SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – I – WATER AND ENVIRONMENT – SCIA1403

INTRODUCTION

SOURCES OF WATER:

i) Surface water
- Ponds and lakes
- Streams and rivers
- Storage reservoirs
- Oceans

ii) Sub- surface water (or) underground sources
- Springs
- Infiltration galleries
- Infiltration wells and
- Open Wells and tube-wells.

Surface water:
Water that gets collected on the surface of the ground or top layer of a body of water is called surface water.

Ponds and Lakes:
A natural large sized depression formed within the surface of the earth, when gets filled with water is known as pond or lake.
The difference between the pond and lake is only size.
If size is small, its termed as pond, large size lake
Flow of water in lake is like flow in stream channel
Quality of water in lake is good
Quality of water available in lake is small
Quality depends upon the catchment area of the lake basin, annual rainfall and geological formation
Due to smaller quantity of water available for them, lakes are not considered as principal sources of water supplies.

Streams and Rivers:
Small stream channels feed their waters to the lake or rivers which is not used for water Supply.
Larger and perennial streams are used a source of water by providing storage reservoirs, barrages etc.
Rivers are most important sources of water for public supply.
Quality of water obtained from rivers is generally not reliable.

Storage Reservoirs:
Barrier in the form of dam, may be constructed across the river so as to form a pool of water o the upstream side of the barrier.
This pool or artificial lake formed on the upstream side of the dam is known a storage reservoir.

Water can store in reservoir can be used not only for water supply but also for other purposes.
Various kinds of dams are
- Earth dams + made of soil
- Rock fill dams + made of loose rocks
- Solid masonry gravity dams – made of stone masonry.

Oceans:
Not used as water supply source normally.

Sub- surface water (or) underground sources:
Springs:
Natural outflow of ground water at the earth's surface forms a spring
A pervious layer sandwiched between two impervious layers form a spring.
Capable of supplying very small amount of water, not recommended for water supplies.
Good developed springs can sometimes use for water supply source for small towns, especially in hilly areas.

The two types of springs are
a) Gravity springs – when the ground water raises high and water overflows through the sides of a natural; valley or depression.
b) Surface springs – sometimes an impervious obstruction (or) stratum supporting the underground storages become inclined causing water table to go up and get exposed to the ground surfaces.
c) Artesian springs – when water comes out of pressure it's called artesian springs. Since water comes out of pressure; they are able to provide higher yields and may be considered as source of water supply.

Infiltration Galleries:
Horizontal tunnels constructed at shallow depth (3-5m) along the banks of rivers through the water bearing strata.
Also called as horizontal wells.
Constructed of masonry walls with roof slabs and extract water from the aquifer by various porous lateral drain pipes located at suitable intervals in the gallery.
Discharge from gallery can be computed using Darcy's law, Q=KiA

Infiltration Wells:
Shallow wells constructed in series along the banks of a river in order to collect the river water seeping through their bottoms
Constructed of brick masonry with open joints.
Various infiltration wells are connected by porous pipes to a sum well, called jack well.

Open wells:
Open masonry wells having bigger diameter and suitable for low discharge (18 cumecs/hr)

Discharge is limited to 3 to 6 l/s.
Diameters vary from 2 to 9m and less than 20m in depth.
Yield is limited
Can put 8 to 10 cm diameter bore hole in the center of the well, to extract additional water.

Tube wells:

Deep as 70 to 300m and tap more than one aquifer
Yield as high as 200 to 220 l/s.
Types:
a) deep tube well
b) shallow tube well
c) cavity type tube well – draws water from the bottom of well
d) screen type tube well – drawn from the sides
1. Strainer tube well
2. Slotted pipe gravel pack tube well

OBJECTIVES OF PUBLIC WATER SUPPLY:

- To supply safe and wholesome water to the consumers.
- To supply water in adequate quantity.
- To make water available within easy reach of the consumers so as to encourage the general cleanliness.
- A water distribution system consists of a network of pipelines of various sizes with control valves for carrying water to all streets and supplying water to the consumers through the service connections to the properties.
- Water distribution system may be either continuous or intermittent.

REQUIREMENTS OF WATER SUPPLY:

- Water quality should not get deteriorated in the distribution pipes.
- It should be capable of supplying water at all the intended places with sufficient pressure head.
- It should be capable of supplying the requisite amount of water during firefighting.
- The layout should be such that no consumer would be without water supply, during the repair of any section of the system.
- All the distribution pipes should be preferably laid one meter away or above the sewer lines.
- It should be fairly water-tight as to keep losses due to leakage to the minimum.

NEED OF PROTECTED WATER SUPPLY:

- The source
- Quantity of water
- Check calculation
- Distance and difference in elevation
- Quality of water
- Methods of purification
- Service reservoir
- Distribution system

PLANNING FACTORS FOR PUBLIC WATER SUPPLY:

- Population Forecast
- Assessment of Water Demand
- Record of Industry
- Record of Public Places

REQUIREMENTS OF WATER FOR VARIOUS USES:

- Drinking & Cooking
- Bathing
- Washing of clothes and utensils
- Gardening
- Swimming pools, Fountains, etc.
- Fire Fighting and
- Trades & Industries

TYPES OF WATER DEMAND:

- Domestic Demand
- Commercial & Institutional Demand
- Industrial Demand
- Public Demand
- Fire Demand
- Compensate Losses

Domestic Demand

- Water required for drinking, bathing, cooking, washing etc.
- Water demand depends on habits, social status, climate and custom of people.
- In India, the average domestic consumption under normal condition is 135 litres/capita/day.
- For developed countries, the average domestic consumption under normal condition is 350 litres/capita/day.
- The increase in water consumption in developed countries is mainly due to use of air coolers, air conditioners, maintenance of lawns, automatic household appliances such as home laundries, disc washers etc.
- The total domestic water consumption is 50 to 60% of total water consumption.
- Total domestic water demand = Total Design Population x Per capita domestic consumption.

Use	Consumption in litres /day/ person
(a) Drinking	5
(b) Cooking	5
(c) Bathing	55
(d) Washing of clothes	20
(e) Washing of utensils	10
(f) Washing and cleaning of houses and residences	10
(g) Flushing of Latrines etc.	30
Total	135

Commercial Demand

- The water demand for office, hotels, restaurants, theatres etc.
- Commercial Demand is 25 litres/capita/day to 40 litres/capita/day.

Industrial Demand

- Industrial water demand is focused on cooling, processing and manufacturing operations, power generation etc.

- Industrial Demand is 20% to 25% of total water demand of the city.

Public Demand

- The water demands for various public uses like public toilets, public parks, gardening, washing and sprinkling on roads, use in public fountains, swimming pool etc.
- A nominal amount not exceeding 5% of the total consumption may be added to meet this demand.

Fire Demand

- During the fire breakdown large quantity of water is required for throwing it over the fire to extinguish it.
- Therefore, provision is made in the water work to supply sufficient quantity of water or keep as reserve in the water mains for this purpose.
- Fire Demand is the function of population but with a minimum limit, because greater the population, greater the number of buildings and greater the risk of fire.

Compensate Losses

- Defective pipe joints, crack in pipe,
- Fault in valve fittings,
- Public taps damaged,
- Wasting water keeping the taps in open condition,
- Unauthorized connection.
- 15% of total water requirement.

System of water Supply

CONTINUOUS WATER SUPPLY	INTERMITTENT WATER SUPPLY
lesser diameter pipes are required	Bigger diameter pipes are required
water is available for 24 hours	water is supplied at regular intervals throughout the day

As the supply is continuous, so there is more consumption of water and less chances of contamination.	As it is not continuous supply so the consumption is less.
negative pressure cannot occur and as a result the quality of water is better.	Due to negative pressure, the quality of water is not so good compared to the case of continuous supply.

WATER SUPPLY SYSTEMS:

- The Municipal water systems consist of the following units
  - ✓ Collection works
  - ✓ Conveyance works
  - ✓ Treatment works and
  - ✓ Distribution works.

PER CAPITA DEMAND:

- The average daily water required per person per day based on the annual average demand.
- If Q is the total quantity of water required by a town per year in litres and the population of the town is P, then,

  Per capita Demand = Q / (Px365) litres/capita/day
- The per capita demand of the town depends on various factors and will be according to the living standard of the public and the type of the commercial places in the town etc.
- For an average Indian town, the requirement of water in various uses is given below.

  Domestic Use – 135 lpcd

  Industrial Use – 40 lpcd

  Commercial Use – 25 lpcd

  Public Use – 15 lpcd

Loss & Waste – 55 lpcd

Total = 270 lpcd.

- Total quantity of water required by the town/day = 270 lpcd x population.

FACTORS AFFECTING PER CAPITA DEMAND:

- Climatic Conditions
- Cost of Water
- Distribution Pressure
- Habits of Population
- Industrial & Commercial Activities
- Policy of metering and method of charging
- Quality of water
- Existing Sewerage Facilities
- Size of the city
- System of supply

FLUCTUATION OR VARIATIONS IN WATER DEMAND:

Seasonally or Monthly Fluctuation

- Water demand varies from season to season.
- Summer water demand is maximum.
- This demand goes on reducing and in winter it becomes minimum.
- The variation may be upto 15% to the average demand of the year.

Daily Fluctuation

- Variation depends on the general habits of people, climatic conditions and character of city.
- More water demand will be on Sundays and hoildays.

Hourly Fluctuation

- Peak hour flow will be from 6 to 10 A.M and 4P.M to 8P.M.
- Minimum flow may be between 12P.M to 4P.M.

POPULATION DATA

- The Population data is determined by the Census Department.
- Official surveys are carried out by the government at intervals of about 10 years to estimate the future population.

POPULATION DENSITY

- It indicates the number of persons per unit area.
- The distribution of population is studied by determining the population densities of various parts of the city.

POPULATION FORECAST

- Estimating the future population is known as population forecast. The population change can occur in following three ways.
- By birth (gain in population)
- By death (loss in population)
- By migrations (loss or gain in population)

USES OF POPULATION FORECAST:

- To assist the government agencies for the preparation of economic, employment and social programmes.
- To collect information for location of an industry, its future expansion, availability of labored marketing and distribution of the product etc.
- To design water supply system and sewerage system.
- To provide data to transportation industry.
- To workout requirements for other public utilities such as telephones, electric power etc.

METHODS OF POPULATION FORECAST:

- Arithmetical Increase Method
- Geometrical Increase Method
- Incremental Increase Method
- Decreasing rate of growth method
- Graphical method
- ✓ (a) Simple
- ✓ (b) Comparative
- Master Plan Method (or) Zoning Method
- Logistic Curve Method
- Ratio Method

Arithmetical Increase Method:

This method is based on the assumption that the population increases at a constant rate or the rate of change of population with time is constant.

$$P_n = P + n.C$$

Where,

P_n = Forecasted Population after n decades

P = Population at present

n = Number of decades between present and future C = Average arithmetic increase of population.

Geometrical Increase Method:

In this method, it is assumed that the percentage increase in population from decade to decade remains constant. This method is also known as uniform increase method. The increase is compounded over the existing population in every decade.

$$P_n = P + (1+ (I_G /100))^n$$

Where,

P_n = Forecasted Population after n decades

P = Population at present

n = Number of decades between present and future

I_G = Average percentage growth at the end of the decade.

Incremental Increase Method:

This method is an improved method of other two methods. The average increase in the population is determined by the arithmetic method and to this is added the average of the net incremental increase once for each future decade.

$$P_n = P + n (Ia +Ic)$$

Where,

P_n = Forecasted Population after n decades

P = Population at present

n = Number of decades between present and future

Ia = Average Arithmetical Increase

Ic = Average Incremental Increase.

Decreasing rate of growth method:

In this method, the average decrease in the percentage increase is worked out and is then subtracted from the latest percentage increase for each successive decade.

Problems:

1. The following data have been noted from the census department. Calculate the probable population in the year 1980,1990 and 2000 by Arithmetical Increase method.

YEAR	POPULATION
1940	8,000
1950	12,000
1960	17,000
1970	22,500

YEAR	POPULATION		INCREASE IN POPULATION
1940	8,000		-
1950	12,000		4000 (12000 – 8000)
1960	17,000		5000 (17000 – 12000)
1970	22,500 TOTAL AVERAGE	 = =	5500 (22500 – 17000) 14500 4833

YEAR	POPULATION
1980	22,500 + 1X4833 = 27,333
1990	27,333 + 1X4833 = 32,166
2000	32,166 + 1X4833 = 36,999

2.The following data have been noted from the census department. Calculate the probable population in the year 1980,1990 and 2000 by Geometrical Increase method.

YEAR	POPULATION
1940	8,000
1950	12,000
1960	17,000
1970	22,500

$P_n = P + (1+ (I_G /100))^n$

YEAR	POPULATION	INCREASE IN POPULATION	% INCREASE IN POPULATION
1940	8,000	-	-
1950	12,000	4000 (12000 – 8000)	4000/8000 X 100 = 50.0 %
1960	17,000	5000 (17000 – 12000)	5000/12000 X 100 = 41.7 %
1970	22,500	5500 (22500 – 17000)	5500/17000 X 100 = 32.4 %
	TOTAL	14500	124.1 %

	AVERAGE	4833	41.37 %

YEAR	POPULATION
1980	22,500+ (41.37/100X22,500) = 31,808
1990	31,808+ (41.37/100X31,808) = 44,967
2000	44,967+ (41.37/100X44,697) = 63,570

3.The following data have been noted from the census department. Calculate the probable population in the year 1980,1990 and 2000 by Incremental Increase method.

YEAR	POPULATION
1940	8,000
1950	12,000
1960	17,000
1970	22,500

YEAR	POPULATION	INCREASE IN POPULATION	INCREMENTAL INCREASE IN POPULATION
1940	8,000	-	-
1950	12,000	4000 (12000 – 8000)	-
1960	17,000	5000 (17000 – 12000)	+ 1000 (5000 – 4000)
1970	22,500	5500 (22500 – 17000)	+ 500 (5500 – 5000)
	TOTAL	14,500	+ 1500
	AVERAGE	4,833 (14,500/3)	+ 750 (1500/2)

$P_n = P + n\ (Ia + Ic)$

P in 1980 = 22,500 + 1 X (4833 + 750)

= 28,083

P in 1990 = 28,083 + 1 X (4833 + 750)

= 33,666

P in 2000 = 33,666 + 1 X (4833 + 750)

= 39,249

4.The following data have been noted from the census department. Calculate the probable population in the year 1980,1990 and 2000 by Decrease rate of growth method.

YEAR	POPULATION
1940	8,000
1950	12,000
1960	17,000
1970	22,500

YEAR	POPULATION	INCREASE IN POPULATION	% INCREASE IN POPULATION	DECREASE IN THE % INCREASE
1940	8,000	-	-	-
1950	12,000	4000 (12000 – 8000)	4000/8000 X 100 = 50.0 %	-
1960	17,000	5000 (17000 – 12000)	5000/12000 X 100 = 41.7 %	+ 8.3 % (50 – 41.7)
1970	22,500	5500 (22500 – 17000)	5500/17000 X 100 = 32.4 %	+ 9.3 % (41.7 – 32.4)
	TOTAL	14,500		17.6
	AVERAGE	4,833		8.8

YEAR	NET % INCREASE IN POPULATION	PROBABLE POPULATION
1980	32.4 – 8.8 = 23.6	22,500 + (23.6/100 X 22,500) = 27,810
1990	23.6 – 8.8 = 14.8	27,810 + (14.8/100 X 27,810) = 31,926
2000	14.8 – 8.8 = 6.0	31,926 + (6.0/100 X 31,926) = 33,842

DESIGN PERIOD:

- The number of years for which the designs of the water works have been done is known as design period.
- Mostly water works are designed for design periods of 20 – 30 years which is a fairly good period.

SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – II – CONVEYANCE OF WATER – SCIA1403

INTRODUCTION

INTAKE:

- The main function of the intakes structure is to collect the water from the surface source and then to discharge this water by means of pumps or directly to the water treatment plants.
- It essentially consists of opening, grating or strainer through which the raw water from river, canal or reservoir and is carried to a sump well by means of conduits.
- Water from the sump well is pumped through the rising mains to the treatment plants.

Intake consists of

- ✓ Conduit with protective works
- ✓ Screens at open ends
- ✓ Gates and Valves to regulate flow

Factors Governing Location of Intake:

- As far as possible, the site should be near the treatment plant so that the cost of conveying water to the city is less.
- The intake must be located in the purer zone of the source to draw best quality water from the source, thereby reducing load on the treatment plant.
- The intake must never be located at the downstream or in the vicinity of the point of disposal of wastewater.
- The site should be such as to permit greater withdrawal of water, if required at a future date.
- The intake must be located at a place from where it can draw water even during the driest period of the year.
- The intake site should remain easily accessible during floods and should not get flooded. Moreover, the flood waters should not be concentrated in the vicinity of the intake.

TYPES OF INTAKES:

- Depending upon source of water, intakes are classified as,
- ✓ Reservoir intakes.
- ✓ River Intakes
- ✓ Canal Intakes.
- ✓ Lake Intakes
- Depending upon the position, intakes are classified as,

- ✓ Wet intake
- ✓ Dry intake

Reservoir intakes:

- ➢ There are large variations in discharge of all the rivers during monsoon and winter.
- ➢ The discharge of some rivers in summer remains sufficient to meet up the demand, but some rivers dry up partly or fully and cannot meet the hot weather demand.
- ➢ In such cases reservoirs are constructed by constructing weirs or dams across the rivers.
- ➢ Reservoir intakes is mostly used to draw the water from earthen dam reservoir.
- ➢ It essentially consists of an intake tower constructed on the slope of the dam at such place from where intake can draw sufficient quantity of water even in the driest period.
- ➢ Intake pipes are fixed at different levels, so as to draw water near the surface in all variations of water level.
- ➢ These all inlet pipes are connected to one vertical pipe inside the intake well.
- ➢ Screens are provided at the mouth of all intakes to prevent the entrance of floating and suspended matter in them.
- ➢ The water which enters the vertical pipe is taken to the other side of the dam by means of an outlet pipe.
- ➢ At the top of the intake tower, sluice valves are provided to control the flow of water.
- ➢ The valve tower is connected to the top of the dam by means of a foot bridge gang - way for reaching it.

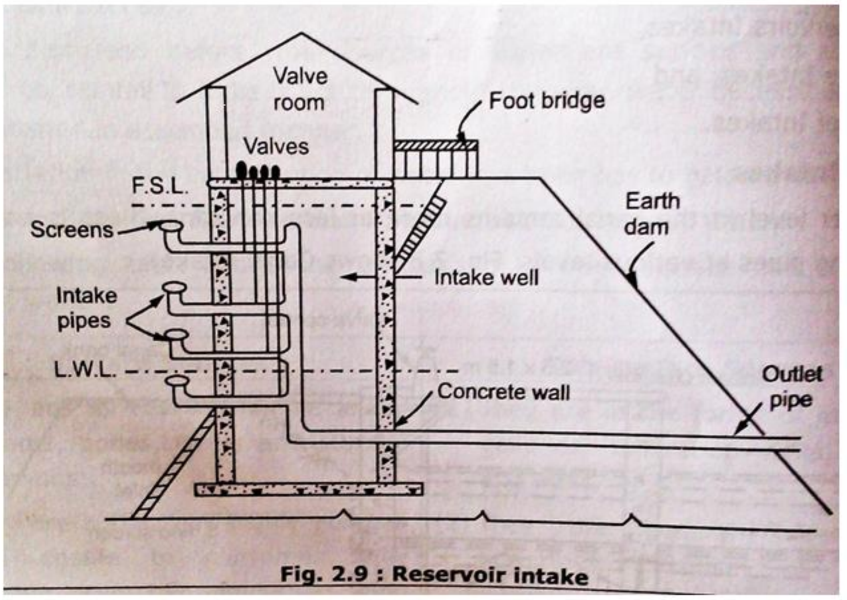


Fig. 2.9 : Reservoir intake

River Intake:

- Water from the rivers is always drawn from the upstream side, because it is free from the contamination caused by the disposal of sewage or industrial waste water disposal in it.
- It is circular masonry tower of 4 to 7 m in diameter constructed along the bank of the river at such place from where required quantity of water can be obtained even in the dry period.
- The water enters in the lower portion of the intake known as sump-well from penstocks.
- The penstocks are fitted with screens to check the entry of floating solids and are placed on the downstream side so that water free from most of the suspended solids may only enter the jack well.
- Number of penstock openings are provided in the intake tower to admit water at different levels.
- The opening and closing of penstock valves is done with the help of wheels provided at the pump house floor.

