.

where, V = mean velocity in m/sec.
C = Chezy's Constant
m = hydraulic mean depth in m.
i = longitudinal slope or hydraulic gradient.

The Chezy's Constant (C) can be obtained by Bazin's Formula or Kutter's Formula.

2. Bazin's Formula.

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

or

$$C = \frac{87}{1 + \frac{K}{\sqrt{m}}}$$

where C, m = as above
K = Bazin's Constant.

Problem-1

Design the diameter of Combined Sewer having the following data

1. Area = 500 hectares
2. population = 1,00,000
3. water Supply = 150 lits/capita/day
4. Intensity of rainfall = 15 mm/hr
5. Impermeability Factor = 0.50
6. Maximum permissible velocity = 2.0 m/sec.

Assume reasonable data if necessary.

Solution:-

Assuming 80% of water supply appears as Sewage.

$$\text{Average discharge} = \frac{1,00,000 \times 150 \times 0.80}{24 \times 60 \times 60} = 139 \text{ lits/sec.}$$

Assuming maximum discharge as 1.5 times, the average discharge. Max, discharge $= 139 \times 1.5 = 208.5$ lits/sec,

$\therefore$ D.W.F = 208.5 lits/sec

Storm water is given by $Q = \frac{kiA}{360}$

$$= \frac{0.50 \times 1.5 \times 500}{360}$$
$$= 10.41 \text{ m}^3/\text{sec}$$
$$= 10410 \text{ lits/sec.}$$

where $K = 0.50$
$i = 15$ mm/sec
$A = 1000$ hectares

Combined discharge $= 208.5 + 10410$
$= 10618.5$

i.e. $Q = 10.618$ m³/sec. $(1\text{m}^3 = 1000 \text{ lits})$

Assuming, the Sewer running full at maximum velocity.

$$Q = A \times V, \quad A = \frac{Q}{V} = \frac{10.618}{2} = 5.309 \text{ m}^2$$

where, A = C/s area of Sewer
V = 2m/sec Permissible velocity

Let,

d = diameter of Sewer

So, $\frac{\pi d^2}{4} = 5.309$

or $d = \frac{\sqrt{5.309 \times 4}}{\pi}$

$\therefore \quad d = 2.6 \text{ m.}$

Problem-2

A Sewer of diameter 1m is to be laid along a road with Self-cleaning velocity as 90 cm/sec. Find the gradient of the Sewer line to achieve the said velocity Considering the Sewer running half filled. Assume Bazin's Constant = 0.30.

Solution :-

Given, diameter = 1m

Bazin's Constant (K) = 0.30

C/S Area $= \frac{\pi d^2}{4}$

wetted perimeter $p = \frac{\pi d}{2}$

Hydraulic mean depth $= m = \frac{\pi d^2}{4} \times \frac{2}{\pi d}$

$= \frac{d}{2} = \frac{1}{2} = 0.5 \text{ m.}$

value of Chezy's Constant, C is found out by Bazin's formula $C = \frac{157.6}{1.81 \times \frac{K}{\sqrt{m}}} = \frac{157.6}{1.81 \times \frac{0.30}{\sqrt{0.50}}} = 70.54$

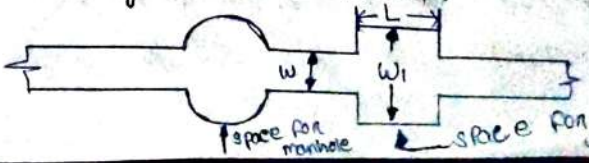
From Chezy's formula,

$V = C\sqrt{mi}$

The distance between the upper edge of sight rail and the invert level is determined and noted on the sight rail for finding the exact invert level by boning rod. The length of boning rod is adjusted according to the height as noted in sight rail. The cross-head is levelled with the upper edge of sight rail and the bottom edge indicates the invert level.

2. Excavation of Trench –

The way of marking for the excavation of trench. The width of the trench (w) is marked on the road which is about 15cm more than the external diameter or external dimension of sewer. At the probable point of joining, the width of the trench (W_1) is made 60 cm more than the external diameter and a length (L) of about 60 cm is kept clear for the operation of joining. The position of manhole is also marked according to its dimension.



Now, the excavation is started according to the marking. The invert level is fixed by boning rod, which is adjusted according to the height written in sight rail. The Cross head of boning rod is levelled with the upper edge of sight rail and the verticality of rod is maintained by Plump bob. The bottom edge of the shoe will indicate the invert level. In this way, the excavation is continued.

3) Bracing of the Trench :-

Timber bracings or sheet piling should be provided on both sides of the

Minimum velocity of flow in Sewers - Self Cleansing velocity

A Sewer should be so designed that the solid matter present in the Sewage is not deposited at the bottom of the Sewer and thus clogging of the Sewer is prevented. The deposition of the Solid matter and the resulting clogging of the Sewer can be prevented if the solid matter is held in Suspension in the flowing Sewage.

In order to keep the solid matter in Suspension Certain minimum velocity of flow of Sewage is required. Such a minimum velocity of flow is known as Self-Cleansing velocity. Thus Self-cleansing velocity may be defined as the minimum velocity of flow at which the solid particles present in the Sewage will be held in Suspension and also at which the Scour of the deposited particles will take place so that the Sewer will be kept clean.