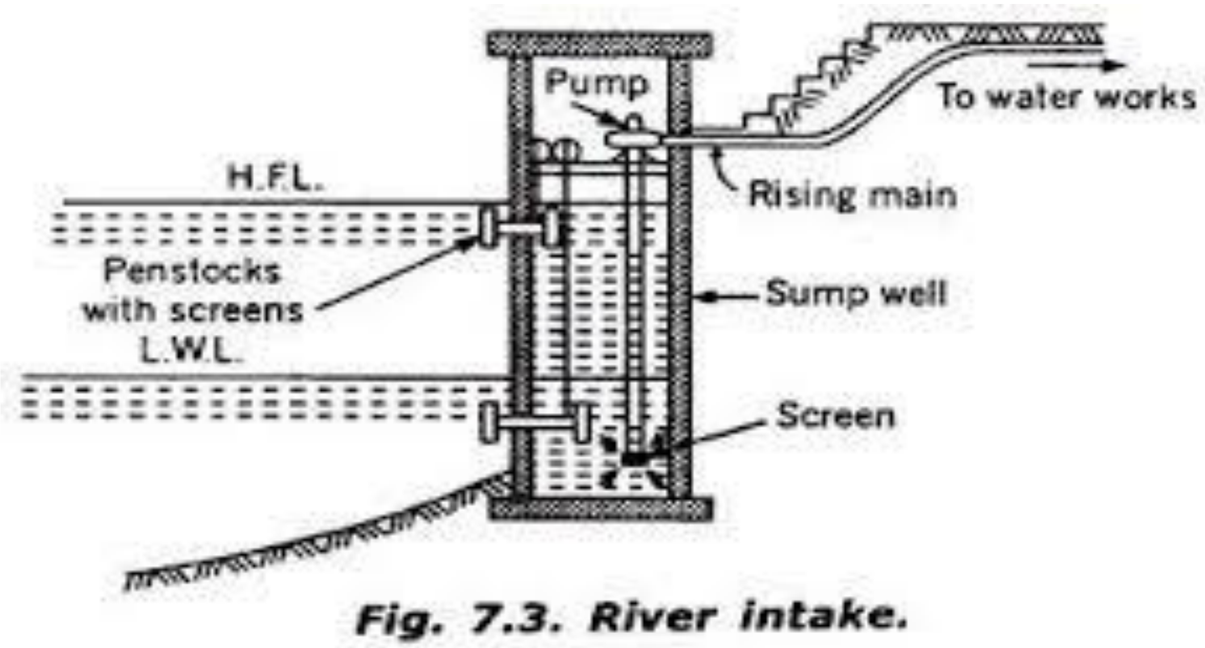
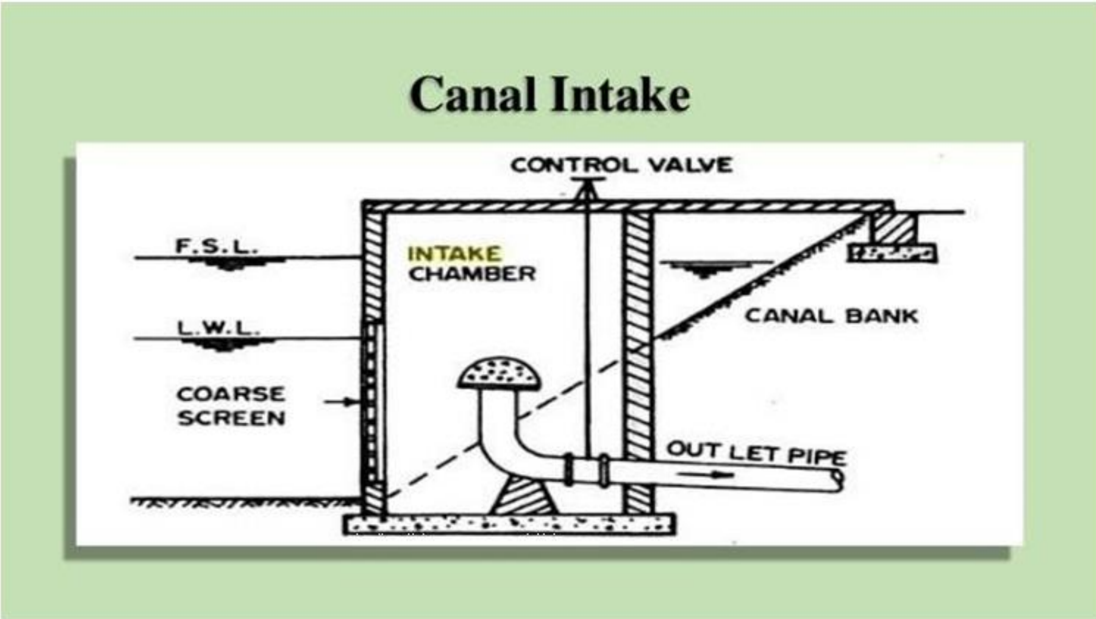


Fig. 7.3. River intake.

Canal intake:

- Canal intake is a very simple structure constructed on the bank.
- It essentially consists of a pipe placed in a brick masonry chamber constructed partly in the canal bank.
- On one side of the chamber, an opening is provided with coarse screen for the entrance of water.

- The end of the pipe in side chamber is provided with the bell mouth fitted with a hemispherical fine screen.
- The outlet pipe carries the water to the other side of the canal bank from where it is taken to the treatment plants.
- One sluice valve which is operated by a wheel from the top of the masonry chamber is provided to control the flow of water in the pipe.



Lake intake:

- For obtaining water from lakes mostly submersible intakes are used.
- These intakes are constructed in the bed of the lake below the slow water level so as to draw water in dry season also.
- It essentially consists of a pipe laid in the bed of the river.
- One end which is in the middle of the lake is fitted with bell mouth opening covered with a mesh and protected by timber or concrete crib.
- The water enters in the pipe through the bell mouth opening and flows under gravity to the bank where it is collected in a sump-well and then pumped to the treatment plants for necessary treatment.
- If one pipe is not sufficient two or more pipes may be laid to get the required quantity of water.
- Advantages of lake intake:

- No obstruction to the navigation.

- No danger from floating bodies
- No trouble due to ice.

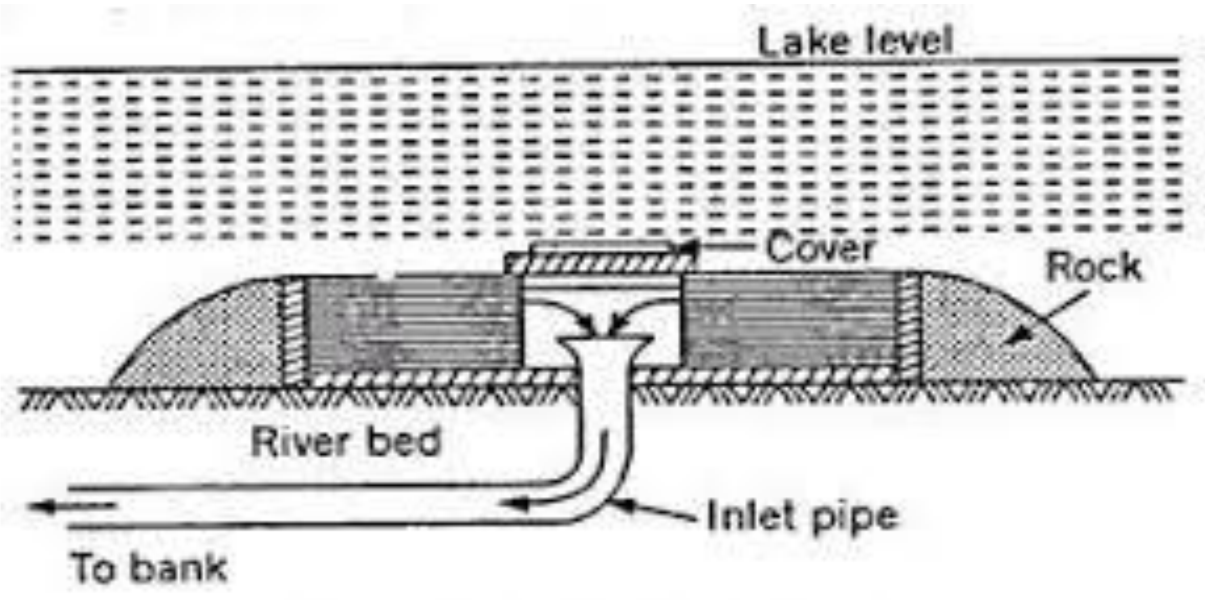


Fig. 7.1. Lake Intake.

Channels and pipes for conveying water:

- Conduits are the channels for conveying water.
- Depending upon conditions and characteristics of flow, conduits are classified as
    - ✓ Gravity conduits
    - ✓ Pressure conduits

GRAVITY CONDUITS:

Channels:

These are occasionally used to convey water from the source to treatment plant.

These can be easily and cheaply constructed by cutting in high grounds and banking low grounds.

The channels should be lined properly to prevent the seepage and contamination of water.

As water flows only due to gravitational force a longitudinal uniform slope should be given.

The velocity of water in channels should not exceed the permissible limit, otherwise scouring will start in the bed and water will get dirty.

In channels there is always loss of water by seepage and evaporation.

Aqueducts:

It’s the closed conduit constructed with masonry and used for conveying water from source to treatment plant.

It may be constructed with bricks, stones or R.C.C.

In older days, rectangular aqueducts were used, but now-a-days horse-shoe or circular sections are used.

The velocity should be 1m/sec.

Tunnels:

This is also a gravity conduit, in which water flows under gravitational force.

But sometimes, water flows under pressure and in such cases, these are called pressure tunnels.

In pressure tunnels, the depth of water in general such that the weight of the overlying material will be sufficient to check the bursting pressure.

Tunnels should be water- tight and there should be no loss of water.

Flumes:

These are open channels supported above the ground over trestles etc.

It’s used for conveying water across valleys and minor low-lying areas or over drains and other obstructions coming in water

It may be constructed with a R.C.C, wood or metal

The common sections are rectangular and circular.

PRESSURE CONDUITS:

These are circular conduits in which the water flows under pressure.

Now a day’s pressure pipes are used in every place

In distribution system, pipes of various diameters having many connections and branches are used.

The cost of pipeline depends on the internal pressure and the length of pipeline.

To prevent the bursting of pipes due to water hammer, surge tanks or stand pipes are provided at the end of the pipes.

The pipe material which will give the smallest annual cost or capitalized cost will be selected because it will be more economical.

PIPE MATERIALS:

- ➢ The selection of material for the pipe is done on the following points,
- ✓ Carrying capacity of the pipe

- ✓ Durability and life of pipe
- ✓ Type of water to be conveyed and its corrosive effect
- ✓ Availability of funds
- ✓ Maintenance, cost, repair etc.

Types of Pipe Materials:

- ➢ Cast iron pipes
- ➢ Wrought iron pipes
- ➢ Steel pipes
- ➢ Concrete pipes
- ➢ Cement lined cast iron pipes
- ➢ Asbestos cement pipes
- ➢ Copper and lead pipes
- ➢ Wooden pipes
- ➢ Vitrified clay pipes
- ➢ Plastic pipes
- ➢ Galvanized iron pipes

Cast Iron Pipes:

- ✓ These pipes were earlier cast vertically but, thus type has been largely superseded by spun iron pipes which are manufactured by spinning and centrifugal action.
- ✓ These spun iron pipes are lighter in weight, longer in length and have improved metal qualities.

Wrought iron and steel pipes:

- ✓ These pipes are stronger than cast iron pipes can withstand higher pressure but are of lighter section are easier to transport.
- ✓ They are less durable, more liable to corrosion and is also difficulty of availability of pipes specials viz, joints, bends etc.

Concrete Pipes:

- ✓ These pipes are durable, heavier and can be had in sizes 1800mm.
- ✓ Transportation costs are much reduced if pipes are cast in situ. Concrete pipes have low
- ✓ maintenance is resistant to corrosion and particularly suitable to soft and acidic waters.
- ✓ They however can withstand high pressure until reinforced.

Hume Steel Pipes:

- ✓ These pipes are made from a then mild steel shell lined and out coated with cement concrete or cement mortar through a centrifugal process.
- ✓ They are available up to 1350mm and are used for trunk and distribution mains. They are heavy and difficult to handle and concrete coating gets damaged while fixing branch connection.

Asbestos Cement Pipe:

- ✓ These pipes are composed of asbestos fibre and Portland cement combined under pressure into dense homogenous structure.
- ✓ Available in large variation from 50 to 600mm.

Wood Pipe:

- ✓ These pipes are built of staves of wood held together by steel bands.
- ✓ Wood is less durable for pipe material and pipe must be constantly full of water to prevent crackdown due to alternate wet and dry conditions.

PIPE JOINTS:

- ➢ Requirements of a jointing material.
- ✓ Imperviousness
- ✓ Elasticity
- ✓ Strength
- ✓ Durability
- ✓ Adhesiveness
- ✓ Availability
- ✓ Workability
- ✓ Economy

TYPES OF JOINTS:

- ➢ Spigot and socket Joint
- ➢ Expansion Joint
- ➢ Flanged Joint
- ➢ Mechanical Joint
- ➢ Flexible Joint
- ➢ Screwed Joint
- ➢ Collar Joint
- ➢ A.C. pipe Joint

Spigot and Socket Joint:

- ✓ Joint is commonly used in case of cast iron pipe.
- ✓ Spigot of one pipe is centered into socket of preceding pipe, tared gasket or hemp yarn is then wrapped around spigot leaving unfilled required depth of socket for lead.
- ✓ The gasket or hemp yarn is caulked tightly home with a yarning tool.
- ✓ A jointing ring or kneeded clay using is then placed around barrel and against face of socket molten pig lead is powered into remainder of socket.

Flanged Joint:

- ✓ A gasket of rubber canvas or lead is introduced h/w two flanges of cast iron pipes which are tightened with bolt and nuts.
- ✓ Flanged joints are strong and rigid are easy to disjoint as such used where pipe joints are occasionally opened for repair pipe.

Mechanical Joint:

- ✓ When two ends of cast iron, steel or wrought iron pipes are plain, a mechanical coupling is required to make a water tight joint.

Special Joints:

- ✓ Used for special pipes in case of cast iron pipes.
- ✓ Examples are expansion joints and flexible joints.
- ✓ Expansion joints are used on pipes exposed to considerable differences of temperature allowing free expansion or contraction without any thermal stresses.
- ✓ Flexible joints used in pipes to be laid submerged under water.

LAYING OF PIPES:

Preparing detailed map:

Preparing detailed map of roads and streets showing position of rocks, other underground water pipes, gas pipes, telephone cables.

Locating proposed alignment on ground:

Bench line is marked by driving centrally stakes 30 m apart on straight trenches and 7.5 – 1.5 m apart on cover.

Excavating trenches:

With width sufficient to allow pipes to be properly laid and jointed and with depth sufficient to give adequate protection to pipes against impact of traffic and other factors.

Dewatering of Trenches:

Dewatering involves controlling groundwater by pumping, to locally lower groundwater levels in the vicinity of the excavation.

The simplest form of dewatering is sump pumping, where groundwater is allowed to enter the excavation where it is then collected in a sump and pumped away by robust solids handling pumps.

Timbering of Trenches:

When the depth of trench is large, or when the sub-soil is loose, the sides of the trench may cave in.

The problem can be solved by adopting a suitable method of timbering.

Timbering of trenches, sometimes also known as shoring consists of providing timber planks or boards and struts to give temporary support to the sides of the trench.

Timbering of deep trenches can be done with the help of the following methods:

1. Staybracing.
2. Boxsheeting
3. Verticalsheeting
4. Runnersystem
5. Sheet piling.

Bottoming up of trenches:

Bottoming of trench should be carefully prepared so that barrel of pipe can be bedded true to line and gradient for its entire length on firm surface.

Lowering of pipes:

After transporting to site, pipes are stacked on either side of trench.

These should be gently lowered into trench so as not to damage their outer protective coating.

Laying of pipes:

Pipes are seldom laid with a flat slope parallel to hydraulic gradient thus it avoids any lock troubles.

The pipes shall be lowered into the trench by means of suitable pulley blocks, sheer legs chains, ropes etc. In no case the pipes shall be rolled and dropped into the trench.

One end of each rope may be tied to a wooden or steel peg driven into the ground and the other end held by men which when slowly release, will lower the pipe.

After lowering, the pipes shall be arranged so that the spigot of one pipe is carefully centered into the socket of the next pipe, and pushed to the full distance, that it can go.

The pipe line shall be laid to the level required.

Specials shall also be laid in their proper position as stated above.

If so directed, the pipes and specials may be laid on masonry or concrete pillars.

All the pipes shall rest continuously on the bottom of the trench.

The pipes shall not rest on lumps of earth or on the joints.

Some clayey soils like black cotton soil are drastically affected by extremes of saturation and dryness.

While changing from saturation to dry condition, these soils are subjected to extraordinary shrinkage which is usually seen in the form of wide and deep cracks and may damage the underground structures.

At such places an envelope of 10 cm minimum of tamped sand shall be made around the pipe line.

At slopy bed of pipe lines having more than 30° slope, it is necessary to anchor few pipes against sliding downward.

Jointing of pipes:

The connection at the ends of pipes that ensures tight sealing and strength.

The most common types used for general-purpose metal pipes are welded, flanged, threaded, and bell-and-spigot joints.

Welded joints are made between straight sections of pipe of the same diameter by butt-welding the pipe ends.

Anchoring of pipes:

At all bends, tees, valves and other branch connections it would be necessary to provide thrust blocks of concrete to transmit hydraulic thrust and distribute to wider area.

Anchor blocks of concrete would be required to be provided at regular intervals and pipes would be firmly secured to them with steel straps.

Back filling:

Refilling of trench with excavated material. The material around pipe should be soft, free from lumps or rock or large stone and laid preferably in layer of 15 cm or 30 cm.

TESTING OF PIPES:

- Testing for Straightness.
- Testing for Obstruction.

Testing for Straightness:

The straightness of the sewer pipe can be tested by placing a mirror at one end of the sewer line and a lamp at the other end.

If the pipe line is straight, the full circle of light will be observed.

However, if the pipe line is non-straight, this would be apparent and the mirror will also indicate any obstruction in the pipe barrel.

Testing for Obstruction:

Any obstruction present in the pipe can also be tested by inserting at the upper end of the sewer a smooth inserting at the upper end of the sewer a smooth ball of diameter 13mm less than internal diameter of the sewer pipe.

In the absence of any obstruction, such as yarn or mortar projecting through the joints etc. the ball shall roll down the invert of the sewer pipe and emerge at the lower end.

PUMPS:

- ➢ The function of the pump is to lift the water at higher elevation or higher pressure.
- ➢ In water works pumps are required under the following circumstances,
- ✓ To lift the raw water from rivers, streams, wells and to pump it to the treatment works.
- ✓ For pumping the chemical solutions at treatment plant.
- ✓ To increase the pressure in the pipe lines by boosting up the pressure.
- ✓ For filling the elevated distribution reservoirs or overhead tanks.
- ✓ For the backwashing of filters and increase their efficiency.