The Self-Cleansing velocity depends on the size of the solid particles present in the Sewage and their Specific gravity. It is, however, not possible to maintain the Self-Cleansing velocity throughout the day because of fluctuations in the quantity of Sewage flow. During minimum flow of Sewage the velocity of flow will be less than the Self-Cleansing velocity.

However, the design should be such that Self-Cleansing velocity is maintained in the Sewer at least once in a day so that the solid particles which might have deposited gets eroded and transported by the flowing Sewage, and the Sewer is rendered clean.

Characteristics

Introduction :-

The study of characteristics of sewage plays an important role in sanitary engineering, because the process of treatment should be determined according to the characteristics. Again, the treatment should be such that the effluent can be disposed of to the natural water sources safely. The characteristics and divided into three categories:

1. Physical characteristics
2. Chemical characteristics
3. Biological characteristics

Before carrying out the testing of sewage, the sampling should be done properly. The testing involves the following

① Physical tests
② Chemical tests
③ Biological tests

Again, the treatment of sewage involves the determination of following factors:

① Biochemical oxygen demand (B.O.D)
② Chemical oxygen demand (C.O.D.)

In this chapter, the characteristics and examinations are described stage by stage.

Definition of some terms :-

1. Algae :- The unicellular plants which contain chlorophyll are known as algae. The algae absorb carbon-dioxide

and release oxygen by the process of photosynthesis.

2. Fungi :-

The fungi are also unicellular plants, but they do not contain chlorophyll. They are colourless and can decompose starch, sugar, cellulose, fats, proteins etc. Their yeast is a kind of fungi.

3. Protozoa :-

These are unicellular worms. They can destroy pathogenic bacteria, but they survive by eating other bacteria.

4. Bacteria :-

The microscopic unicellular organisms are known as bacte--ria. The bacteria may be harmful or harmless to human being. But the presence of bacteria is essential for the decomposition of sewage.

5. Pathogenic Bacteria :-

The bacteria which are responsible for water-borne diseases like cholera, dysentry, typhoid, etc, are known as pathogenic bacteria.

6. Non-pathogenic bacteria :-

The bacteria which are harmless to human being are known as non-pathogenic bacteria.

7. Aerobic bacteria :-

The bacteria which require light and free oxygen for their survival are known as aerobic bacteria.

8. Anaerobic bacteria :-

The bacteria which do not require light and free oxygen for their survival are known as anaerobic bacteria.

9. Facultative bacteria :-

The bacteria which can survive with or without the presence of light and free oxygen are known Facultative bacteria.

10. B-Coli :-

The pathogenic and non-pathogenic bacteria form a group which is known as bacillus Coli group. This group is briefly known as B-coli. This group of bacteria is present in the intestines of all living animals.

11. E-Coli :-

The most common type of Coliform group is Escherichia Coli which is briefly known as E-coli. The germs of E-Coli are discharged from the faeces (i.e stool) of human being

PHYSICAL CHARACTERISTICS :-

The following are the physical characteristics of Sewage:

1. Specific Gravity :-

The specific gravity of sewage is slightly more than that of water.

2. Colour :-

The fresh sewage has yellowish grey colour. As the decomposition goes on, the colour also goes on changing. It becomes black when the sewage attains the Septic stage. The colour of the industrial sewage depends on the waste products.

3. Odour :-

The fresh sewage has ~~yellowish grey colour. As the~~ soapy or oily odour. But the stale or septic sewage has offensive odour due to hydrogen sulphide and other gases.

4. Temperature :-

The temperature of Sewage is slightly higher than the temperature of water Supplied. while passing through the conduits the temperature rises and the bacteria activities start.

5. Turbidity :-

The turbidity of Sewage is due to the suspended particles.

6. Solids :-

The Sewage Contains 0.1% of Solid matters and 99.9% of water. The Solid matters may be Suspended, dissolved or in colloidal states. Again, the Solids may be inorganic or organic Solids are grits. Sand, etc. and organic Solids are Cellulose, Sugar, Starch, etc.

CHEMICAL CHARACTERISTICS :-

The following are the chemical characteristics of Sewage :-

1. The Fresh Sewage is alkaline in nature, and the Septic Sewage is acidic in nature.

2. Organic Compounds :-

(i) Nitrogeneous Compounds : It include Urea, Proteins, amino acids, etc.

(ii) Non-nitrogeneous Compound : It include Fats, Soaps, Carbohydrates etc.

3. Inorganic Compounds :-

It include Sand, gravel, grit, etc.

4. Colloidal matters :-

It include silt, clay etc.

BIOLOGICAL CHARACTERISTICS :-

The Sewage Contains the following bacteria and micro-organisms :

1. Bacteria :-

The bacteria may be of the following type :-

I. Pathogenic bacteria :-

This is the root of all water-borne diseases.

(ii) Non-pathogenic bacteria :-

This is practically harmless to human being.

(iii) Aerobic bacteria :-

It helps the decomposition of sewage in oxidation po lagoons. etc.

(iv) Anaerobic bacteria :-

It helps the decomposition of sewage in septic tank Cesspool, etc,

(v) Facultative bacteria :-

This bacteria has no function in sewage treatment.