Classifications of Pumps:

- ➢ Based on their principle of operation:
- ✓ Displacement pumps
- ✓ Centrifugal pumps
- ✓ Air lift pumps
- ✓ Impulse pumps
- ➢ Based on the type of power required:
- ✓ Electrically driven pumps
- ✓ Gasoline engine pumps
- ✓ Steam engine pumps
- ✓ Diesel engine pumps
- ➢ Based on the type of service:

- ✓ Low lift pumps
- ✓ High lift pumps
- ✓ Deep well pumps
- ✓ Booster pumps
- ✓ Stand-by pumps.

Factors affecting the Selection of Pumps:

- ➢ In order to select proper pumps, the following factors should be considered,
    - ✓ Capacity – it should be capable of pumping required quantity of water
    - ✓ Reliability – it should be reliable and should not fail suddenly and cause troubles
    - ✓ Cost – it should be cheap in initial cost
    - ✓ Power – the power which is used for running pumps should be available easily at low cost
    - ✓ Maintenance – the maintenance cost of running pumps should be as small as possible
    - ✓ Efficiency – pump should have higher efficiency
    - ✓ Depreciation – it should have long life and depreciation cost should be small
    - ✓ Cost of labour – it should be low
    - ✓ Number of pumping – more units required
    - ✓ Total lift of water required.
    - ✓ Quality of water to be pumped
    - ✓ Quantity of water to be pumped
    - ✓ Importance of water supply scheme
    - ✓ Space requirements for locating the pump
    - ✓ Life of pump
    - ✓ Variations in pumping head and pumping rate
    - ✓ Discharge and suction condition
    - ✓ Position of pump (horizontal or vertical)
    - ✓ Type of power available
    - ✓ Type of supply service (continuous or intermittent)
    - ✓ Working or operating conditions

- ✓ Total head of liquid.

LOSS OF HEAD IN PIPES:

Manning's Formula,

$$H_L = \frac{m^2V^2L}{R^{4/3}}$$

Where, m = Manning's Coefficient.

L = Length of the pipeline in m.

R = Hydraulic mean depth of pipe in m.

V = Velocity of flow in m/sec.

2. Hazen William's Formula,

$$V = 0.85\ C_H\ R^{0.63}\ S^{0.54}$$

Where, C_H = Coefficient of hydraulic capacity.

S = Slope of the energy line.

R = Hydraulic mean depth of pipe in m.

3.Darcy – Weisbach Formula,

$$H_L = \frac{f\ L\ V^2}{2\ g\ d}$$

Where, H_L = Loss of head in m.

L = Length of pipe in m.

d = diameter of the pipe in m.

V = Velocity of flow in m/sec.

g = acceleration due to gravity.

f = friction factor.

PROBLEMS:

1.Determine the hydraulic gradient in a 90 cm diameter old cast iron pipe carrying a discharge of 0.75 cu.m/sec by using Manning's formula, Darcy's formula and Hazen William's formula. Assume suitable data not given.

Solution:

Discharge, Q = 0.75 cu.m/sec

Area of the pipe, $A = \frac{\pi d_2}{4}$

$= \frac{\pi \times 0.90^2}{4}$

$= 0.636\ m^2$.

Velocity of flow, V = Q/A = 0.75/0.636

= 1.18 m/sec.

Assuming the value of m = 0.014

R = d/4 = 0.90/4 = 0.225 m.

Using Manning's formula, $\frac{H_L}{L} = \frac{m^2V^2}{R^{4/3}}$

$= \frac{0.014^2 \times 1.18^2}{0.225^{(4/3)}}$

Thus, the hydraulic gradient = 1/502.

Assuming the value of f = 0.015

Using Darcy-Weisbach formula,

$$\frac{H_L}{L} = \frac{f V^2}{2 g d}$$

$$H_L = \frac{0.015 \times 1.18^2}{0.90 \times 2 \times 9.81}$$

Thus, the hydraulic gradient = 1/845.

Assume C = 120.

Using Hazen William formula,

$V = 0.85\ C_H\ R^{0.63}\ S^{0.54}$

$1.18 = 0.85 \times 120 \times (0.90/4)^{0.63} \times S^{0.54}$

S = 1/672.

Thus, the hydraulic gradient = 1/672.

2.Water is to be supplied to a town of population of 1.5 lakh. If the water works is situated at a lower elevation of 50 m than the water level in the source. Determine the size of the gravity main to convey the water from source to the water work, if the length of the gravity main is 25 Km and the per capita demand of the town is 150 litres/day/capita. Take value of f = 0.075

Solution:

Quantity of water required by the town = 150000 X 150

$= 225 \times 10^5$ litres/day or

$= 22500\ m^3/day$.

Let the pump work for 12 hours,

then the quantity of water carried by the pipe, = 22500/12 = 22500/12 X 60 X 60

= 0.52 m /sec.

Now, discharge, $Q = \frac{\pi d^2}{4} \times V$

$$0.52 = \frac{\pi d^2}{4} \times V$$

$$V = \frac{0.52 \times 4}{\pi d^2} = \frac{0.66}{d^2}$$

By using Darcy-Weisbach formula, $H_L = \frac{f L V^2}{2 g d}$

$$= \frac{0.075 \times 25 \times 1000}{d \times 2 \times 9.81} \times (0.66/d^2)^2$$

$$50 = \frac{0.075 \times 25 \times 1000}{d \times 2 \times 9.81} \times (0.66/d^2)^2$$

$d^5 = 0.83$

d = 0.9635 m OR 1 m.

d = 100 cm.

PIPE APPURTENANCES:

- The different devices required for controlling the flow of water, for preventing leakage and other purposes in water supply system are called “appurtenances”.
- The distribution pipes are provided with various pipe appurtenances or accessories so as to make the distribution of water easy and effective.
- **Various Pipe Appurtenances:**
- ✓ Sluice valves

- ✓ Check Valve or Reflux Valve
- ✓ Air relief valves
- ✓ Fire hydrants
- ✓ Drain valves or blow off valves
- ✓ Scour Valves

Sluice valves:

These are also known as gate-valves or stop valves. These valves control the flow of water through pipes.

These valves are cheaper, offers less resistance to the flow of water than other valves.

The entire distribution system is divided into blocks by providing these valves at appropriate places.

They are provided in straight pipeline at 150-200 m intervals. When sluice valve is closed, it shuts off water in a pipeline to enable to undertake repairs in that particular block.

The flow of water can be controlled by raising or lowering the handle or wheel.

Check valve or Reflux valve:

These valves are also known as non-return valves.

A reflux valve is an automatic device which allows water to go in one direction only.

When the water moves in the direction of arrow, the valve swings or rotates around the pivot and it is kept in open position due to the pressure of water.

When the flow of water in this direction ceases, the water tries to flow in a backward direction.

But this valve prevents passage of water in the reverse direction.

Reflux valve is invariably placed in water pipe, which obtain water directly from pump.

When pump fails or stops, the water will not run back to the pump and thus pumping equipment's will be saved from damage.

Air Relief Valves:

Sometimes air is accumulated at the summit of pipelines and blocks the flow of water due to air lock.

In such cases the accumulated air has to be removed from the pipe lines. This is done automatically by means of air relief valves

This valve consists of a chamber in which one or two floats are placed and is connected to the pipe line.

When there is flow under pressure in the pipeline water occupies the float chamber and makes the float to close the outlet.

But where there is accumulation of air in the pipeline, air enters the chamber, makes the float to come down, thus opening the outlet.

The accumulated air is driven out through the outlet.

Fire Hydrants:

A fire hydrant is a connection point by which firefighters can tap into a water supply.

It is a component of active fire protection.

It is purely a water based firefighting system to extinguish the blazing fire that happens during the emergencies.

Fire hydrant installation consists of a system of pipe work connected directly to the water supply main to provide water to each and every hydrant outlet and is intended to provide water for the firemen to fight a fire.

Drain Valves Or Blow Off Valves:

These are also called wash out valves they are provided at all dead ends and depression of pipelines to drain out the waste water.

These are ordinary valves operated by hand.

Scour Valves:

These are similar to blow off valves.

They are ordinary valves operated by hand.

They are located at the depressions and dead ends to remove the accumulated silt and sand.

After the complete removal of silt, the valve is to be closed.

CORROSION OF PIPES:

- Pipeline corrosion is a natural deterioration and destruction of pipe material and essential properties due to electrochemical and other ingredient reactions of pipeline materials with their environment - on the inside as well as outside surfaces.
- Corrosion is a deterioration of something due to reacting with its environment.
- In very simple terms, the metal from the pipe simply dissolves because of a reaction to the water or to other environmental factors.

Prevention for Corrosion of Pipes:

- Using coatings are one of the easiest ways to protect your pipes against corrosion.
- Coatings and linings can be used on pipes that are above or underground.
- They frequently are used in combination with cathodic protection.
- Some materials that are used to add defense to your pipelines include epoxy and zinc.

SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – III – QUALITY OF WATER – SCIA1403

INTRODUCTION

➢ **WHOLESOME WATER:**

✓ Wholesome water is the water that is safe and potent for drinking to human health.

✓ It is cleaned of harmful contaminants, transparent, odourless, harmless and

✓ Wholesome water is fit to use for drinking, cooking, food preparation or washing without any potential danger to human health by meeting the requirements free from any disease-causing bacteria.

✓ Water which is not chemically pure but does not contain anything harmful to human health.

➢ **Requirements of wholesome water:**

✓ It should be free from bacterias which may cause disease.

✓ It should be colourless and sparkling which may be accepted by the public.

✓ It should be tasty, odour-free and cool.

✓ It should corrode pipes.

✓ It should be free from all objectionable matter.

✓ It should have dissolved oxygen and free carbonic acid so that it may remain fresh.

➢ **PALATABLE WATER:**

The water which is tasteful for drinking and aesthetically pure is known as palatable water.

➢ **POTABLE WATER:**

The water which has both the characteristics of wholesome water and palatable water is known as potable water.

➢ **POLLUTED WATER:**

The water which consists of undesirable substances which make it unfit for drinking and domestic use is known as polluted water.

➢ **CONTAMINATED WATER:**

✓ The water containing pathogenic organisms is called as contaminated water.

✓ The contaminated water is always be polluted but the polluted water may not be contaminated.

IMPURITIES IN WATER

Suspended impurities:

✓ Impurities are dispersion of solid particles that are large enough to be removed by filtration on surface and heavier ones settle down.

- ✓ Suspended impurities which have same specific gravity as that of water, are mixed in the water.
- ✓ Suspended impurities include Clay, silt, Algae, protozoa, Fungi, Organic and Inorganic matters and mineral matter etc.,
- ✓ These all impurities are macroscopic and cause turbidity in the water.
- ✓ The concentration of suspended matter in water is measured by its turbidity.
- ✓ The size of suspended impurities ranges from $0 – 10^{-3}$ mm.

Colloidal impurities:

- ✓ It is very finely divided dispersion of particles in water.
- ✓ These particles are so small that these cannot be removed by ordinary filters and are not visible to the naked eye.
- ✓ As a matter of fact, all the colloidal impurities are electrically charged and remain in continuous motion.
- ✓ The electric charge is due to the presence of absorbed ions on the surface of the solid.
- ✓ These colloidal impurities are generally associated with organic matter containing bacteria's and are the chief source of epidemics.
- ✓ Most of the colour of the water is due to colloidal impurities.
- ✓ The size of colloidal particles is between (1 = 1 micron = 0.001mm) to 1 = 1 milli micron = 0.000001mm) or (10^{-3} mm to 10^{-6} mm)

Dissolved impurities:

- ✓ Some impurities are dissolved in water when it moves over the rocks, soil etc.,
- ✓ Solids, liquids and gases are dissolved in natural waters.
- ✓ These dissolved impurities may contain organic compounds, inorganic salts and gases etc.
- ✓ The concentration of total dissolved solids is usually expressed in p.p.m and is obtained by weighing the residue after evaporation of the water sample from a filtered sample.
- ✓ Dissolved impurities include Calcium and magnesium, Sodium, Metal, Gases.
- ✓ Suspended solids are substances that are not completely soluble in water and are present as particles.
- ✓ These particles usually impart a visible turbidity to the water. Dissolved and suspended solids are present in most surface waters.

CHARACTERISTICS OF WATER

PHYSICAL CHARACTERISTICS

- ✓ Temperature
- ✓ Colour
- ✓ Turbidity
- ✓ Taste and Odours
- ✓ Specific conductivity of water

Temperature:

- ✓ The temperature of water is measured by means of ordinary thermometers.
- ✓ The temperature of surface water is generally same to the atmospheric temperature, while that of ground water may be more or less than atmospheric temperature.
- ✓ The most desirable temperature for public supply is between 4.4 °C to 10 °C.
- ✓ Temperature above 28 °C are undesirable and above 35 °C are unfit for public supply, because it is NOT PALATABLE (NOT ACCECTABLE TO TASTE).

Colour:

- ✓ The colour of water is usually due to presence of organic matter, but sometimes it is also due to mineral and dissolved organic and inorganic impurities.
- ✓ The colour of water is compared with standard colour solution.
- ✓ The permissible colour for domestic water is 20 ppm on platinum cobalt scale.
- ✓ The colour in water is not harmful but it is objectionable.

Turbidity:

- ✓ **I**t is caused due to presence of suspended and colloidal matter in the water.
- ✓ The character and amount of turbidity depends on the type of soil over which the water has moved ground waters are less turbid than the surface water
- ✓ Turbidity is a measure of resistance of water to the passage of light through it.
- ✓ Turbidity is expressed as NTU (Nephelometric Turbidity Units) or PPM (parts per million) or Milligrams per litre (mg/l).

Taste and Odours:

- ✓ Taste and odours in water may be due to the presence of dead or alive micro-organisms, dissolved gases such as hydrogen sulphide, methane, carbon dioxide or oxygen combined with organic matter, mineral substance such as sodium chloride, iron compounds, and carbonate and sulphates of other substances.

- ✓ The test of these are done by sense of smell and taste because these are present in such small proportions that it is difficult to detect them by chemical analysis.
- ✓ The odour of water also changes with temperature.
- ✓ The odour may be classified as fishy, mouldy, sweetish, vegetable, greasy etc.
- ✓ The odour of both cold and hot water should be determined.
- ✓ The water having bad smell or odour is objectionable and should not be supplied to the public.
- ✓ The intensities of the odours are measured in terms of threshold number.

Specific conductivity of water:

- ✓ The total amount of dissolved salts present in water can be easily estimated by measuring the specific conductivity of water.
- ✓ The specific conductivity of water is determined by means of portable dionic water tester and it expressed in micro-mohs per cm at 25° C (Mho is the unit of conductivity).
- ✓ The specific conductivity of water in micro-mhos per cm at 25° C is multiplied by a coefficient (generally 0.65) so as to directly obtain the dissolved salt content in mg/litre or ppm.
- ✓ The exact value of this coefficient depends upon the type of salt present in water.

CHEMICAL CHARACTERISTICS

- ✓ pH-value
- ✓ Total Solids
- ✓ Hardness
- ✓ Chlorides
- ✓ Dissolved gases
- ✓ Nitrogen
- ✓ Iron and manganese
- ✓ Lead and arsenic
- ✓ Metals and chemical substance
- ✓ Acidity
- ✓ Alkalinity
- ✓ Sulphates

pH-value:

Depending upon the nature of dissolved salts and minerals, the water found in natural sources may be acidic or alkaline.

The acidity or alkalinity is usually measured in p.p.m. of the dissolved salts and is expressed in terms of equivalent weight of calcium carbonate.

Denotes the concentration of hydrogen ions in the water and it is a measure of acidity or alkalinity of a substance.

$$pH = -\log_{10}[H+] \quad \text{or} \quad 1 / \log_{10}[H+]$$

Depending upon the nature of dissolved salts and minerals, the PH value ranges from 0 to 14.

For pure water, pH value is 7 and 0 to 7 acidic and 7 to 14 alkaline ranges.

For public water supply pH value may be 6.5 to 8.5.

The lower value may cause tuberculation and corrosion, whereas high value may produce incrustation, sediment deposits and other bad effects.

pH value of water is generally determined by pH papers or by using pH meter.

Its knowledge is also helpful in controlling softening and coagulation processes in water treatment.

There are two methods of determine pH value of water:

- ✓ Colourimetric method,
- ✓ Electrometric method

Total solids:

Includes the solids in suspension, colloidal and in dissolved form.

The quantity of suspended solids is determined by filtering the sample of water through fine filter, drying and weighing.

The quantity of dissolved and colloidal solids is determined by evaporating the filtered water obtained from the suspended solid test and weighing the residue.

The total solids in a water sample can be directly determined by evaporating the filtered water obtained from the suspended solid test and weighing the residue.

The total solids in a water sample can be directly determined by evaporating the water and weighing the residue of the residue of total solids is fused in a muffle furnace the organic solids will decompose whereas only inorganic solids will remain.

Hardness:

It is a property of water, which prevents the lathering of the soap.

It is caused due to the presence of carbonates and sulphates of calcium and magnesium in the water.

Sometimes the presence of chlorides and nitrates of calcium and magnesium also cause hardness in the water.

- ✓ Hardness is of two types.
- ▪ Temporary hardness:
- ✓ It is caused due to the presence of carbonates and sulphates of calcium and magnesium. It is removed by boiling.
- ▪ Permanent hardness:
- ✓ It is caused due to the presence of chlorides and nitrates of calcium and magnesium. It is removed by zeolite method.
- ✓ Hardness is usually expressed in mg/litre or ppm. of calcium carbonate in water.
- ✓ Hardness of water is determined by EDTA method.
- ✓ For potable water hardness ranges from 5 to 8 degrees.

Chloride content:

- ✓ Sodium chloride is the main substance in chloride water.
- ✓ The natural water near the mines and sea have dissolve sodium chloride.
- ✓ Similarly the presence of chlorides may be due to the mixing of saline water and sewage in the water.
- ✓ Excess of chlorides is dangerous and unfit for use.
- ✓ The chlorides can be reduced by diluting the water.
- ✓ Chlorides above 250p.p.m. are not permissible in water.
- ✓ Chlorides are estimated by titration the water with standard silver nitrate solution using potassium chromate as indicator.
- ✓ In this titration process reddish colours will be formed if chlorides are present.

Chlorine:

- ✓ Dissolved free chlorine is never found in natural waters
- ✓ It is present in the treated water resulting from disinfection with chlorine.
- ✓ The chlorine remains as residual in treated water for the sake of safety against pathogenic bacterias.
- ✓ Residual chlorine determined by the starch iodide test.
- ✓ The residual chlorine should remain between 0.5 p.p.m. to 0.2 p.p.m. in the water so that it remains safe against pathogenic bacteria.

Nitrogen content:

- ✓ The presence of nitrogen in the water indicates the presence of organic matters in the water. The nitrogen may be present in the water may be in one or more of the following forms.
  - Nitrites
  - Nitrates
  - Free ammonia
  - Albuminoid nitrogen.
- ✓ Excess presence of nitrogen will cause "MATHEMOGLOBINEMIA" disease to the children.

Nitrites:

- ✓ The presence of nitrites in the water due to partly oxidized organic matters, is very dangerous.
- ✓ Therefore, in no case nitrites should be allowed in the water, their presence must be nil.
- ✓ The nitrites are rapidly and easily converted to nitrates by the full oxidation of the organic matters.
- ✓ The presence of nitrates is not so harmful.
- ✓ But in no case its quantity should increase 45 p.p.m., because excess presence of nitrate will cause "mathemoglobinemia" disease to the children.
- ✓ Nitrite in water is either due to oxidation of ammonium compounds or due to reduction of nitrate.
- ✓ As an intermediate stage in the nitrogen cycle, it is unstable.
- ✓ A usual concentration in natural water is in the range of some tenths of mg/L.
- ✓ Higher concentrations are present in industrial wastes, sewage and in biologically purified effluents and in polluted streams.
- ✓ Very high nitrite levels are usually associated with water of unsatisfactory microbiological activity.
- ✓ The presence of nitrites or nitrate can be determined by colour matching methods.
- ✓ For determining the presence of nitrites, the colour is obtained by adding sulphonic acid and napthamine.
- ✓ For testing presence of nitrates, the colour is obtained if phenol-di-sulphonic acid and potassium hydroxide are added.
- ✓ The colours so developed are compared with standard colours to ascertain the p.p.m. contents.

Nitrate:

- ✓ Nitrate constitutes the final stage in the oxidation of nitrogen compounds, and normally reaches important concentrations in the final stages of biological oxidation.
- ✓ The nitrate contained in pure well water derived from an extensive catchment is largely the result of biological activity in the surface layers of the soil, enhanced by cultivation and the application of manures.
- ✓ When the nitrate in in the excessive amounts, it contributes to the illness known as infant methemoglobinemia.
- ✓ Nitrate is measured either by reduction to ammonia or by matching the colours produced with phenol-di-sulphonic acid.

Free ammonia:

- ✓ Free ammonia is obtained from the decomposition of organic matters in the beginning.
- ✓ Therefore, if free ammonia is present in the water, it will indicate that the decomposition of the organic matters has started recently.
- ✓ The presence of nitrates indicates partly decomposition of organic matters. Whereas the presence of nitrates indicates fully oxidized organic matters.
- ✓ The presence of free ammonia in water should not exceed 0.15 p.p.m. the presence of free ammonia can be easily determined by boiling the water and measuring the ammonia gas obtained.
- ✓ Ammonia is produced by the microbiological degradation of organic nitrogenous matter.
- ✓ It appears, therefore, in many ground waters as well as surface waters.
- ✓ Concentrations of ammonia above a certain level in water polluted either due to sewage or industrial waste is toxic to fish.
- ✓ The proportions of the two forms of ammonia nitrogen in surface water depend on pH.
- ✓ For accurate results, it is generally preferable to distill off ammonia from the sample, and absorb in boric acid.
- ✓ It is then determined either by titration or colorimetrically using Nessler reagent.

Albuminoid Nitrogen:

- ✓ The presence of albuminoid nitrogen in water indicates the pollution of water.
- ✓ Its measurement is done by adding strong alkaline solution of potassium permanganate to the already boiled water.
- ✓ In no case the quantity of albuminoid nitrogen should exceed 0.3 p.p.m.

Dissolved gases:

- ✓ Oxygen and carbon di-oxide are the gases mostly found in the natural water.
- ✓ The surface water contains large amount of dissolved oxygen because they absorb it from the atmosphere.
- ✓ Algae and other tiny plant life of water also give oxygen to the water.
- ✓ The presence of oxygen in the water in dissolved form keeps it fresh and sparkling.
- ✓ But more quantity of oxygen causes corrosion to the pipes material. Water absorbs carbon-dioxide from the atmosphere.
- ✓ If water comes across calcium and magnesium salts, carbon-dioxide reacts with the salts and converts them into bicarbonates, causes hardness in the water.
- ✓ The presence of carbon-dioxide is easily determined by adding lime solution to water gives milky white colour.

Iron & Manganese:

- ✓ These are generally found in ground water.
- ✓ If these are present less than 0.3 p.p.m., it is not objectionable, but if exceeds 0.3 p.p.m. the water is not suitable for domestic, bleaching, dyeing and laundering purposes.
- ✓ The presence of iron and manganese in water makes brownish red colour in it, leads to the growth of microorganism and corrodes the water pipes.
- ✓ Iron and manganese also cause taste and odour in the water.
- ✓ The quantity of iron and manganese is determined by colorimetric methods.

Lead & Arsenic:

- ✓ These are not usually found in natural waters.
- ✓ But sometimes lead is mixed up in water from lead pipes or from tanks lined with lead paint when water moves through them.
- ✓ These are poisonous and dangerous to the health of the public.
- ✓ The presence of lead and arsenic is detected by means of chemical tests for it.

Metals & other chemical substances:

- ✓ Water contains various types of minerals or metals such as iron, manganese, copper, lead, barium, cadmium, selenium, fluoride, arsenic etc.
- ✓ The concentration of iron and manganese should not be allowed more than 0.3 p.p.m.
- ✓ Otherwise they will cause discolouration of clothes during washing.
- ✓ They may also cause incrustation in water mains due to deposition of ferric hydroxide and manganese oxide.

- ✓ As barium and lea are very toxic, a low p.p.m. of these are allowed.
- ✓ Arsenic, selenium is poisonous and may cause fatality, therefore they must be removed totally.
- ✓ Human lungs are affected by presence of high quality of copper in the water.
- ✓ A laxative effect is caused in the human body due to presence of sulphates in the water.
- ✓ Fewer cavities in the teeth will be formed due to excessive presence of fluoride in water more than 1 p.p.m.

BIOLOGICAL CHARACTERISTICS:

Total count of bacteria

Bacteria coli (B-coli) test

Total count of bacteria:

- ✓ Bacterial examination of water is very important, since it indicates the degree of pollution.
- ✓ Water polluted by sewage contain one or more species of disease producing pathogenic bacteria.
- ✓ Pathogenic organisms cause water borne diseases, and many non-pathogenic bacteria such as E.Coli, a member of coliform group, also live in the intestinal tract of human beings.
- ✓ Coliform itself is not a harmful group but it has more resistance to adverse condition than any other group.
- ✓ So, if it is ensured to minimize the number of coliforms, the harmful species will be very less.
- ✓ So, coliform group serves as indicator of contamination of water with sewage and presence of pathogens.
- ✓ The methods to estimate the bacterial quality of water are:
    - ✓ Standard Plate Count Test
    - ✓ Most Probable Number
- ✓ Membrane Filter Technique

Bacteria coli (B-coli) test:

- ✓ Sometimes this is also called as E–coli test.
- ✓ There are two tests for B-coli, first is presumptive and second confirmative.

- ✓ In the presumptive test, definite amount of diluted sample of the water in standard fermentation tubes containing lactose broth as culture medium is kept in incubator at 37 C for 24 to 48 hours.
- ✓ If some gas is produced in the fermentation tube, it indicates the presence of B-coli.
- ✓ In the confirmation test some sample from the presumptive tube is taken and placed in another fermentation tube containing "brilliant green lactose bile" as culture medium.
- ✓ It is again kept in incubator at 37 C for 48 hours, if there is formation of gas in the tube, it confirms the presence of B-coli and the water is unsafe for use.
- ✓ Nowadays a new technique of finding out the B-coli is developed which is called 'Membrane Filter Technique".
- ✓ This is a very simple method.
- ✓ In this method the sample of water is filtered through a sterilized membrane of special design due to which all the bacteria are retained on the membrane.
- ✓ The member is then put in contact of culture medium-M-Endo's medium in the incubator for 24 hours at 37 C.
- ✓ The membrane after incubating is taken out and the colonies of bacteria are counted by means of microscope.
- ✓ This method is known as 'membrane filter technique".

Membrane filter technique:

- ✓ Now a days a new technique of finding out the B-coli.
- ✓ Alternative to MPN.
- ✓ Membrane contains microscopic pores which are capable of retaining bacteria.
- ✓ Water is filtered through the membrane and it is then incubated for a period of 20 hours along with nutrients.
- ✓ The colonies of bacteria can then be counted.

Most Probable Number:

- ✓ It is the number which represents the bacterial density which is most likely to be present.

Coliform Index:

- ✓ Coliforms are the rod, shaped, non-pathogenic bacteria whose presence or absence in water indicates the presence or absence of fecal pollution.
- ✓ The total coliform group consists of members whose normal habitat is the – (lower portion of intestines) of humans and warm- and cold-blooded animals and soil.
- ✓ Some members which are not found in soil and vegetation constitute about 96% of all the coliforms of human fecal.

- ✓ Such members are called fecal coliforms and recently named by WHO.
- ✓ The total coliform group is widely used as a indicator organism of choice for drinking water.
- ✓ Escherichia coli (E-Coli) is the predominant member of the fecal coliform group.
- ✓ Used to measure coliform bacteria present in water sample.
- ✓ It is defined as the reciprocal of the smallest quantity of sample which would give a positive B-coli test.
- ✓ Should be preferably less than 3 and should not exceed 10
- ✓ But due to the development of the 'Membrane Filter technique" the MPN or C.I methods are not used.
- ✓ For the drinkable water it is necessary that it must be free from pathogenic bacteria.

WATER BORNE DISEASES:

- ✓ When water contains certain harmful and disease producing matter, it may lead to many diseases on being consumed by healthy persons.
- ✓ Water – borne diseases may cause by following factors:
    - Presence of micro organisms
    - Presence of parasite ova
    - Presence of inorganic matter
- Presence of organic mater

Presence of Microorganisms:

- ✓ Bacteria (Cholera, typhoid, paratyphoid dysentery, diarrhea)
- ✓ Virus diseases of poliomyelitis (infective hepatitis (Jaundice)
- ✓ Protozoa infection (amoebic dysentery)

Presence of Parasite ova:

- ✓ Egg or developed embryos of the eggs of round worms and tape worms, mosquito eggs.
- ✓ Malaria nematodes flukes, guinea worm and hook worm infections.

Presence of Inorganic matter:

- ✓ Fluorides >1.5 mg/l causes – erupting teeth.
- ✓ Nitrate – blue babies.

Presence of organic matter:

- ✓ Excess of vegetable matter

- ✓ Sewage effluents (diarrhea and gastric disturbance)

Types of Water borne diseases:

Common Cold and Flu:

- ✓ The disease that catches people across the age lines.
- ✓ You will get wet, constant sneezing, throat and fever are the severe symptoms of common cold and flu.
- Prevention:
- ✓ Avoid getting in rain.
- ✓ And if it is caught, the best homemade remedy is hot turmeric milk.

Dengue:

- ✓ The very common disease during rainy seasons.
- ✓ The virus is spread by the Aedes mosquito.
- ✓ The symptoms include high fever, pain in joints & muscles, vomiting, bleeding from nose, gums & even under skin due to hemorrhagic fever.
- Prevention:
- ✓ Stay away from mosquitoes & clean your surroundings so that the mosquitoes doesn't multiply.

Chikungunya:

- ✓ Another mosquito transmitted disease.
- ✓ The virus is spread by the Aedes Aegyptus mosquito.
- ✓ The symptoms include fever, swelling & stiffness of joints, muscular pain, headache, fatigue & nausea.
- Prevention:
- ✓ Protect yourself from mosquito bites.

Cholera:

- ✓ It spreads through contaminated food, water & poor hygienic conditions.
- ✓ The symptoms include diarrhea, vomiting, low blood pressure, dry mouth etc.
- Prevention:
- ✓ Keep drinking boiled water and maintain personal hygiene.

Typhoid fever:

- ✓ The disease that spreads during the monsoon season.

- ✓ The disease is spread through contaminated food & water.
- ✓ The symptoms include prolonged fever, abdominal pain & headache.
- Prevention:
- ✓ Getting a vaccination in advance. Get high intake of fluid to prevent dehydration.

Prevention: Waterborne Disease

- ✓ Improve quality and quantity of drinking at source, at the tap, or in the storage vessel.
- ✓ Interrupt routes of transmission by emptying accumulated water sources.
- ✓ Chlorinate water.
- ✓ Change hygiene behavior, like hand washing.
- ✓ Proper use of latrines.
- ✓ Careful disposal of all waste products.
- ✓ Proper maintenance of water supply, sanitation systems, pumps and wells.
- ✓ Good food hygiene-wash before eating, protect from flies.
- ✓ Improved immunizations practices, especially rotavirus.
- ✓ Develop or enhance public health surveillance system.
- ✓ Faster responses to emergent and dangerous pandemic strains of pathogenic infections.
- ✓ Health education programs across the country.

SCHOOL OF BUILDING AND ENVIRONMENT

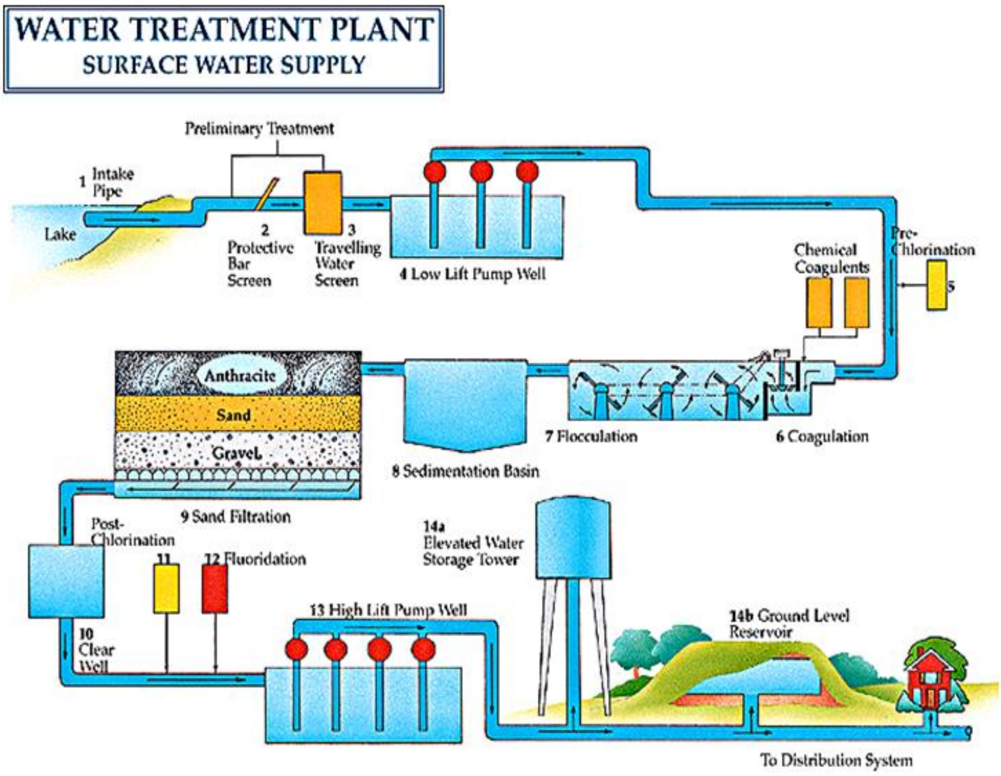
DEPARTMENT OF CIVIL ENGINEERING

UNIT – IV – TREATMENT OF WATER – SCIA1403

INTRODUCTION

OBJECTIVES OF WATER TREATMENT:

- In general, Water contains many impurities, such as trace minerals, metals, chemicals etc.
- The following are the objectives of water treatment:
- ✓ To remove the dissolved gases and colour of water.
- ✓ To remove the unpleasant and objectionable tastes and odours from the water.
- ✓ To kill all the pathogenic organisms which are harmful to the human health.
- ✓ To make water fit for domestic use such as cooking, washing and various industrial purposes as dyeing, steam generation etc.
- ✓ To eradicate the contaminants that are contained in water as found in nature.
- ✓ To control the impurities from scale formation.
- ✓ Pure water quality is required to minimize the corrosion, radiation levels and fouling of heat transfer surfaces in reactor facility systems.
- ✓ To prove safe potable water to the public.
- ✓ To reduce the physical, chemical and biological contaminants in water.
- ✓ To eliminate the tuberculating and corrosive properties of water which affects the conduits and pipes.
- ✓ Water treatment is required for surface waters and some ground waters for drinking purposes.
- ✓ Water treatments involves the removal of pollutants generated from different sources and to produce water that is pure and suitable for human consumption without causing any long term or short-term adverse health effects.
- ✓ To improve the quality of water for several purposes, water treatment is required.
- ✓ To provide appropriate treatment technology to the contaminated water, which will be useful to all population’s groups.



Location of Treatment Plants:

- The water treatment plants should be located as near to the towns as possible.
- If the source of water supply is tube well the treatment plant should be located in the central part of the town, so that purified water may reach the public as early as possible.
- If the city is very large to which water cannot be supplied from one tube well, the city should be divided into zones and a separate tube well with necessary treatment plants should be provided for each zone.
- If the source of water is river or reservoir, the treatment plant should be located as near the town as possible preferably in the central place.
- The following points should be kept in mind while giving the layout of any treatment plant,
- All the plants should be located in order of sequence, so that water from one process should directly go into next process.
- If possible, all the plants should be located at such elevations that water should flow from one plant to next under its force of gravity only.
- All the treatment units should be arranged in such a way that minimum area is required, it will also insure economy in its cost.
- Sufficient area should be occupied for future extension in the beginning.

- Staff quarters and office should also be provided near the treatment plants, so that operators can watch the plants easily.
- The site of treatment plant should be very neat and give very good aesthetic appearance.

WATER TREATMENT PROCESSES:

- The water treatment processes directly depend on the impurities present in water.
- For removing various types of impurities, the following treatment processes are used.

Screening:

- ✓ Removal of floating matters as leaves, dead animals etc.

Plain Sedimentation:

- ✓ Removal of suspended impurities as silt, clay, sand etc.

Sedimentation with coagulation:

- ✓ Removal of fine suspended matter.

Filtration:

- ✓ Removal of micro-organisms and colloidal matters.

Aeration and chemical treatment:

- ✓ To remove the dissolved gases, tastes and odours.

Water Softening:

- ✓ Removal of hardness.

Disinfection:

- ✓ Removal of pathogenic bacteria.

Screening:

- Screening is a unit operation that separates large floating materials from water and from entering water treatment facilities and mains.
- A screener is a device with openings (usually uniform in size) to remove the floating materials and suspended particles.
- The process of screening can be carried out by passing water through different types of screeners (with different pore sizes)
- The screeners are classified as coarse, medium or fine, depending on the size of the openings.
- The coarse screen has larger openings (75-150 mm).

- The openings for medium and fine screens respectively are 20-50 mm and less than 20 mm.
- Different types of screens-fixed bar screen (coarse or medium) disc type fine screen, drum type fine screen is in use.

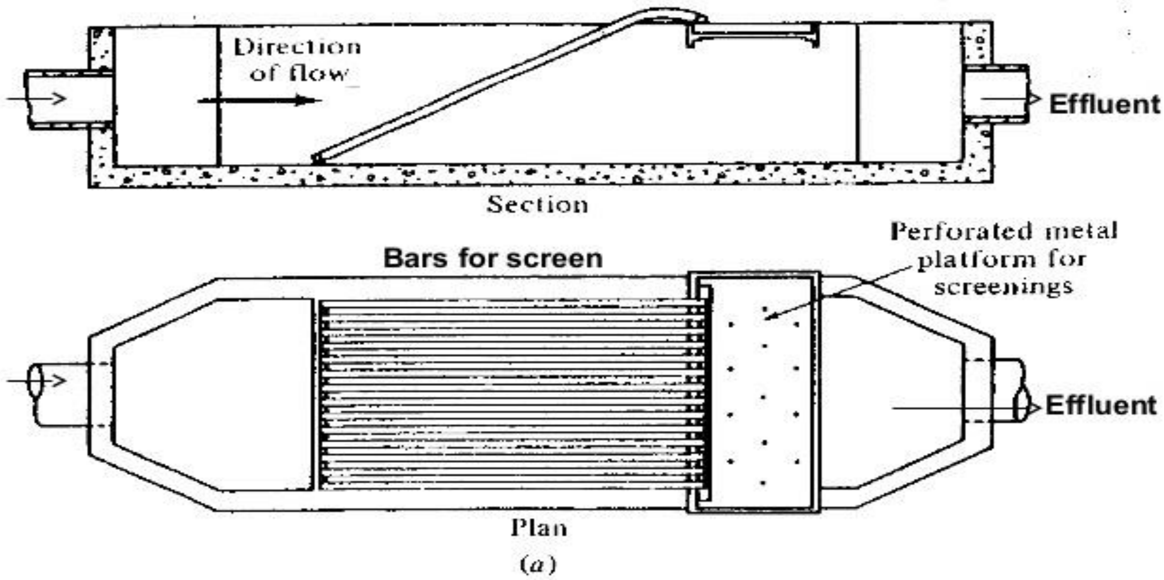


Figure : Fixed Bar-Screen (course or medium)

Plain Sedimentation

- Plain sedimentation is the process of removing suspended matters from the water by keeping it quiescent in tanks, so that suspended matter may settle down in the bottom due to force of gravity.
- Sedimentation, or clarification, is the processes of letting suspended material settle by gravity.
- Suspended material may be particles, such as clay or silts.
- Sedimentation is a physical water treatment process using gravity to remove suspended solids from water.
- Solid particles entrained by the turbulence of moving water may be removed naturally by sedimentation in the still water of lakes and oceans.
- Sedimentation is the process of removing suspended coarser particles in water by settling down them to the bottom of tank.
- For a particle to settle down, the flow velocity must be reduced.