2. Microorganisms :-

The microorganisms like algae, fungi and Protozoa help the process of decomposition of sewage by photosynthe or by breaking the organic Compounds.

SAMPLING OF SEWAGE :-

The following are the Procedures of collecting the Sample of Sewage for the various laboratory tests:-

(ii) The Samples bottles should be of Capacity 100 C.C. to 150 C.C.

~~(i) The Sampling bottles should be of Ca~~

(i) The Samples of Sewage are collected at an interval of one hour during the day.

(iii) The bottles should be cleaned ~~tightly~~ Properly before taking the Samples.

(iv) The bottles should be closed tightly by Stopper as Soon as it is filled up.

(v) The bottle should be kept in a Cool place.

(vi) The Samples should be collected from different points of the Sewer.

(vii) The analysis of Sewage should be started within two hours from the time of collection.

(viii) The date, time and place of collection of Sample should be noted on the bottles.

1. Total Solids :-

It is very essential to know the quantity of ~~Tot~~ total Solids in Sewage. Because, it helps to know the rate of deposition of Sludge in the Primary Sedimentation tank and at the Same time it is possible to indicate the organic and inorganic Substances in Sewage which help in the Sewage treatment. The Amount of total Solids are found out as follows:-

A known amount of Sewage (say 1 lit) is taken and the water is evaporated at 100°C. The residue at 100°C. The residue is dried properly and weighed. The weight of the dry residue represents the total solids. Again, the total solids may be of two types:

(i) Votatile Solids.
(ii) Suspended Solids.

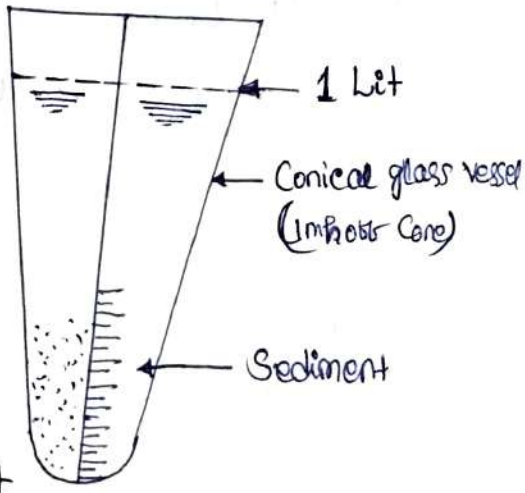
(a) Volatile Solids :-

The dried total solids (as obtained previously) are heated or ignited in electric furnace. After ignition, the remaining solids are weighed. The loss of weight will indicate the volatile solids present in sewage. The volatile solids are due to the presence of organic matters.

(b) Suspended Solids :-

The solids which settle down due to the phenomenon of hydraulic subsidence are known as suspended or settleable solids. The amount of settleable solids are found out as follows :-

A Conical glass vessel, known as Imhoff Cone, is taken. Figure 7.1 shows an Imhoff Cone. The capacity of the Cone is 1 lit and it is graduated in ml from the bottom. The sample of sewage of quantity 1 lit is taken in the Cone and it is allowed to rest for about two hours. The amount of solids settled at the bottom of the Cone is



read from the graduation. Now to know the exact amount of settleable solids the moisture from the sediment is removed and weighed.

3. Dissolved oxygen :-

The oxygen in dissolved state in sewage is required for the living organisms to perform their metabolic process. Again, it is very essential in precipitating and oxidising inorganic substances. The amount of dissolved oxygen depends on the temperature of sewage. However, the determination of dissolved oxygen in sewage is a very complicated process. It may be determined in the laboratory by using the reagents manganese sulphate, concentrated sulphuric acid, starch indicator, sodium thiosulphate etc.

4. Biochemical oxygen Demand (B.O.D.)

The function of oxygen is to oxidise the inorganic and organic matters in sewage. Again, the presence of oxygen is required for the survival of organisms. These organisms are responsible for the aerobic decomposition of organic matters. When the oxygen is exhausted, the anaerobic decomposition starts which is indicated by foul smell. Now, the quantity of oxygen required for the biological decomposition of sewage under aerobic condition should be worked out. This demand of oxygen is known as biochemical oxygen demand or B.O.D (Details of B.O.D. is given in art)

5. Chemical oxygen demand (C.O.D.)

The amount of oxygen which is required for the chemical decomposition of organic matters in sewage is known as

Chemical oxygen demand (C.O.D). The tests for C.O.D. is required to know the contents of organic mattens which should be oxidised by chemical oxidising agents. (Details of C.O.D. is given in art 7.14)

7. pH - Value :-

The pH - value of Sewage is to be determined to know its nature - whether it is acidic or alkaline. The treatment methods depend on the pH - value. At the beginning, the fresh Sewage is alkaline in nature, but it is converted to acidic nature after few hours. The bacteria cannot survive in acidic Sewage. However, the pH value of Sewage is determined by electrometric method or Colourimetric method.