- This process is carried out in a structure called sedimentation tank or settling tank.
- The main principle involved in the sedimentation tank is to reduce the flow velocity of water which allows the major number of suspended particles to settle down.
- The velocity with which the particle is settling is known settling velocity.
- The number of suspended particles collected at bottom of the tank is based on different factors like shape and size of tank, size of particle, temperature of water, flow velocity, detention period etc.

Discrete Particle:

- ✓ Any particle which does not alter its size, shape and weight while rising or settling in any fluid is called discrete particle.
- ✓ All the particles having more specific gravity than the liquid will move vertically downward due to gravitational force.

Settling Velocity:

- ✓ When any discrete particle is falling through a quiescent fluid, it will accelerate until the frictional resistance or drag force becomes equal to the gravitational force acting upon the particle.
- ✓ At such stage, the particle will settle at uniform velocity.
- ✓ This uniform velocity is called "settling velocity" and is a very important factor.

$$V_s = \frac{1}{18} \frac{g}{\mu} (\rho_s - 1) d^2$$

Where,

V_s = settling velocity in cm/sec.

g = 981 cm/sec.

ρ_s = specific gravity of the particle.

d = diameter of the settling particle in cm.

μ = viscosity of water in centi-stokes.

Detention Time:

The time for which the water is detained in the settling tank is called detention time.

$$\text{Detention time} = \frac{\text{Capacity of tank}}{\text{Rate of flow of water}}$$

Advantages of Plain Sedimentation:

- It lightens the load on the subsequent process.

- The operation of subsequent purification process can be controlled in a better way, because plain sedimentation delivers less variable quality of water.
- The cost of cleaning the chemical coagulation basins are reduced.
- No chemical is lost with sludge discharged from the plain settling basin.
- Less quantity of chemicals is required in the subsequent treatment processes.

Types of Sedimentation Tanks:

- Depending upon various factors sedimentation tanks are classified as follows.
- Based on methods of operation
- ✓ Fill and draw type tank
- ✓ Continuous flow type tank
- Based on shape
- ✓ Rectangular tanks
- ✓ Circular tanks
- ✓ Hopper bottom tanks
- Based on location
- ✓ Primary tank
- ✓ Secondary tank

Fill and Draw Type Sedimentation Tank:

- In case of fill and draw type sedimentation tank, water from inlet is stored for some time.
- The time may be 24 hours.
- In that time, the suspended particles are settled at the bottom of the tank.
- After 24 hours, the water is discharged through outlet.
- Then settled particle are removed.
- This removal action requires 6-12 hours.
- So, one complete action of sedimentation requires 30-40 hours in case of fill and draw type sedimentation tank.

Continuous Flow Type Sedimentation Tank:

- In this case, water is not allowed to rest.
- Flow always takes place but with a very small velocity.
- During this flow, suspended particles are settled at the bottom of the tank.

➢ The flow may be either in horizontal direction or vertical direction.

Horizontal flow type sedimentation tank:

✓ These tanks generally in rectangular shape. They have more length twice its width.

✓ Because they need to flow more distance to settle all suspended particles.

✓ The maximum permissible velocity in this case is 0.3m/sec.

Vertical flow type sedimentation tank:

✓ The vertical flow type sedimentations tanks are generally in circular shape and flow takes place in vertical direction.

✓ Hopper bottom is provided at the bottom of the tank to dispose the collected sludge.

2. Continuous type:

A. Horizontal Flow Type

(a) Rectangular tanks with longitudinal flow

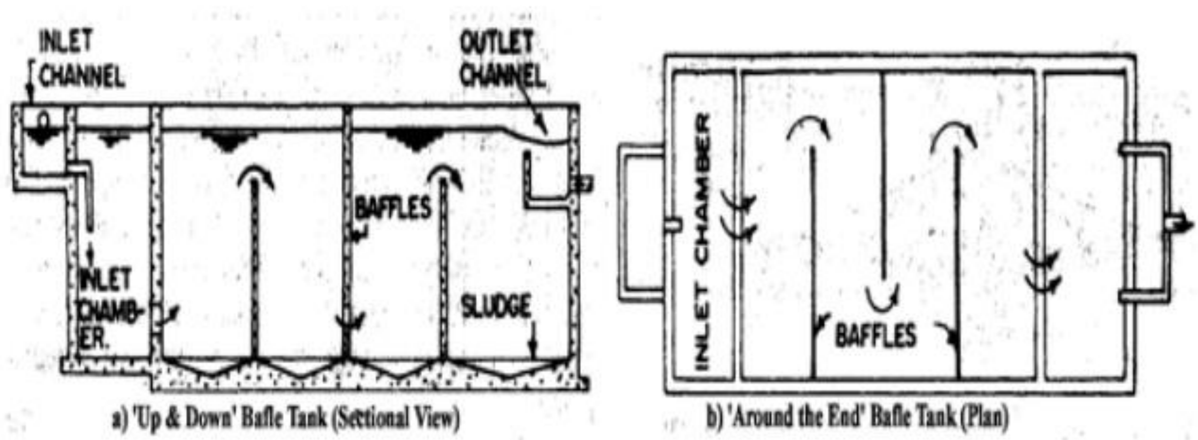


Fig 6.5 Rectangular sedimentation tank (ST) with baffles

(Source: Punmia et al., 2005)

2

➢ Rectangular sedimentation tanks are mostly preferred sedimentation tanks and are used widely.

➢ The flow takes place in horizontal direction that is length wise in rectangular tanks and consists of large number of baffle walls.

➢ The function of baffle walls is to reduce the velocity of incoming water to increase the effective length of travel of the particle and prevent the short circuiting.

➢ Maintenance costs are low in case of rectangular sedimentation tanks.

- They are also suitable for large capacity plants.
- These tanks are generally provided with channel type inlet and outlet extending on the full width.
- The floor between two baffles is made like a hopper sloping towards centre where sludge pipe is provided.
- The sludge is taken out through sludge outlet under hydrostatic force by operating the gate valve.

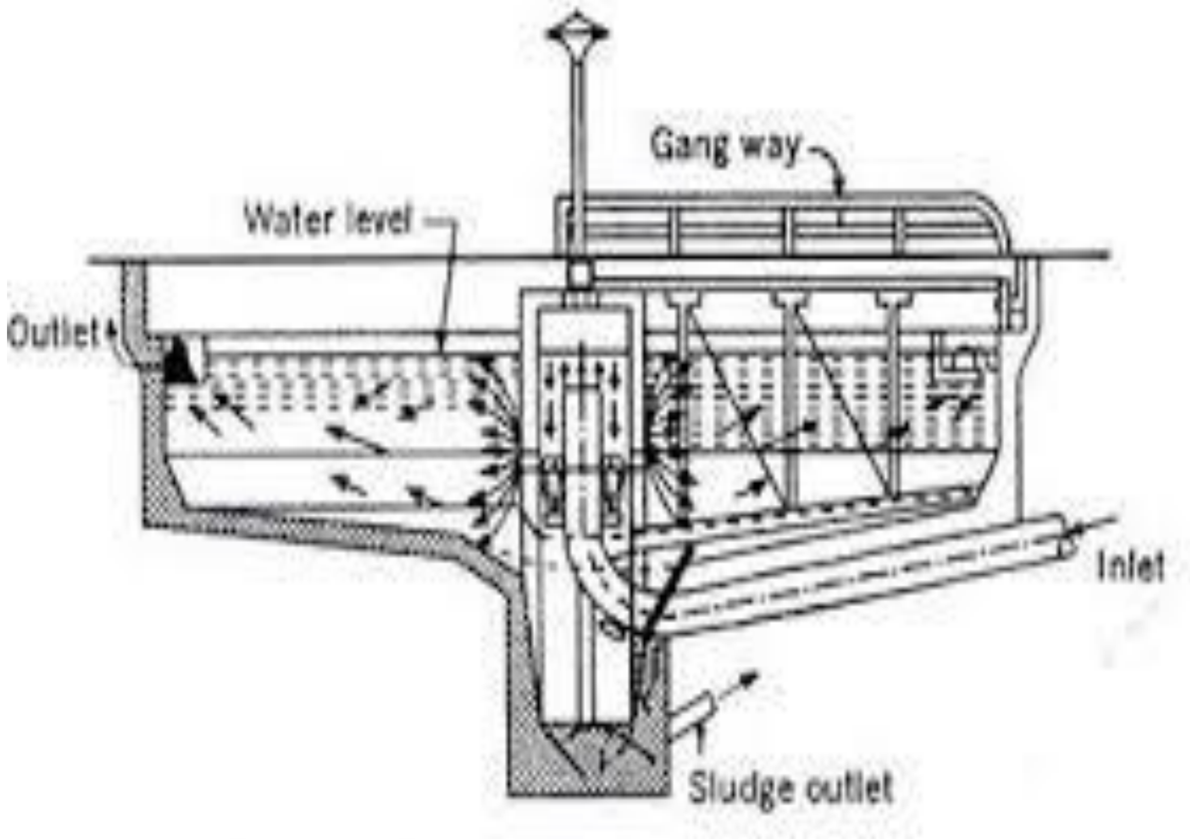


Fig. 11.7. Radial flow circular-tank.

- These are generally not used in plain sedimentation, but are mostly used in sedimentation with coagulation.
- Circular sedimentation tanks are preferred for continuous vertical flow type sedimentation tanks.
- In this case influent is sent through central pipe of the tank and radial flow takes place.
- Mechanical sludge scrappers are provided to collect the sludge and collected sludge is carried through sludge pipe provided at the bottom.

- ➢ But circular tanks are uneconomical as compared to rectangular tanks but they have high clarification efficiency.
- ➢ It is of two types,
- ✓ Radial flow circular tank
- ✓ Circumferential flow circular tank.

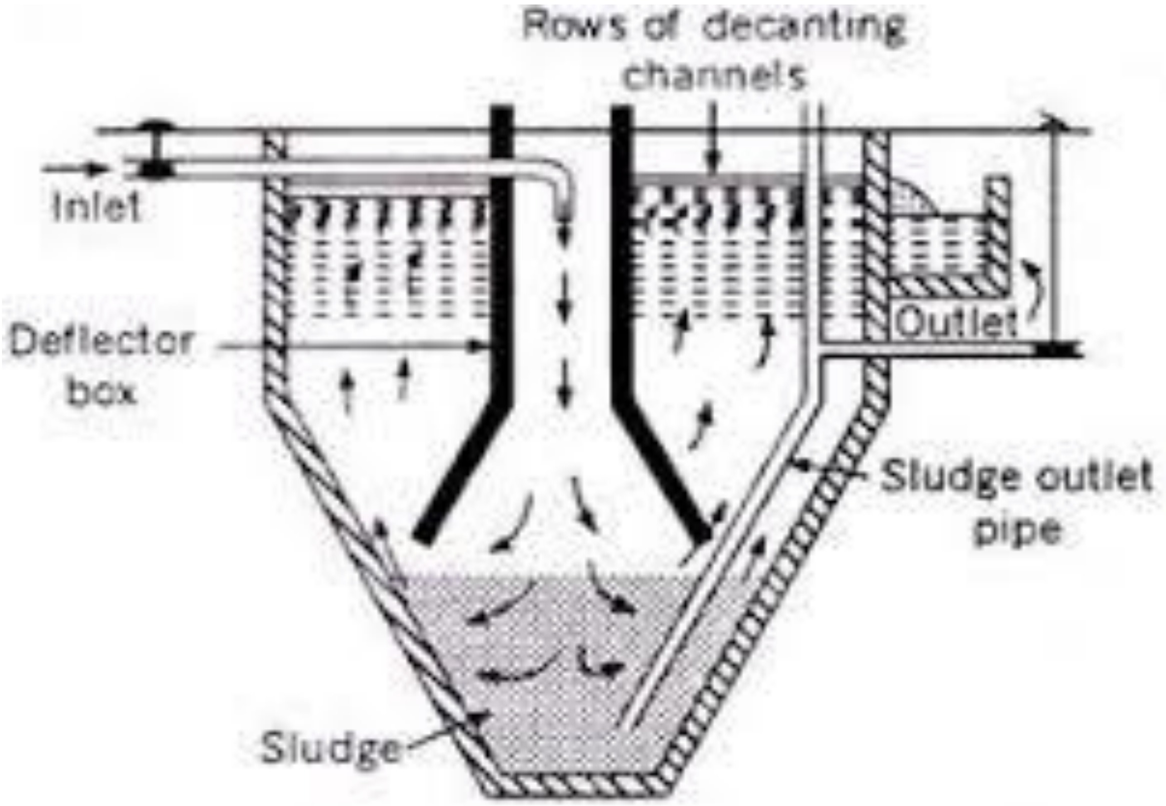


Fig. 11.9. Hopper bottom settling tank.

- ➢ These are vertical flow tanks, because water flows upward and downward in these tanks.
- ➢ The water enters in these tanks from the top into deflector box.
- ➢ After flowing downward inside the deflector box, the water reverses its direction and starts flowing upward around the deflector box.
- ➢ The suspended particles having specific gravity more than one, cannot follow the water at the time of reversing its direction, and settle in the bottom, from where they are removed through sludge outlet pipe under hydrostatic pressure.
- ➢ Sludge is collected at the bottom and it is disposed through sludge pump.
- ➢ Rows of decanting channels are provided at the top to collect the clear water.

- The water after flowing in the channel is taken out from the outlet channel provided on one side of the tank.
- These tanks are mostly used in sedimentation with coagulation process.

Primary Sedimentation Tank

- ✓ Primary sedimentation tank is a normal sedimentation tank in which water is stored at rest for some time and sludge collected at bottom and oily matter collected at top are removed.
- ✓ After primary sedimentation process the wastewater is discharged into aerobic filter where activated sludge process take place.

Secondary Sedimentation Tank

- ✓ After activated sludge process the wastewater enters secondary sedimentation tank in which suspended particles contains microbes are removed and are reflected towards aerobic filter to maintain high microbe concentration in aerobic filter.

Sedimentation Tank Design Parameters

- To design Sedimentation tank following elements are required in the consideration:
- ✓ Velocity of flow
- ✓ Capacity of tank
- ✓ Detention period
- ✓ Overflow rate
- ✓ Dimensions or Shape of the tank
- ✓ Free Board
- ✓ Sludge capacity and sludge removal.

PROBLEMS

1. A water has to purify the water for a town whose daily demand is $9 X 10^6$ litres/day. Design the suitable sedimentation tank of the water works fitted with mechanical sludge remover. Assume the velocity of flow in the sedimentation tank as 22 cm/minute and the detention period as 8 hours.

Solution:

Quantity of water to be treated by the sedimentation tank during detention period of 8 hours =

$$\frac{9 X 10^6}{24} X 8 = 3 X 10^6 \text{ litres} = 3 X 10^3 \text{ m}^3.$$

Capacity of the sedimentation tank required = 3000 m^3.

Velocity of flow inside the tank is given as 22 cm/minute = 0.22 m/minute.

Length of the tank = Velocity of flow X Detention period

$$= 0.22 \times (8 \times 60) = 106 \text{ m.}$$

The cross-sectional area of tank required $= \dfrac{\text{Capacity of the tank}}{\text{Length of the tank}} = \dfrac{3000}{106} = 28.3 \text{ m}^2$

Assume the depth of the water as 3.5 m.

Required width of the tank $= \dfrac{28.3}{3.5} = 8.10$ m.

Providing a free board of 0.5 m,

Overall depth of the tank = 0.5 + 3.5 = 4.0 m.

Dimension of the tank = 106 X 8.10 X 4.0 m.

2. Design a sedimentation tank for a water works, which supplies 1.4 X 10^6 litre/day water to the town. The sedimentation period is 5 hours, the velocity of flow is 12 cm/minute, depth of water in the tank is 4.0 m. Assuming an allowance for sludge is to be made as 80 cm.

Solution:

Quantity of water to be treated by the sedimentation tank during detention period of 5 hours = $\dfrac{1.4 \times 10^6}{24} \times 5$ litres = 292 m^3

The velocity of flow has been given as 12 cm/min. = 0.12 m/min.

Required length of the tank = Flow velocity X Detention time

$$= 0.12 \times (5 \times 60) = 36.0 \text{ m.}$$

Cross sectional area of the tank $= \dfrac{\text{Tank capacity}}{\text{Tank length}} = \dfrac{292}{36} = 8.12 \text{ m}^2$

Depth of the water in the tank = 4.0 m

Depth of sludge = 0.8 m

Net water depth = 4.0 – 0.8 = 3.2 m

Width of the tank $= \dfrac{\text{Cross sectional area}}{\text{Depth of water}} = \dfrac{8.12}{3.20} = 2.54$ m say 2.60 m.

Providing free board of 0.5 m, Overall depth = 4.0 + 0.5 = 4.5 m.

Size of the tank = 36 X 2.6 X 4.5 m.

SEDIMENTATION WITH COAGULATION:

- Groundwater and surface water contain both dissolved and suspended particles.
- Very fine suspended clay particles are not removed by plain sedimentation.

- Silt particle of 0.06 mm size requires 10 hours to settle in 3 m deep plain sedimentation tank and 0.02 mm particle will require about 4 days for settling.
- This settling is impracticable.
- In addition to fine suspended matter, water also contains electrically charged colloidal matter which are continuously in motion and never settle down due to gravitational force.
- When water contains such fine clay particles and colloidal impurities, it becomes necessary to apply such process which can easily remove them from the water.
- After long experience it has been found that such impurities can be removed by sedimentation with coagulation.
- It has been found that when certain chemicals are added to water an insoluble, gelatinous, flocculent precipitation is formed.
- This gelatinous precipitate during its formation and descent through the water absorb and entangle very fine suspended matter and colloidal impurities.
- The gelatinous precipitate has the property of removing fine and colloidal particles quickly and completely than by plain sedimentation.
- These coagulants have the advantages of removing colour, odour and taste from the water.
- These coagulants if properly applied are harmless to the public.
- First the coagulants are mixed in the water to produce the required precipitate, then the water is sent in sedimentation basins where sedimentation of fine and colloidal articles takes place through the precipitate.
- Coagulation and flocculation are used to separate the suspended solids portion from the water.

Chemical Coagulants:

- ✓ Aluminium Sulphate (Alum)
- ✓ Sodium Aluminate
- ✓ Ferric Coagulants (Ferric Chloride & Ferric Sulphate)
- ✓ Chlorinated Copperas
- ✓ Ferrous Sulphate and lime.

Dosage of Coagulants:

The dosage of coagulants which should be added in the water depends on the following factors,

- ✓ Kind of coagulant
- ✓ Turbidity of water

- ✓ Colour of water
- ✓ pH of water
- ✓ Temperature of water
- ✓ Mixing and Flocculation time.

Determination of Optimum Dosage of Coagulant:

- ➢ A laboratory procedure that simulates coagulation/flocculation with differing chemical doses.
- ➢ The optimum dosage of coagulants is determined by Jar Test Apparatus.
- ➢ The purpose of the procedure is to estimate the minimum coagulant dose required to achieve certain water quality goals.
- ➢ Samples of water to be treated are placed in six jars.
- ➢ Stirring paddles of non-corrosive metal are placed in each jar, which can be rotated at any desired speed by gear and spindle system.
- ➢ First of all, the samples of water in real amounts is taken in every jar.
- ➢ Then coagulant is added in jar in varying amounts.
- ➢ The quantity of coagulant added in each jar is noted.
- ➢ Then with the help of electric motor all the paddles are rotated at a speed of 30-40 R.P.M for about 10 minutes.
- ➢ After this speed is reduced and paddles are rotated for about 20-30 minutes.
- ➢ The rotation of paddles is stopped and the floc formed in each jar is noted and is allowed to settle.
- ➢ The dosage of coagulant which gives the best floc is the optimum dose of coagulants.

FILTRATION:

- Sedimentation process removes large percentage of suspended impurities, organic material and small percentage of bacteria.
- If sedimentation with coagulation is used, the percentage removal of colloidal particles is increased.
- For removing bacteria, colour , taste, odours and producing clear and sparkling water , filters are used.
- The process of passing the water through beds of sand or other granular materials is known as filtration.
- Water flows through a filter designed to remove particles from within it.
- The filters are made of layers of sand and gravel, and in some cases, crushed anthracite.
- Filtration collects the suspended impurities in water, enhancing the effectiveness of disinfection.
- These filters are routinely cleaned by backwashing.

Types of Filters:

- ✓ Gravity Filters
- ▪ Slow Sand Filter
- ▪ Rapid Sand Filter
- ✓ Pressure Filters
- ▪ Horizontal pressure Filter
- ▪ Vertical pressure Filter

- For small plants and individual colony or industry, pressure filters are employed.
- For water works, pressure filters are not used due to their costly maintenance.

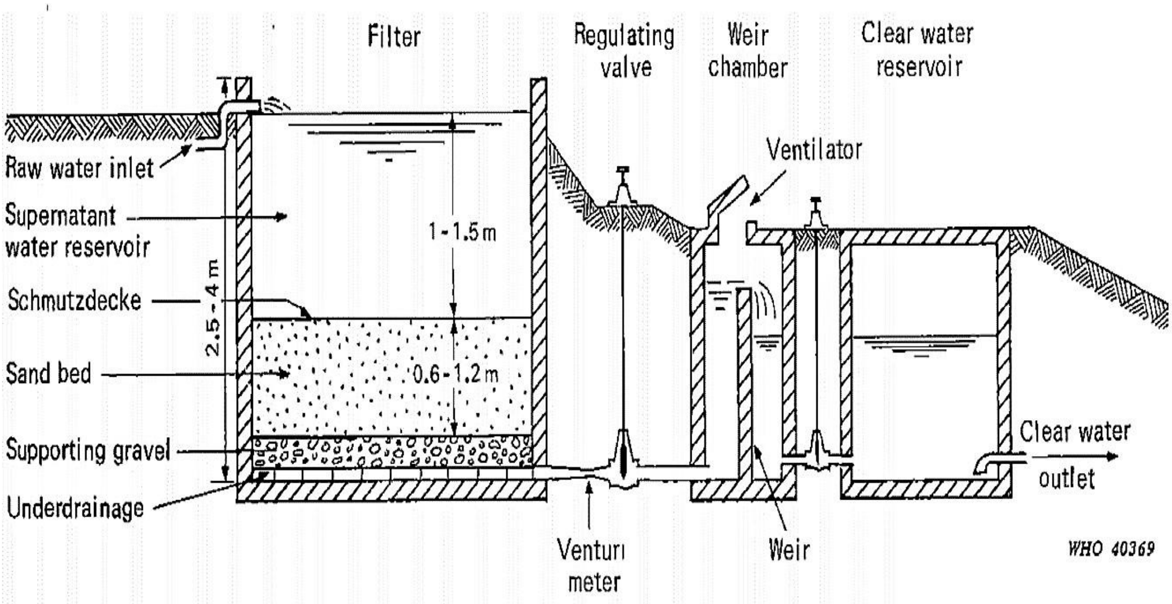
Sand for Filtration:

The sand used for filters should have the following properties:

- ✓ It should be free from clay, loam, lime and organic matter etc.
- ✓ It should be obtained from hard rocks such as basalt, trap and quartz.
- ✓ It should be of uniform size and nature.
- ✓ It should be resistant and hard.

Gravel for Filtration:

- ✓ The gravel used in filtration plant should be clean, hard, durable and rounded.
- ✓ It should be free from clay, loam, shells and other foreign matters.
- ✓ It should not contain flat, thin or long pieces.
- ✓ It should have a density of about 1600 Kg/m^3.



- Slow sand filters are used in water purification for treating raw water to produce a potable product.
- These are watertight shallow tanks about 2.5 m to 4 m deep and having surface area 100 m to 2000 m in plan.
- These tanks contain 60-90 cm thick bed of sand supported on 30-60 cm thick gravel bed.
- Generally, three to four layers of gravel having thickness of 15-20 cm are used.

- ➢ The coarsest gravel is placed in the bottom and the smallest size gravel is used in the topmost layer.
- ➢ The size of the bottom layer gravel is 40-60 mm, the size of the intermediate layer 20-40 mm and 6 mm to 20 mm.
- ➢ The size of the topmost gravel layer is 3-6 mm.
- ➢ The gravel is supported on a bed of concrete sloping towards a central longitudinal drain connected by a system of open jointed under-drains.

Components of Slow Sand Filter:

- ✓ Inlet
- ✓ Underdrainage system
- ✓ Depth of water
- ✓ Outlet
- ✓ Miscellaneous
- ✓ Appurtenances.
- ➢ Operation of Filter:
- ✓ The water from the sedimentation tanks enters the slow sand filter through a submersible inlet.
- ✓ This water is uniformly distributed over the sand bed without causing any disturbances.
- ✓ The water passes through the filtering media at an average rate of 100 to 200 lit/m/hr.
- ✓ This rate of filtration is continued until the difference between the water level on the filter and in the outlet, chamber is slightly less than the depth of water above the sand.
- ✓ The difference between the water above the sand bed and in the outlet, chamber is called loss of head.
- ✓ During filtering, the filtering media gets clogged due to impurities which stay in the pores, the resistance to the passage of water and loss of head also continuously increases.
- ✓ When loss of head reaches its permissible limit the working of filter is stopped and about 2-3 cm sand from the top of bed is scrapped and replaced with clean sand before putting back into service to the filter.
- ✓ The scrapped sand is washed with water, dried and stored for return to the filter at the time of the next washing.

Advantages:

- ✓ Very effective removal of bacteria, viruses, protozoa, turbidity and heavy metals in contaminated fresh water.

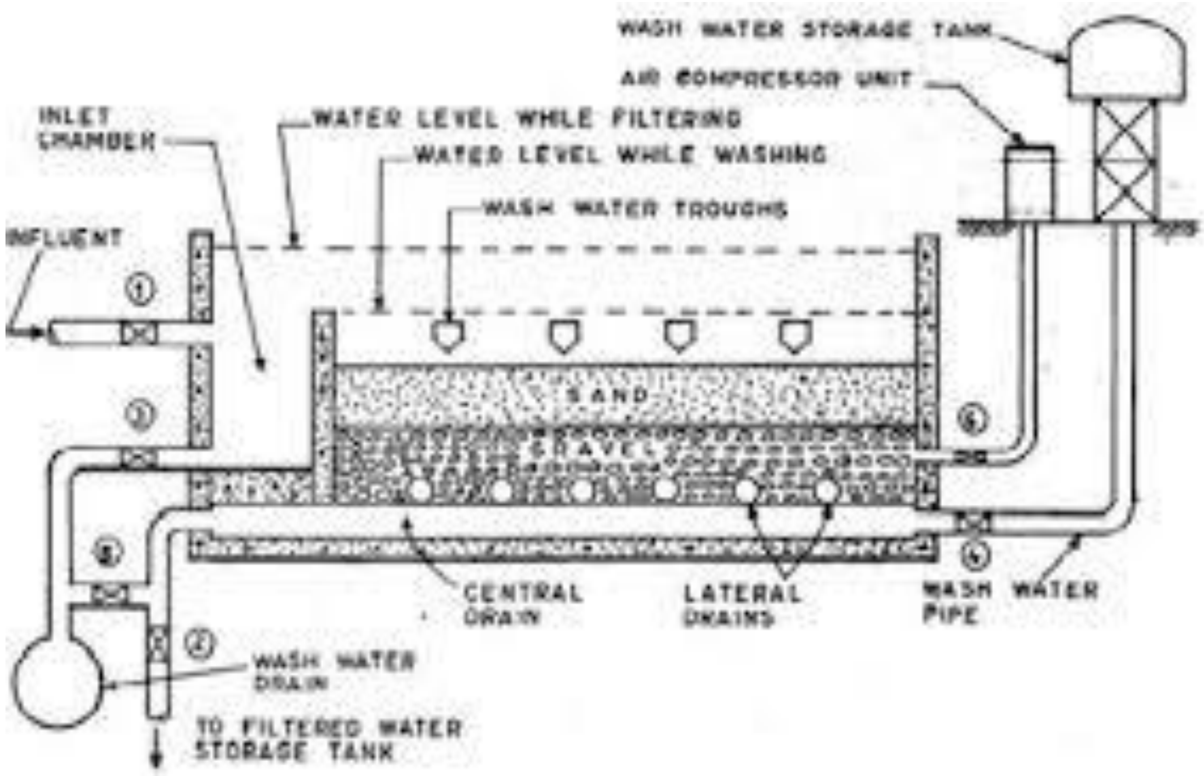
- ✓ Simplicity of design and high self-help compatibility, construction, operation and maintenance only require basic skills and knowledge and minimal effort.
- ✓ If constructed with gravity flow only, no (electrical) pumps required.
- ✓ Local materials can be used for construction.
- ✓ High reliability and ability to withstand fluctuations in water quality.
- ✓ No necessity for the application of chemicals.
- ✓ Easy to install in rural, semi-urban and remote areas, Simplicity of design and operation.
- ✓ Long lifespan (estimated >10 years).

Disadvantages:

- ✓ Very regular maintenance essential.
- ✓ Requirement of a large land area, large quantities of filter media and manual labour for cleaning, Low filtration rate.

Rapid Sand Filter:

- ➢ The rapid sand filter or rapid gravity filter is a type of filter used in water purification and is commonly used in municipal drinking water facilities as part of a multiple-stage treatment system.
- ➢ Rapid sand filters were first developed in the 1890s, and improved designs were developed by the 1920s.



Components of Rapid sand filter:

The major parts of a gravity rapid sand filter are:

- ✓ Filter tank or filter box,
- ✓ Filter media,
- ✓ Gravel support,
- ✓ Under drain system, and
- ✓ Wash water troughs.

Water Filter Tank:

- ✓ The filter tank is generally constructed of concrete and is most often rectangular.
- ✓ The sizes of the filters vary according to the quantity to be treated.
- ✓ The number of filters is selected to minimize the effect of removing the filter from service for washing on remaining filters.
- ✓ A minimum of four filters is desirable, although two to three filters may be used for small plants.
- ✓ Water treatment filter bed sizes vary from 25 to 100 m^2 with lengths in the range of 4 to 12 m and widths in the range of 2.5 to 8 m and length to breadth ratio of 1.25 to 1.33.
- ✓ The wash water collection channel is located on one side along the length of the filter.

- ✓ Filter beds of twice this size can be constructed as two identical beds separated by the wash water collection channel, thus limiting the length of travel of feed water to 5 m.
- ✓ A minimum overall depth of 2.6 m including a free board of 0.5 m is adopted.

Filter media:

- ✓ The filter media is the important component of the water treatments filter which actually removes the particles from the water being treated.
- ✓ Water Treatment filter media is most commonly sand, though other types of media can be used, usually in combination with sand.
- ✓ The sand used in rapid sand filters is coarser than the sand used in slow sand filters.
- ✓ This larger sand has larger pores which do not fill as quickly with particles removed from the water.
- ✓ Coarse sand also costs less and is more readily available than the finer sand used in slow sand filtration.
- ✓ The filter sand used in rapid sand filters is prepared from stock sand specifically for the purpose.
- ✓ Most rapid sand filters contain 60 to 75 cm thickness of sand, but some newer filters are deeper.
- ✓ The sand used as filter media in RSF is generally of effective size of 0.4 to 0.7 mm and uniformity coefficient of 1.3 to 1.7.
- ✓ The standing water depth over filter varies between 1.0 and 2.0 m.

Gravel support:

- ✓ The water filter gravel at the bottom of the water filter bed is not part of the filter media and it is merely providing a support for media above the underdrains and allowing an even distribution of flow of water across the filter bed during filtering and backwashing.
- ✓ The gravel also prevents the filter sand from being lost during the operation.
- ✓ The filter gravel is usually graded of size from 2.5 to 50 mm (largest size being at the bottom) in four to five layers to total thickness of 45 to 50 cm, depending on the type of under drain system used.
- ✓ In case the under-drainage system with porous bottom or false floor no gravel base is required.
- ✓ The filter gravel shall be classified by sieves into four or more size grades, sieves being placed with the coarsest on top and the finest at the bottom.

Under-drainage System:

- ✓ The under-drainage system of the water filter is intended to collect the filtered water and to distribute the wash water during backwashing in such a fashion that all portions of the bed may perform nearly the same amount of work and when washed receive nearly the same amount of cleaning.

- ✓ Since the rate of wash water flow is several times higher than the rate of filtration, the former is the governing factor in the hydraulic design of filters and under drainage system, which are cleaned by backwashing.

Wash water Troughs:

- ✓ Wash-water troughs placed above the filter media collect the backwash water and carry it to the drain system.
- ✓ Proper placement of these troughs is very important to ensure that the filter media is not carried into the troughs during the backwash operation and removed from the filter.
- ✓ The upper edge of the wash water trough should be placed sufficiently nearer to the surface of sand so that a large quantity of dirty water is not left above the filter sand after completion of washing.
- ✓ At the same time, the top of the wash-water trough should be placed sufficiently high above the surface of the sand so that the sand will not be washed into the gutter.
- ✓ Maximum clear spacing between the troughs may be 180 cm.
- ✓ The horizontal travel of wash-water to trough should not be more than 90 cm.
- ✓ These wash water troughs are constructed in concrete, plastic, fiberglass, or other corrosion-resistant materials. The troughs are designed as free-falling weirs.

PROBLEMS

1.Design five slow sand filter beds from the following data for the water works of a town of population 75,000,

per capita demand = 135 litres/day/capita,

Rate of filtration = 210 litres/hour/m^2

Assume maximum demand as 1.5 times the average demand. Out of 5 units, one is to be kept as stand by and used while repairing other units.

Solution:

Average demand of the town = 135 X 75000

$= 10.125 \times 10^6$ litres/day.

Maximum demand of the town = $1.5 \times 10.125 \times 10^6$ litres/day

$= 15.19 \times 10^6$ litres/day.

Rate of filtration = 210 X 24 litres/day/m^2

= 5040 litres/day/m^2

Total surface area of filters required,

$$= \frac{\text{Maximum daily demand}}{\text{Rate of filtration/day}}$$

$$= \frac{15.19 \text{ X } 10^6 \text{ litres/day}}{5040}$$

$= 3014 \text{ m}^2$.

But as out of five units only four units are to be used, therefore,

surface area of each unit, $= \frac{3014}{4}$

$= 753.5 \text{ m}^2$.

Keeping the length of the slow sand filter as 2.5 times its width,

$$2.5 \text{ B X B} = 753.5$$

$$\text{B} = \frac{753.5}{2.5}$$

B = 17.4 m.

L = 2.5 X B

= 2.5 X 17.4 = 43.5 m.

Size of each slow sand filter unit = 43.5 X 17.4 m.

2. Design set of three rapid gravity filters for treating the water at a water works, which has to supply the water to a town of population 1,00,000. Per capita demand of the town is 270 litres/day. The rate of filtration of the rapid gravity filters may be taken as 4500 litres/hour/m^2.

Solution:

Total quantity of water to be treated by the filters = 100000 X 270

$= 27 \text{ X } 10^6$ litres/day

$= \frac{27 \text{ X } 10^6}{24} = 11.25 \text{ X } 10^6$ litres/hour

Total area of filter bed required $= \frac{\text{Quantity of water treated}}{\text{Rate of filtration}}$

$= \frac{11.25 \text{ X } 10^6}{4500} = 250 \text{ m}^2$.

Area of each rapid gravity filter = 250 / 3 = 83.34 m^2.

Keeping the length of the filter 1.5 times its width,

L X B = 83.34

1.5 B X B = 83.34

1.5 B^2 = 83.34

B = 7.5 m.

L = 1.5 X B = 1.5 X 7.5

L = 11.25 m.

Size of each slow sand filter unit = 11.25 X 7.5 m.

3.Design a rapid sand gravity filter unit for treating 5.2 X 10^6 litres/day supply for a town. The filter is to work day and night. Take 4500 litres/hour/m^2 as the rate of filtration.

Solution:

Let half an hour be lost in washing, draining and returning to the service after 24 hours. Therefore, total time will be 23.5 hours. for which filters will work. Now allowing 4 % as the allowance for washing the filter.

Quantity of water to be treated per hour $= \frac{5.2 \text{ X } 10^6}{23.5}$ litres.

Filter area required $= \frac{5.2 \text{ X } 10^6}{23.5 \text{ X } 4500} = 49.19 \text{ m}^2$ Say 49.2 m^2

Providing two units, area of each filter = 24.6 m^2 .

Therefore, provide three units of 7 m X 3.5 m.

Two units of filter will always work.

Third is required during repair work of any one of the others, which can also be used during emergency.

DISINFECTION:

- Disinfection is the process, which involves the elimination of most pathogenic microorganisms (excluding bacterial spores) on inanimate objects.
- Chemicals used in disinfection are called disinfectants.
- Disinfection is the reduction in the number of bacteria, viruses, or fungi to a desired concentration.

Importance of disinfection:

- To minimize number of organisms in the population worldwide.

- The method of disinfection is used internationally for the safety of humans, to decrease the scale of transmission of diseases.

Requirements of Good Disinfectants:

- ✓ They should destroy all the harmful pathogenic organisms from the water and make it perfectly safe for use.
- ✓ They should not take more time in killing pathogens, but do their task within the required time at normal temperature.
- ✓ They should be economical and easily available.
- ✓ They should not require high skill and costly requirement for their application.
- ✓ After their treatment, the water should not become toxic and objectionable to the user.

Methods of Disinfection:

- By Boiling the water
- By ultra violet rays
- By the use of iodine and bromine
- By the use of ozone
- By the use of excess of lime
- By using potassium permanganate
- By treatment with silver.

By Boiling The Water:

- ✓ The water can be disinfected by boiling for 15 to 20 minutes.
- ✓ By boiling water all the disease-causing bacteria are killed and the water becomes for use.

By Ultra Violet Rays:

- ✓ Ultra violet rays are invisible light rays having wave lengths of 1000 to 4000 m.
- ✓ Sun rays also have ultra violet rays which can also be utilized in the disinfection of water.

By the use of Iodine and Bromine:

- ✓ It has been seen that addition of iodine and bromine in the water kills all the pathogenic bacteria.
- ✓ The quantity of iodine and bromine should not exceed 8 ppm and they can kill bacteria in minimum contact period of 5 minutes.

By the use of Ozone:

- ✓ Ozone is an excellent disinfectant.
- ✓ It is used in gaseous form, which is faintly blue in colour of pungent odour.

By the use of excess of lime:

- ✓ Lime is usually used at the water works for reducing the hardness of water.

By using potassium permanganate:

- ✓ This is the most common disinfectant used in the village for disinfection of dug well water, pond water or private source of water.
- ✓ In addition to the killing of bacteria it also reduces the organic matters by oxidising them.

By treatment with silver:

- ✓ This is a very costly method of disinfection, hence not used at the water works.
- ✓ In this method the metallic silver ions are introduced into the water by passing it through solid silver electrodes tubes and passing the current through 1,5 V D.C. battery.