DECOMPOSITION OF SEWAGE :-

The function of bacteria in Sewage is to break up the complex organic compounds into simple and stable compounds. The decomposition of Sewage by bacteria may be of the following two types:

① Aerobic Decomposition :-

Aerobic decomposition is caused by the aerobic bacteria in presence of plenty of oxygen. This type of bacteria cannot survive without oxygen. This decomposition is also known as oxidation. In this process, the aerobic bacteria break up the organic matters and the organic matters are oxidised to form stable compounds. After oxidation the compounds like Carbon dioxide, nitrates, Sulphates etc. are formed. The aerobic decomposition occurs in Contact beds, oxidation Ponds, trickling filters, etc.

2. Anaerobic Decomposition

Anaerobic decomposition is caused by the anaerobic bacteria in absence of oxygen. This type of bacteria can

survive without oxygen. This decomposition is also known as Putrefaction. The anarobic bacteria break up the complex organic compounds and convert them into solids, liquids and gases. After Putrefaction, the compounds like humas (black residue), ammonia methane, hydrogen sulphide, etc. are formed. The anaerobic decomposition occurs in septic tanks, Imhoff tanks and sludge digestion tanks.

Sewer Appurtenance

Introduction :-

For the efficient working, cleaning and repairing of the Sewer, Some structures are constructed along the Sewer line at Some specific points which are known as Sewer appurtenance. The following are the important structures.

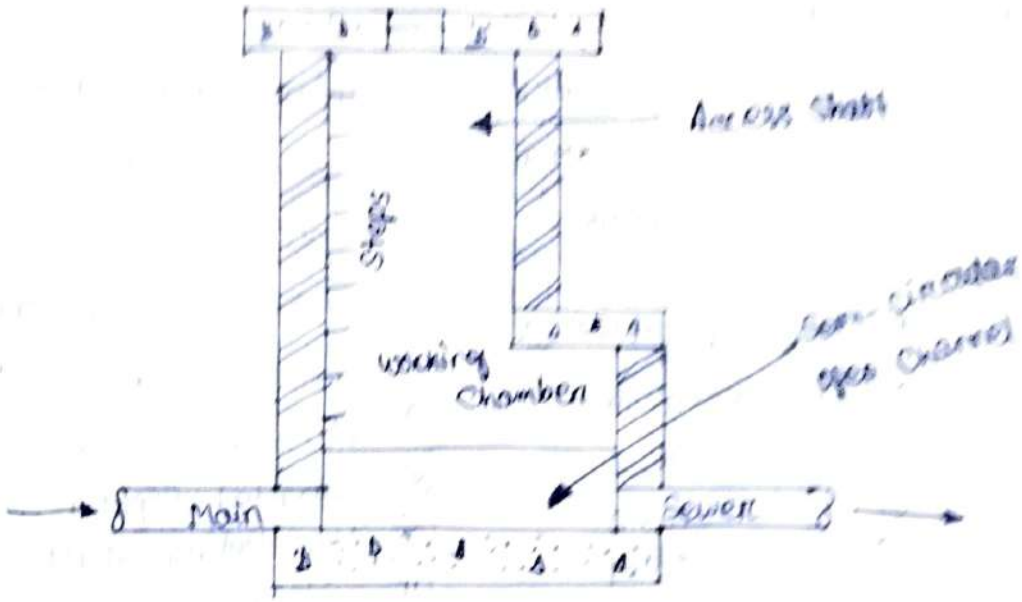
1. Manhole
2. Drop manhole
3. Lamp hole
4. Catch basin
5. Street inlet
6. Grease and oil trap
7. Flushing tanks
8. Inverted Siphon
9. Ventilating Shaft
10. Storm regulator

MANHOLE

A hole which is made from the ground level to the under-ground Sewer for the entrance of men for inspection, cleaning and repairing works, is known as a manhole. The manholes are provided at specified interval, change of direction, change of grade, junction points, etc.

Depending upon the depth, the manholes may be Shallow, normal and deep. The depth below 1m is considered as normal manhole and the depth above 1.5 m is considered as deep manhole.

As shown in Fig. 6.1, the deep manhole is constructed with brick masonry over a Concrete Foundation. The bottom portion is wider which is known as working chamber and the upper portion is narrower which is known as access Shaft. The access shaft is made narrow by Corbe-lling or by providing R.C.C. Slab as offset.



The following are the components of a deep manhole:-

(a) Access Shaft :-

The access shaft may be rectangular or circular. The minimum size of the rectangular shaft should be 90 cm x 100 cm and minimum diameter of circular shaft should be 90 cm. The height of the shaft depends on the height of the working chamber. The shaft serves the purpose of removing the debris from the sewer and acts as a passage for the workers to conduct the maintenance works

(b) Working Chamber :-

The purpose of working chamber is to provide sufficient space for the workers for cleaning the sewer and for conducting maintenance works. The height of the working chamber should be 2 m so that a worker can work comfortably. The size of rectangular chamber should be 120 cm x 150 cm and diameter of circular chamber should be 120 cm.

(C) Steps :-

The steps are Provided on the wall of the manhole for the entry and exit of the workers. The steps may be made of cast iron which are embedded in the wall in zig-zag manner. If the manhole is too deep, then it is better to Provide a ladder instead of steps.

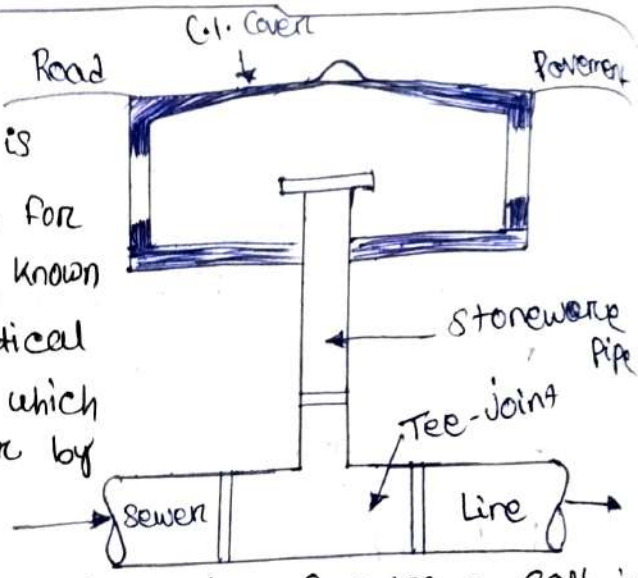
(d) Invert :-

The main Sewer just ends at both sides of the manhole. A Semicircular section channel is Constructed to Connect the two ends so the there is an open channel within the manhole. The sides of the channel are made sloping with Concrete. This is known as benching. The sediments or obstructions in the Sewer are pushed towards the man-hole and these are collected in the open channel from where those are taken out through the access shaft.

(e) Manhole Cover :-

Generally, the manhole cover is circular and made of Cast-iron. The cover should be thick and heavy and stable enough to resist the wear and tear caused by moving vehicles. The diameter of the cover should be 60 cm to 75 cm so that a man can enter the man-hole easily. The frame of the cover is embedded in road pavement and the cover is placed on the groove firmly.

LAMP HOLE



A hole or opening which is provided in a sewer line for lowering a lamp inside is known as lamp hole. It is a vertical pipe made of stoneware which is connected to the sewer by a Tee-joint. At the top a box-like compartment is made which carries a cast-iron cover. The cover may be solid or perforated as shown in fig. 6.3.

The construction of lamp hole is advisable for the following conditions:-

(i) when the spacings of regular manholes are at longer interval.

(ii) when the it is difficult to construct a regular manhole.

(iii) when a change of direction or change of grade comes in the sewer line.

The following are the functions of lamp hole:-

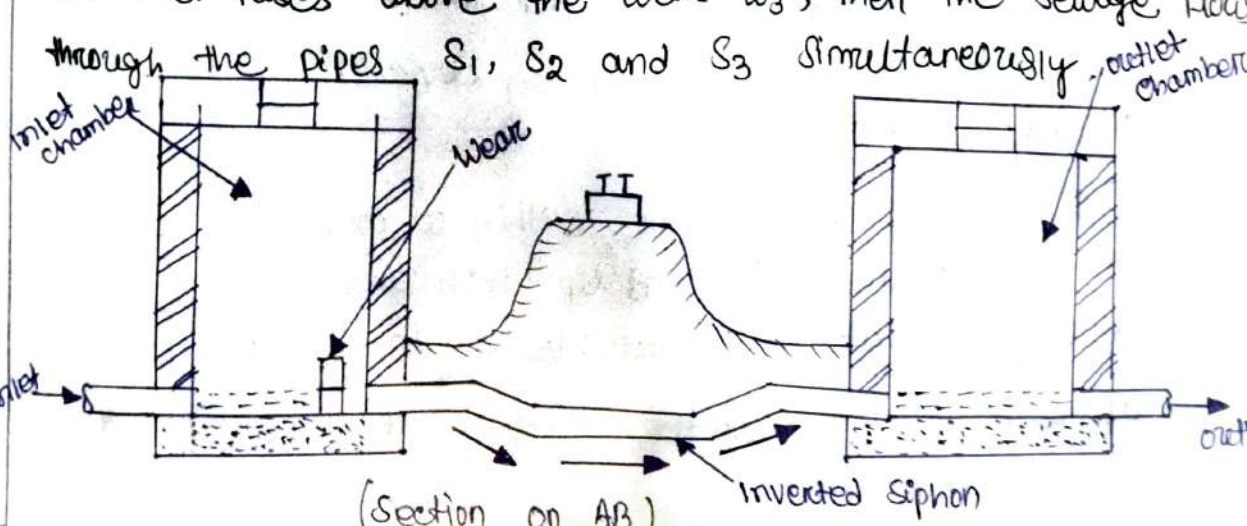
(i) By removing the C.I. cover, an electric lamp is inserted into the sewer. If the sewer is clear, the light will be visible from the adjacent manholes. If there is any obstruction, the light will not be visible from the manholes. Then the operation of clearing will be done accordingly.

(ii) For clearing the obstruction, the flushing devices may be applied through the manholes.