WATER SOFTENING:

- ➢ The removal or reduction of hardness from the water is known as water softening.
- ➢ From health point of view, it is necessary at all times to remove the hardness from the water.
- ➢ Water softening is a process in which the ions of calcium, magnesium and sometimes iron are removed.
- ➢ By doing this, the water softening removes the offending minerals from the water.
- ➢ The resulting soft water requires less soap for the same cleaning effort, as soap is not wasted bonding with calcium ions.
- ➢ Hard water contains significant amounts of calcium and magnesium ions, which can clog pipes and complicate the dissolving of soap and detergent in water.
- ➢ It requires more consumption of soap in producing lather and washing of clothes with hard water than soft water.
- ➢ The main advantage is reduction in the consumption of soap.
- ➢ In industries hard water also causes various types of troubles and difficulties in the industrial processing.
- ➢ The hard water forms scale in the boiler and it requires more quantity of fuel for the production of steam.
- ➢ The hard water also greatly interferes with the dyeing works.

Description	Hardness range (mg/L as CaCO3)
Soft	**0 - 75**
Moderately hard	**75 - 100**
Hard	**100 - 300**
Very hard	**> 300**

CARBONATE HARDNESS is because of presence of

HCO_3^- and CO_3^{2-} of Ca^{2+} and Mg^{2+} ;

Carbonate hardness is also known as temporary hardness as it can be removed by boiling.

NON-CARBONATE HARDNESS is associated with

Cl^- and SO_4^{2-} of Ca^{2+} and Mg^{2+}

And is often termed as Permanent Hardness.

Types of hardness:

Total Hardness = Ca^{2+} hardness+ Mg^{2+}hardness

1.Temporary Hardness:

- Hardness of water due to the presence of soluble bicarbonates of calcium and Magnesium is called temporary hardness.
- When water containing dissolved carbon-dioxide passes over solid carbonates (chalk or limestone deposits etc.), these compounds get dissolved in water.

- ✓ Rainwater and distilled water are always soft because they do not have dissolved (soluble) salts.

2.Permanent Hardness:

- ✓ This is due to the presence of chlorides and sulphates of calcium and magnesium.
- ✓ Such a hardness can be removed by the addition of washing soda.
- ✓ This removes both the temporary and the permanent hardness of water.

METHODS OF SOFTENING OF WATER:

Removal of Temporary Hardness:

- ✓ Temporary hardness is removed in the following ways:
- ✓ By boiling the water: On boiling, the soluble bicarbonate is decomposed into insoluble carbonate.
- ✓ Chemical methods: -By adding slaked lime [$Ca\ (OH)_2$] to hard water, insoluble carbonates are formed.

Removal of Permanent Hardness:

- ✓ Removal of permanent hardness from the water is difficult and requires special methods and equipment for its removal.
- ✓ Following are the methods:
- ▪ Lime soda Process
- ▪ Base Exchange Process
- ▪ Demineralization Process

Lime Soda Process:

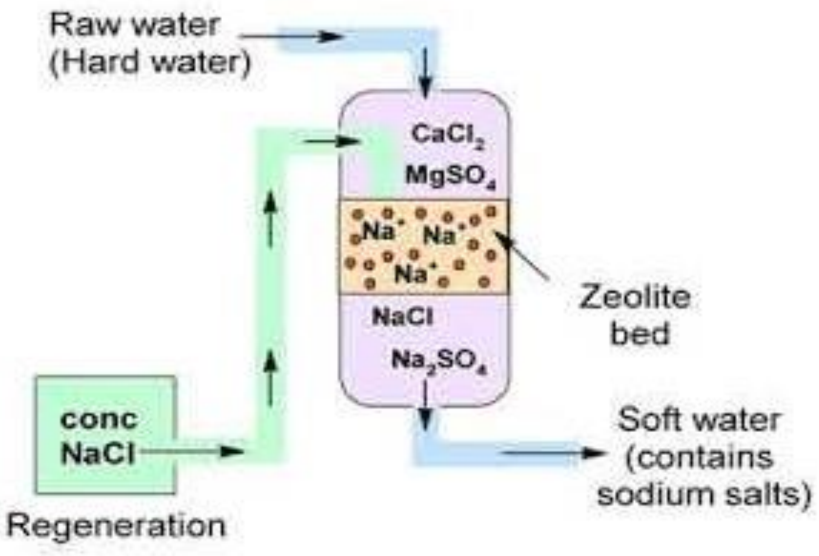
- ✓ If water contains sulphates of calcium and magnesium, simply addition of lime cannot remove the hardness.
- ✓ But if soda ash is added in lime, the non-carbonate hardness can be easily removed.
- ✓ This method is known as Lime Soda process.
- ✓ Chemical precipitation is one of the more common methods used to soften water.
- ✓ Chemicals normally used are lime (calcium hydroxide, Ca (OH)2) and soda ash (sodium carbonate, Na2CO3).
- ✓ When lime and soda ash are added, hardness-causing minerals form nearly insoluble precipitates.
- ✓ Calcium hardness is precipitated as calcium carbonate ($CaCO_3$). Magnesium hardness is precipitated as magnesium hydroxide ($Mg\ (OH)_2$).

- ✓ These precipitates are then removed by conventional processes of coagulation/flocculation, sedimentation, and filtration.
- ✓ Because precipitates are very slightly soluble, some hardness remains in the water--usually about 50 to 85 mg/l (as $CaCO_3$).

BASE EXCHANGE or ZEOLITE PROCESS:

- Ion-exchange is used extensively in small water systems and individual homes.
- Ion-exchange resin, (zeolite) exchanges one ion from the water being treated for another ion that is in the resin (sodium is one component of softening salt, with chlorine being the other). Zeolite resin exchanges sodium for calcium and magnesium.
- The following chemical reactions show the exchange process, where X represents zeolite, the exchange material.
- Removal of carbonate hardness:
    - $Ca(HCO_3)_2 + Na_2X$ ------> $CaX + 2NaHCO_3$
    - $Mg(HCO_3)_2 + Na_2X$ ------> $MgX + 2NaHCO_3$
- Removal of non-carbonate hardness:
    - $CaSO_4 + Na_2X$ ----- > $CaX + Na2SO_4$
    - $CaCl_2 + Na_2X$ ------> $CaX + CaCl_2$
    - $MgSO_4 + Na_2X$ ------> $MgX + Na_2SO_4$

$MgCl_2 + Na_2X$ ------> MgX + 2NaC1



Merits of zeolite process:

- ✓ It removes the hardness almost completely (about 10 ppm hardness only).
- ✓ The process automatically adjust itself for variation in hardness of incoming water.
- ✓ This process does not involve any type of precipitation; thus, no problem of sludge formation occurs.

Demerits of zeolite process:

- ✓ The outgoing water (treated water) contains more sodium salts.
- ✓ This method only replaces Ca^{+2} and Mg^{+2} ions by Na^{+} ions.
- ✓ High turbidity water cannot be softened efficiently by zeolite process.

DEMINERALISATION PROCESS:

- ➢ Demineralisation process involves removal of minerals by means of Ion Exchange Resins.
- ➢ Demineralization of water is achieved by passing water through Cation Resin Column and then though Anion Resin Column.
- ➢ When minerals, which are salts of acid and base, dissolve in water, they get ionized in to Cations and Anions.
- ➢ Demineralized Water is Water completely free (or almost) of dissolved minerals as a result of one of the following processes:
- ✓ Distillation

- ✓ Deionization
- ✓ Membrane filtration (reverse osmosis or nanofiltration)
- ✓ Electrodialysis
- ✓ Demineralized Water also known as Deionized Water; Water that has had its mineral ions removed.
- ✓ Mineral ions such as cations of sodium, calcium, iron, copper, etc and anions such as chloride, sulphate, nitrate, etc are common ions present in Water.

DESALINATION:

- ➢ Desalination is a process that takes away mineral components from saline water.
- ➢ More generally, desalination refers to the removal of salts and minerals from a target substance, as in soil desalination, which is an issue for agriculture.
- ➢ Desalination is a technique where the excess salts are removed from sea water or brackish water converting it into safe potable or usable water.

DEFLUORIDATION:

- ➢ Defluoridation is the downward adjustment of the level of fluoride in drinking water.
- ➢ Worldwide, fluoride is one of the most abundant anions present in groundwater.
- ➢ Fluoride is more present in groundwater than surface water mainly due to the leaching of minerals.

IRON AND MANGANESE REMOVAL:

- ➢ When combined levels of iron and manganese exceed 10 mg/L, the most effective treatment involves oxidation followed by filtration.
- ➢ In this process, a chemical is added to convert any dissolved iron and manganese into the solid, oxidized forms that can then be easily filtered from the water.
- ➢ Iron and manganese control is the most common type of municipal water treatment.
- ➢ Iron and manganese occur naturally in groundwater.
- ➢ Water containing excessive amounts of iron and manganese can stain clothes, discolor plumbing fixtures, and sometimes add a “rusty” taste and look to the water.
- ➢ Surface water generally does not contain large amounts of iron or manganese, but iron and manganese are found frequently in water systems that use groundwater.
- ➢ The Safe Drinking Water Act secondary standards for iron in drinking water is 0.3 parts per million (ppm) and 0.05 ppm for manganese.
- ➢ If water contains more than 0.05 ppm iron, or 0.01 ppm manganese, the operator should implement an effective hydrant-flushing program in order to avoid customer complaints.

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – V – DISTRIBUTION SYSTEM – SCIA1403

INTRODUCTION

GENERAL REQUIREMENTS OF GOOD DISTRIBUTION SYSTEM:

- The objective of Water distribution system is to deliver water to individual consumers with appropriate quality, quantity and pressure.
- The distribution system describes collectively the facilities used to supply water from its source to the point of usage.
- The water should reach every consumer with the required pressure head.
- This may include extensive system of pipes, storage reservoirs, pumps and related appurtenances.
- The quality of the pipes laid should be good and it should not burst.
- The proper functioning of a water distribution system is critical to providing sufficient drinking water to consumers as well as providing sufficient water for fire protection
- Distribution system should be economical and easy to maintain and operate.
- For efficient distribution system adequate water pressure required at various points.
- It should be water tight and the water losses due to leakage should be minimum as far as possible.

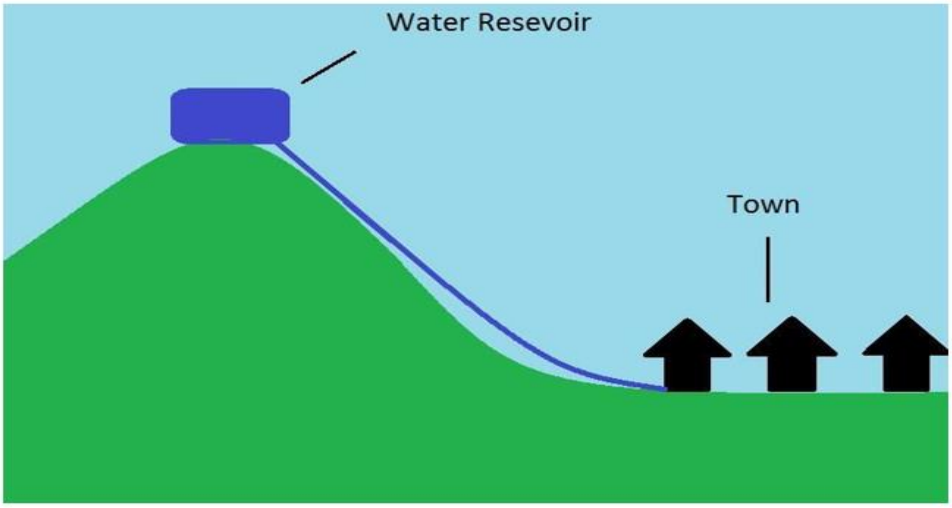
METHOD OF DISTRIBUTION SYSTEM:

- Gravity system
- Pumping system
- Combined gravity and pumping system

Gravity system:

- When some ground, sufficiently high above the city area, is available, this can be best utilized for the distribution system in maintaining pressure in water pipes.
- This method is suitable when source of water supply such as lake, river or impounding reservoir is at sufficient height than city.
- The water flows in the mains due to gravitational force.
- As no pumping is required, therefore it is the most reliable system for the water distribution.
- Most reliable and economical distribution system.

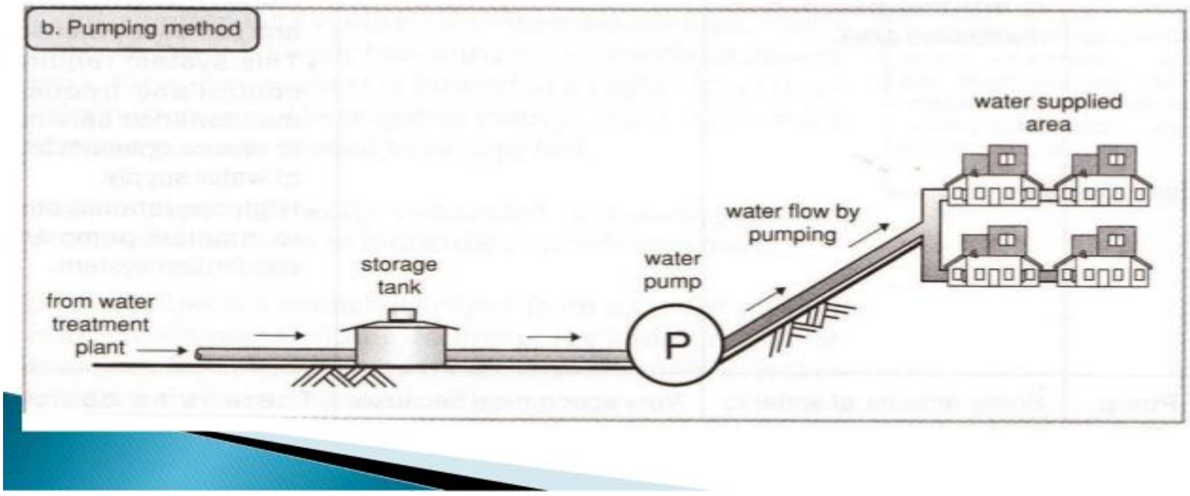
- The water head available at the consumer is just minimum required.
- The remaining head is consumed in the frictional and other losses.
- But in this case, the water will have to be pumped during fires.



Pumping system:

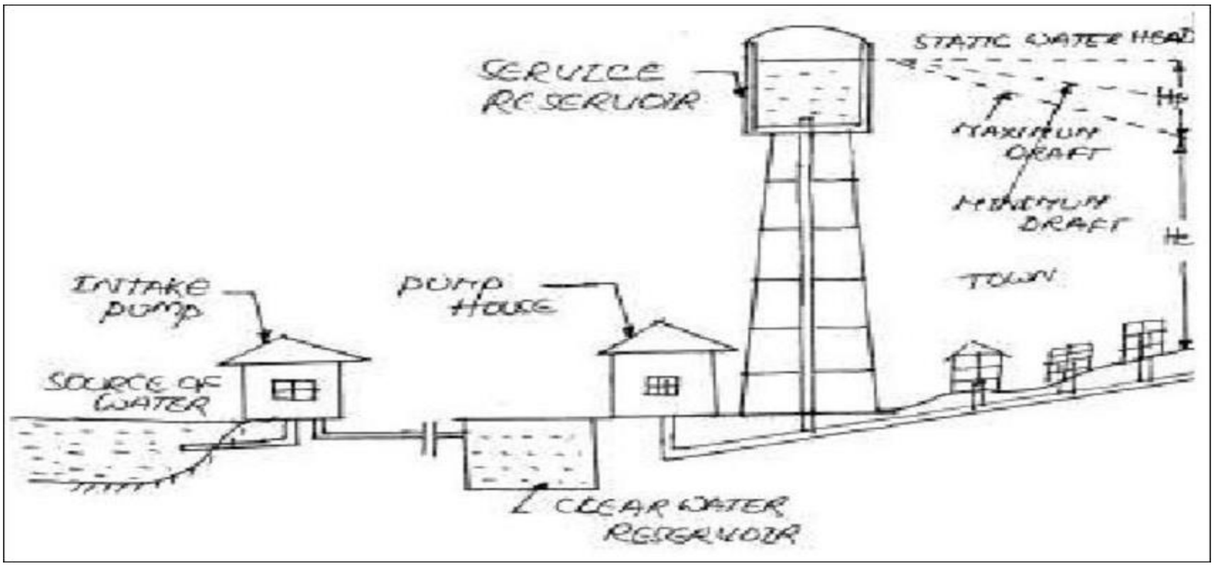
- Treated water is directly pumped in to the distribution main with out storing.
- Also called pumping without storage system.
- If power supply fails, complete stoppage of water supply.
- This method is not generally used.
- During fires, the water can be pumped in the required quantity by the stand by units also.
- High lift pumps are required and their operations are continuously watched.

PUMP SYSTEM



Combined gravity and pumping system:

- It is most commonly used system.
- Treated water is pumped and stored in an elevated distribution reservoir.
- Then supplies to consumer by action of gravity.
- The excess water during low demand periods get stored in reservoir and get supplied during high demand period.
- As in this system water comes from two sources one from reservoir and second from pumping station, it is called dual system.
- Economical, efficient and reliable system.



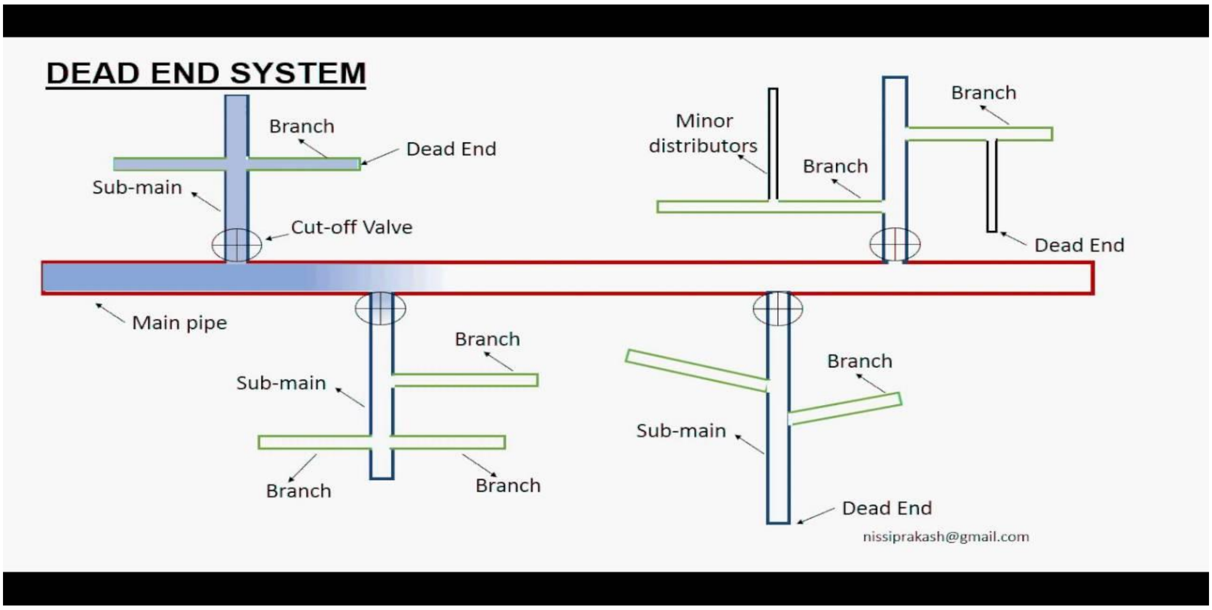
LAYOUTS OF DISTRIBUTION SYSTEM:

- The distribution pipes are generally laid below the road pavements, and as such their layouts generally follow the layouts of roads.
- There are, in general, four different types of pipe networks; any one of which either singly or in combinations, can be used for a particular place.
- They are classified as follows:
  - ✓ Dead End System
  - ✓ Radial System
  - ✓ Grid Iron System
  - ✓ Ring System

DEAD END SYSTEM or TREE SYSTEM:

- It is suitable for irregular developed towns or cities.
- In this system one main starts from service reservoir along the main road.
- Sub-mains are connected to the main in both the directions along other roads.
- In streets, lanes and other small roads which meet the roads carrying sub-mains, branches and minor distributors are laid and are connected to mains.