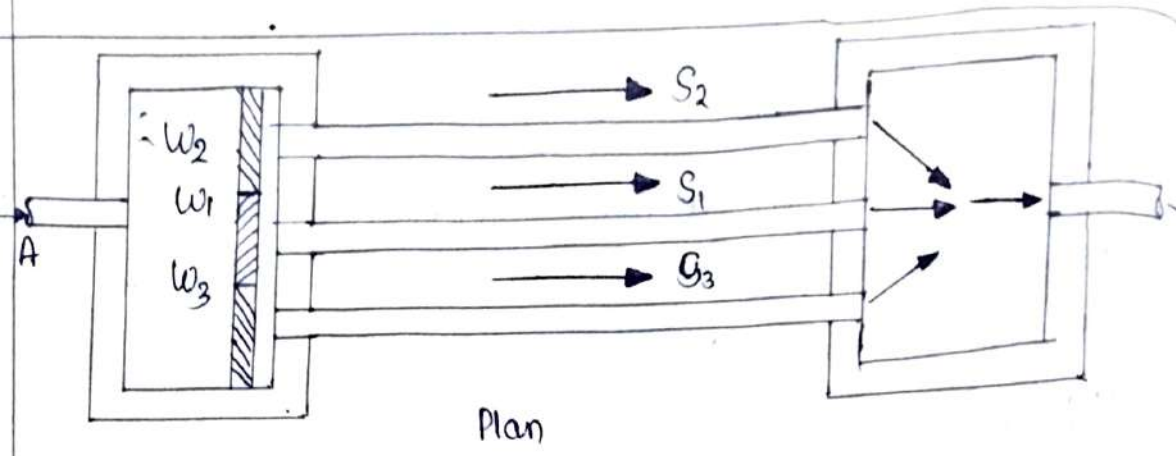
(iii) If the C.I Cover is made perforated, then it will serve the purpose of ventilation of sewer or the removal of sewer gases.

INVERTED SIPHON

During the laying of sewer line, a position may come when it is not possible to maintain the same gradient due to some obstructions such as crossing of railway line, roads, etc. In that case, the inverted siphon should be provided. The condition of siphonic action is that the pipe or tunnel should run full all the time. But in dry season the discharge may not be sufficient to run the inverted siphon full. So, instead of one single line, three single lines, i.e. three lines (S_1, S_2 and S_3) are provided. The flow of sewage is guided by the weirs (W_1, W_2 and W_3) as shown in fig 6.8. In dry period, the sewage spills over the weir W_1 and flows through the pipe S_1 only. When the level rises above the weir W_2 the sewage flows through the pipes S_1 and S_2. In rainy season, when the storm water increases the volume of sewage and the level rises above the weir W_3, then the sewage flows through the pipes S_1, S_2 and S_3 simultaneously.



(Section on AB)



Plan

The inverted siphon may be constructed by cast-iron pipes or hume pipes. If the length of siphon is too great, a vent pipe should be provided in the siphon to prevent air locking.

STORM REGULATOR

In dry season, the combined sewer has to carry small discharge of sewage (i.e. dry weather flow). But in rainy season the discharge increases due to storm water. Sometimes, the intensity of rainfall becomes so great that the quantity of storm water is enormously increased. During that period the discharge may exceed the normal capacity of the combined sewer and it may even exceed the permissible capacity of the treatment plant. So, some devices are adopted for the diversion of the excess storm water to the river or stream.

The following are the common devices:

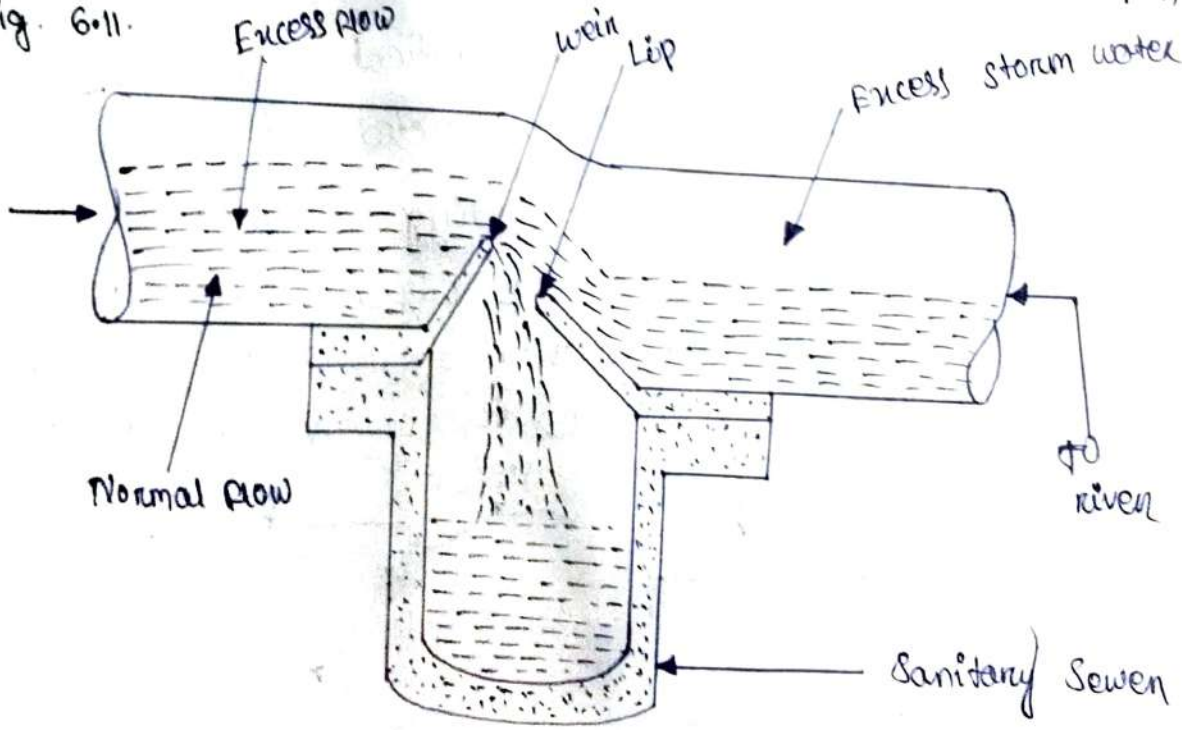
(a) Leaping weir :-

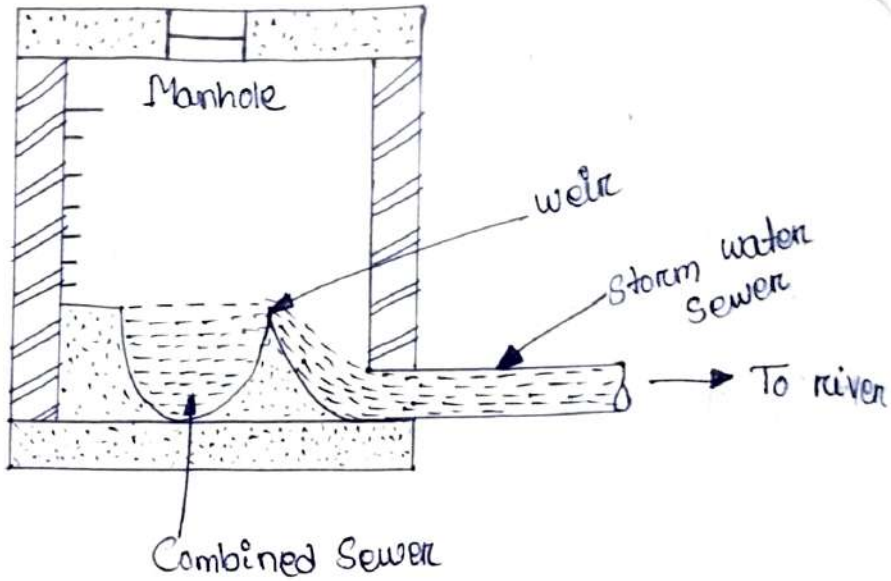
The arrangement is done within a manhole. It consists of an adjustable weir and lip which are adjusted in such a way so that the permissible discharge of sewage is allowed to flow over the crest of the weir and directly

fall in the Sanitary Sewer. When the discharge is increased enormously due to heavy rainfall, the excess storm water jumps over the crest of the weir and falls on the lip which carries the storm water to the river or stream. Figure 6.10 explains the working of leaping weir.

(b) Overflow weir:-

In a manhole, the Combined Sewer is made as an open channel. The channel consists of a weir on one side. Sometimes, weirs may be provided on both sides. In normal condition, the Combined Sewage flows through the open channel. But, when the quantity of storm water is increased due to heavy rainfall, it exceeds the normal capacity of the Combined Sewer. In that case the excess water spills over the weir and falls on the storm water sewer which carries the water to the outfall, as shown in fig. 6.11.

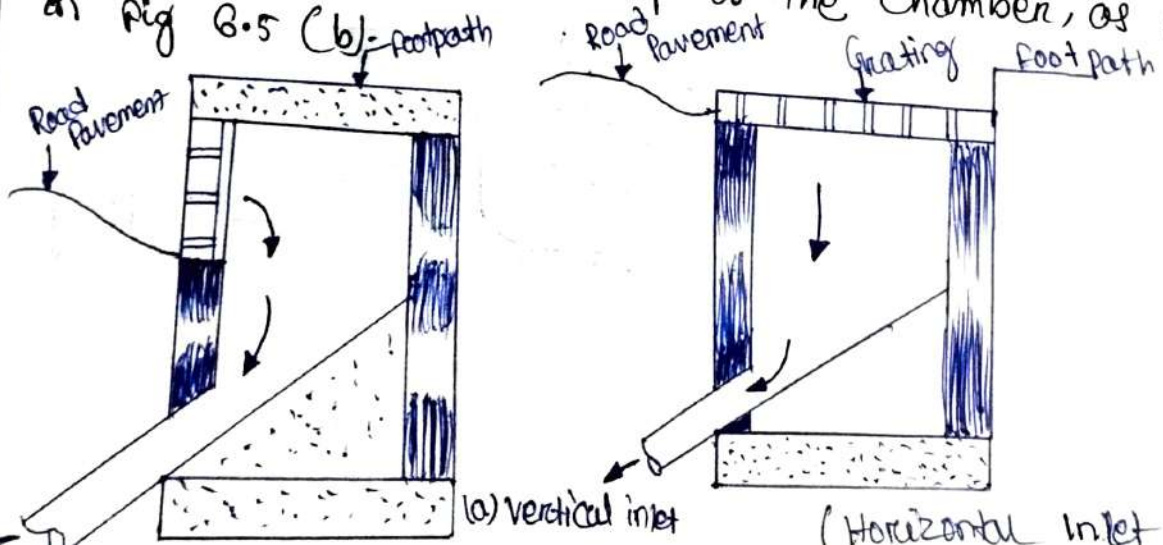




STREET INLET

The Street inlets are the openings Provided by the side of roads to allow the Storm water to enter the Sewers directly without accumulating on the road Pavement. The Spacing of inlets should be 20 m and should be Provided on both sides of the road.

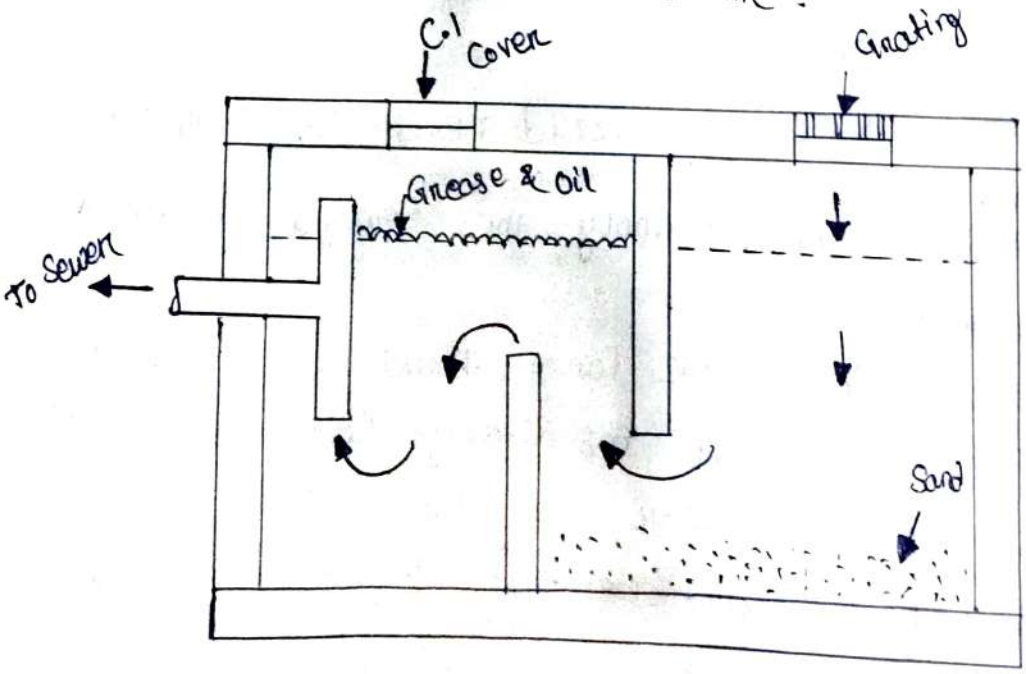
The inlets may be vertical or horizontal. A box-like Compartment is Constructed with brick masonry. In Vertical type, a grating is Provided on the road Curb just at the edge of Foot path, as Shown in fig. 6.5. (a). In horizontal types, a Perforated Cover is placed on the top of the Chamber, as Shown in fig 6.5 (b).



GREASE AND OIL TRAP

The traps or chambers which are constructed on the sewer line for excluding grease and oil from the sewage are known as grease and oil traps. If sewage contains grease and oil, it sticks to the interior surface of the sewer and ultimately get hardened. This decreases the carrying capacity of sewer gradually. So, those oily materials must be removed. The sources of those materials are automobile repairing workshops, kitchens of hotels and restaurants, oil manufacturing industries etc. The traps should be provided by surveying the location of those areas.

Figure 6.6 shows the grease and oil trap. The trap is rectangular chamber having baffle walls at the middle. The sewage containing grease and oil enters the chamber through the inlet grating. The sand, grit, etc. are accumulated at the bottom of the first chamber. The grease and oil floats over the second chamber. The sediments and the floating substances (grease and oil) should be removed from time to time.



SEWAGE FARMING METHOD :-

Definition :-

When Sewage is applied on agricultural land for the growth of Crops, then it is termed as Sewage Farming.

The Sewage Contains much fertiling elements such as nitrates, Sulphates and phasphates. These elements are extracted from the soil by the roots of the plants.

Conditions of Sewage Farming :-

The following Conditions should be remembered while Providing the method of Sewage Farming :-

(i) The Farm Should be located far away from the locality, because it may Create bad smell and insanitary Condition.

(ii) The hygienic Safety of the workers Should always be observed to Protect them from the bad effect of pathogenic bacteria.

(iii) The raw Sewage should never be Supplied to the Farm.

(iv) It is better to apply the Sewage after Primary treatment.

(v) The working of the farm should run on Constant Supervision, so that insanitary Condition may not arise due to over irrigation

(vi) Precautions should be taken to avoid Sewage Sickness.

Application of Sewage

The Sewage may be applied on the land by the following methods:

(a) Surface irrigation System
(b) Sub-Surface irrigation System
(c) Sprinker irrigation System

(a) Surface Irrigation System :-

This System may be of following types:-

(i) Basin method :-

This method is employed for supplying water to orchard In this method, each tree or group of trees are enclosed by circular channel through which Sewage flows. This circular channel is known as basin. Th basins are connected to the supply channel, as shown in Fig 11.1. When the basins are filled up, supply is cut-off.