- From these branches, service connections are made to individual houses.



Advantages:

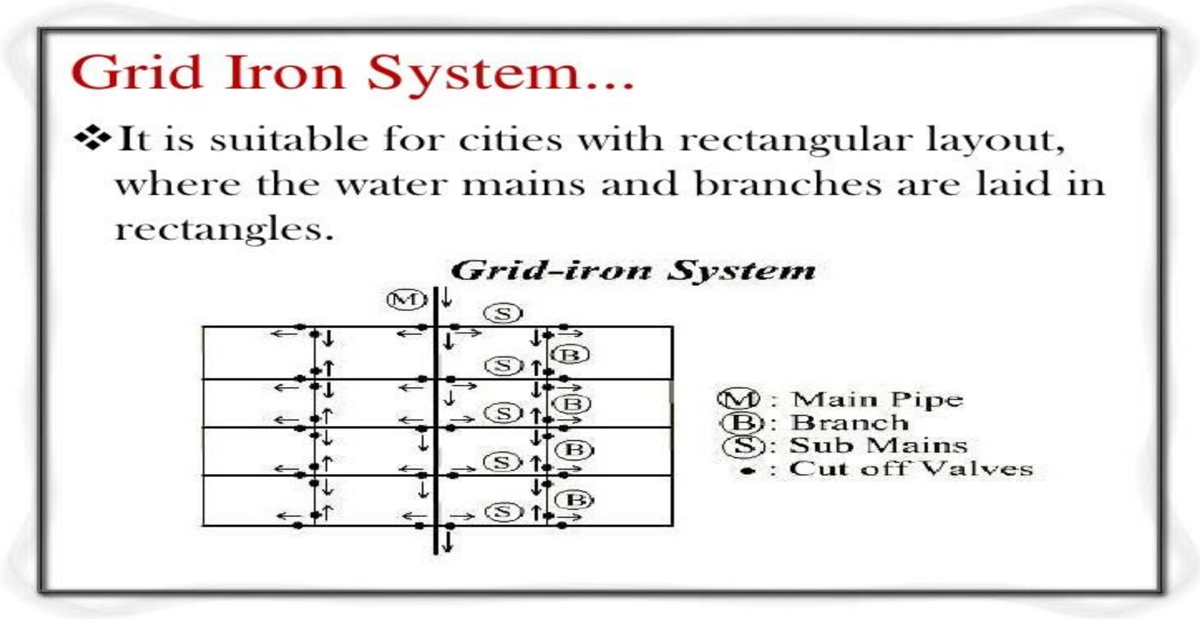
- ✓ Relatively cheap.
- ✓ Determination of discharges and pressure easier due to less number of valves.

Disadvantages:

- ✓ Due to many dead ends, stagnation of water occurs in pipes.
- ✓ If pipe breaks down or is closed for repair, the whole locality
- ✓ beyond the point goes without water.

GRID IRON SYSTEM:

- This system is also known as reticulated system.
- It is suitable for cities with rectangular layout, where the water mains and branches are laid in rectangles.
- Main line is laid along the main road.
- Sub mains are taken in both directions along other minor roads and streets.
- From these sub mains branches are taken out and are inter connected.
- It is an improvement over dead-end system. All the dead ends are interconnected with each other and water circulates freely through out the system.



Advantages:

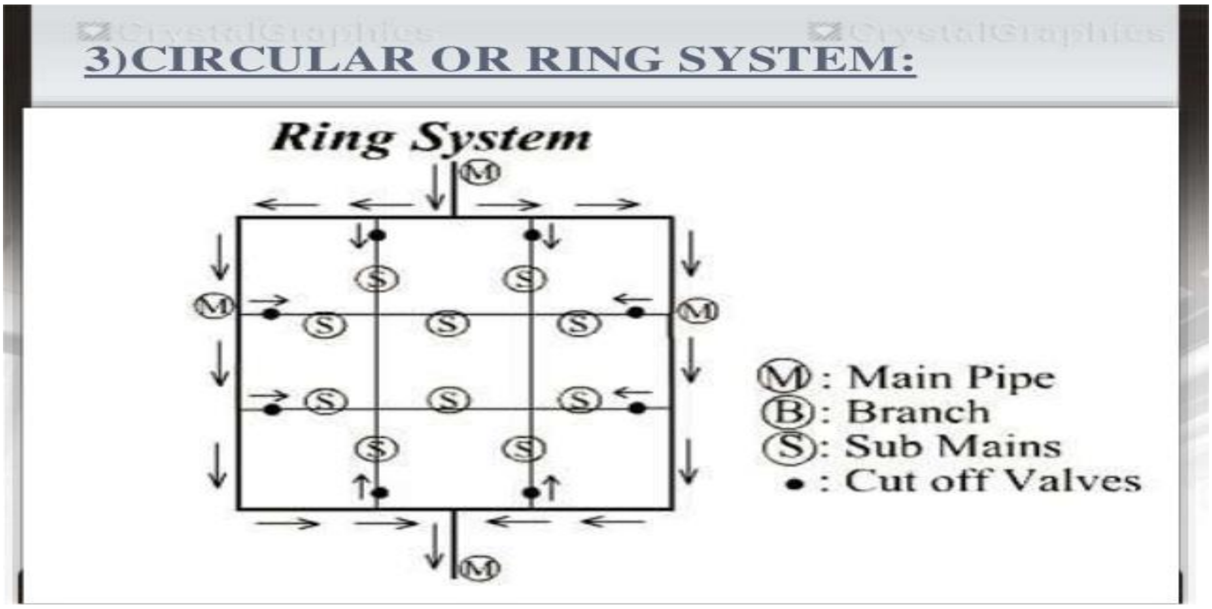
- ✓ Water is kept in good circulation due to the absence of dead ends.
- ✓ In the cases of a breakdown in some section, water is available from some other direction.
- ✓ In case of fire, more quantity of water diverted towards the affected area by closing the valves of nearby localities.

Disadvantages:

- ✓ Exact calculation of sizes of pipes is not possible due to provision of valves on all branches.
- ✓ More number of valves and longer length of pipe is required in this system, thereby increase in the overall cost.

CIRCULAR OR RING SYSTEM:

- ➢ The supply main is laid all along the peripheral roads and sub mains branch out from the mains.
- ➢ This system also follows the grid iron system with the flow
- ➢ pattern similar in character to that of dead end system.
- ➢ So, determination of the size of pipes is easy.



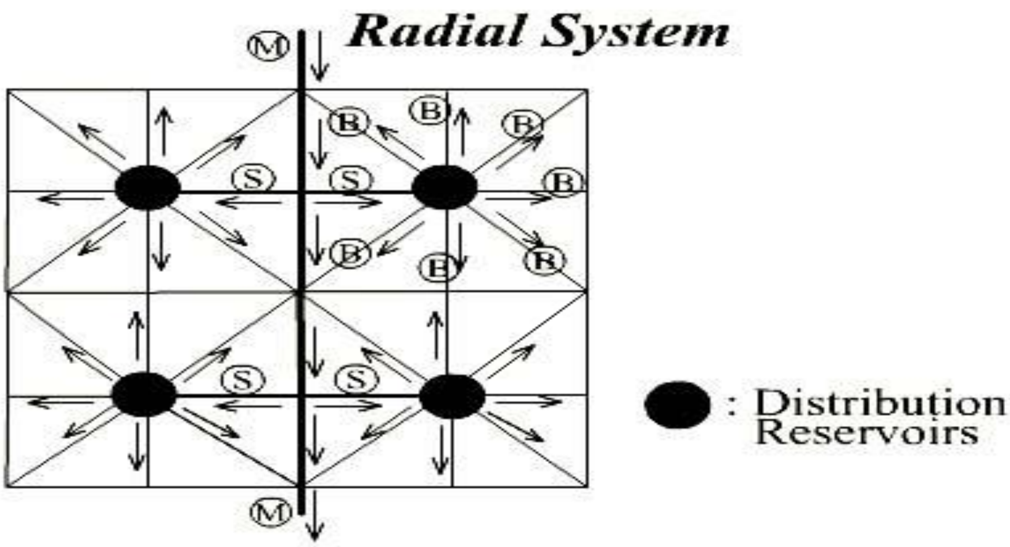
RADIAL SYSTEM:

- The area is divided into different zones.
- The water is pumped into the distribution reservoir kept in the middle of each zone.
- The supply pipes are laid radially ending towards the periphery.

Advantages:

It gives quick service.

Calculation of pipe sizes is easy.



STORAGE AND DISTRIBUTION RESERVOIRS:

- Distribution reservoirs, also called service reservoirs, are the storage reservoirs, which store the treated water for supplying water during emergencies (such as during fires, repairs, etc.) and also to help in absorbing the hourly fluctuations in the normal water demand.

Functions of distribution reservoirs:

to absorb the hourly variations in demand.

to maintain constant pressure in the distribution mains.

water stored can be supplied during emergencies.

Location and height of distribution reservoirs:

should be located as close as possible to the centre of demand.

Water level in the reservoir must be at a sufficient elevation to permit gravity flow at an adequate pressure.

Types of Reservoirs:

- Depending upon their elevation with respect to ground it may be classified into:
  - ✓ Surface reservoirs
  - ✓ Elevated reservoirs
- Depending upon their material of construction it may be classified into
  - ✓ Steel Reservoir
  - ✓ R.C.C
  - ✓ Masonry

Surface Reservoir:

- These also called ground reservoir.
- Mostly circular or rectangular tank.
- Underground reservoirs are preferred especially when the size is large.
- These reservoirs are constructed on high natural grounds and are usually made of stones, bricks, plain or reinforced cement concrete.
- The side walls are designed to take up the pressure of the water, when the reservoir is full and the earth pressure when it is empty.

Earthern Reservoirs:

- When large quantity of water is to be stored before the treatment, usually earth reservoirs are provided because these are the cheapest.
- These reservoirs are excavated to the required depth below the ground surface and using the excavated material for the building of embankments to the necessary height above the ground.
- To make earthen reservoirs impermeable, core walls are constructed.
- The embankments should have minimum top width of 1.3 m or one fourth of the total height.
- As far as possible, greater top width should be used.
- The side slopes should not be steeper than 1 1/2 horizontal to 1 vertical.
- The embankments should be keyed down to the bottom by removing roots, loose soil and permeable material.
- To prevent the leakage and loss of water, the sides and bottom of the reservoirs should be properly lined with bricks, stones, asphalts or concrete etc.
- Outlet pipes should be provided in the embankments walls at various places to minimize the seepage of water.

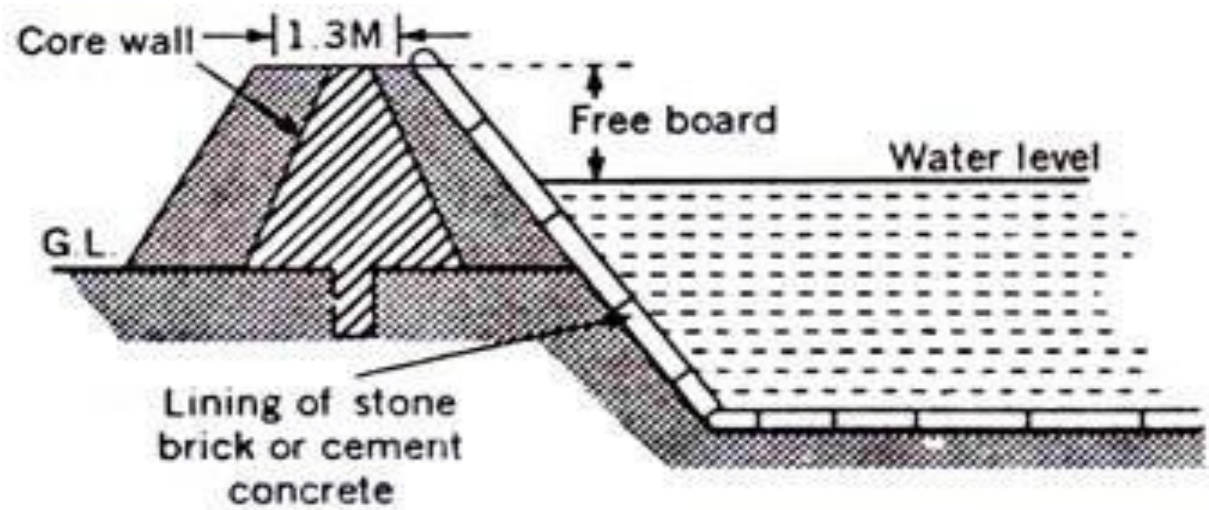


Fig. 18.11. Earthen Reservoir.

Elevated Storage Reservoirs:

- Elevated Storage Reservoirs (ESRs) also referred to as Overhead Tanks are required at distribution areas which are not governed and controlled by the gravity system of distribution.
- These are rectangular, circular or elliptical in shape.
- If the topography of the town not suitable for under gravity, the elevated tank or reservoir are used.
- They are constructed where combine gravity and pumping system of water distribution is adopted.
- These tanks may be steel or RCC.
- Now RCC is commonly preferred.

The accessories of ESR are:

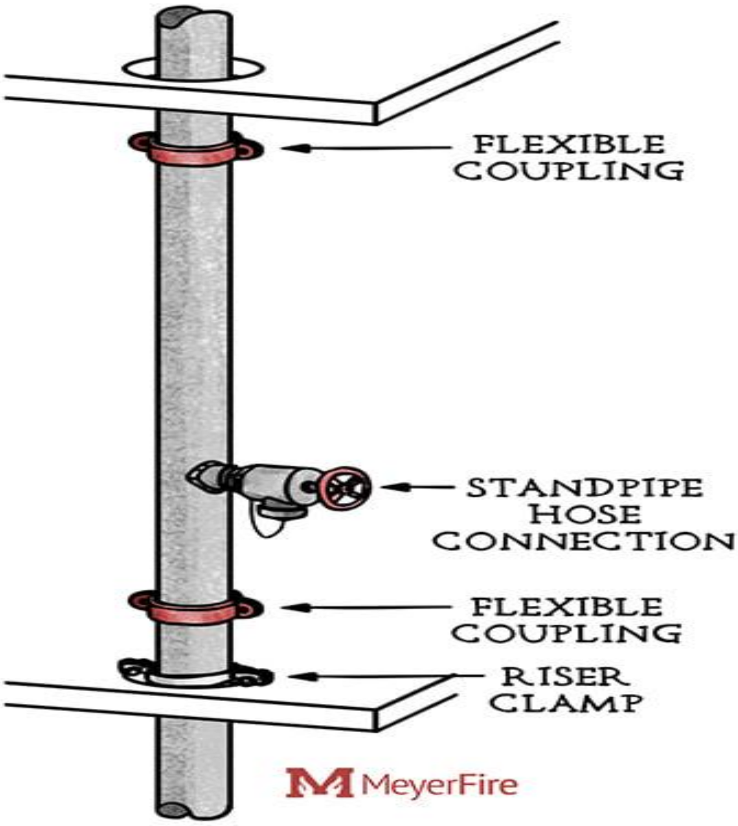
- ✓ Inlet and outlet pipe, overflow pipe discharging into a drain
- ✓ Float gauge, indicating depth of water.
- ✓ Automatic device to stop pumping when the tank is full.
- ✓ A manhole and ladder.
- ✓ Ventilator for circulation of fresh air.

Types of Elevated Reservoirs:

- ✓ Stand pipes
- ✓ Elevated Tanks

Stand Pipes:

- ➢ These are usually made of steel and are circular in plan.
- ➢ The useful storage capacity of these are the volume of tank above the elevation of the high point of distribution.
- ➢ Water in tank below this point serves as additional storage for low distribution area which can be used with booster pumps or for firefighting where fire pumping engines are used.
- ➢ Manhole is provided at the top with ladder for inspection and repair work.



Types of Elevated Tanks:

- R.C.C. TANKS:
- R.C.C tanks are very popular because
  - ✓ They have long life
  - ✓ Very little maintenance
  - ✓ decent appearance
  - ✓ G.I.TANKS:
  - G.I. tanks are generally in rectangular or square in shape. Now a days G.I. tanks are not preferring because
    - ✓ Life of the tank is less
    - ✓ Corrosion of metal
    - ✓ maintenance cost may be more.
- HDPE TANKS:
- ✓ Now a days HDPE tanks are very popular for storing less quantity of water and hence useful for residential purpose.

- ✓ The following are the advantages of HDPE tanks
- ✓ Handling is easy because of light weight
- ✓ Cheap in cost
- ✓ Maintenance cost is low
- ✓ Cleaning of tanks are easy.

Storage Capacity of Distribution Reservoirs:

The total storage capacity of a distribution reservoir is the summation of:

BALANCING STORAGE:

The quantity of water required to be stored in the reservoir for equalizing or balancing fluctuating demand against constant supply is known as the balancing storage (or equalizing or operating storage).

BREAKDOWN STORAGE:

The breakdown storage or often called emergency storage is the storage preserved in order to tide over the emergencies posed by the failure of pumps, electricity, or any other mechanism driving the pumps.

A value of about 25% of the total storage capacity of reservoirs, or 1.5 to 2 times of the average hourly supply, may be considered as enough provision for accounting this storage.

FIRE STORAGE:

The third component of the total reservoir storage is the fire storage.

This provision takes care of the requirements of water for extinguishing fires.

A provision of 1 to 4 per person per day is sufficient to meet the requirement.

When reserve storage is elevated, amount of fire reserve may be determined by, R= (F-P) T

- R= Reserve storage (liters) F= Fire demand, liters/min
- P= Reserve fire pumping capacity, liters/min
- T= Duration of the fire in min.

The total reservoir storage can finally be worked out by adding all the three storages.

VALVES AND FITTINGS:

- ➢ Valves are used throughout the distribution system.
- ➢ Valves are used to isolate equipment, buildings, and other areas of the water system for repair as well as to control the direction and rate of flow.

- They are used to drain the system for seasonal shutdown.

Types of Valves:

- ✓ Gate or Sluice Valve
- ✓ Check or reflux or Non return Valve
- ✓ Pressure Relief Valve
- ✓ Air Relief Valve
- ✓ Drain or Scour or Blow off Valve

Gate or Sluice Valve:

- ✓ A gate valve, also known as a sluice valve, is a valve that opens by lifting a barrier (gate) out of the path of the fluid.
- ✓ Gate valves require very little space along the pipe axis and hardly restrict the flow of fluid when the gate is fully opened.
- ✓ Sluice Valve and/or Gate Valve functions strictly to either start or stop the flow.

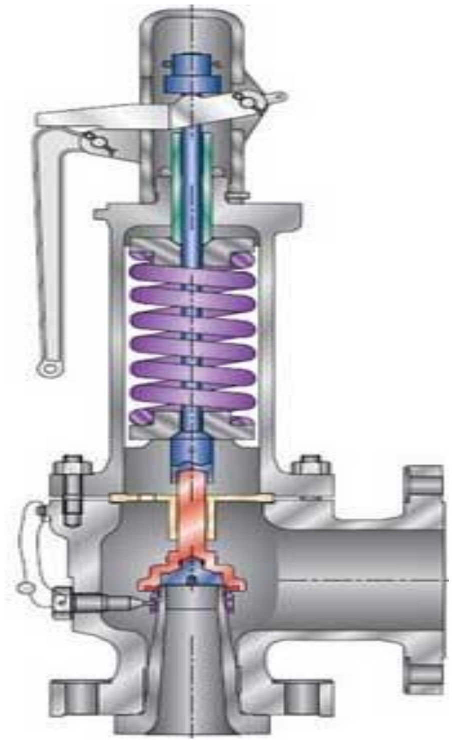
Check or Reflux or Non-Return Valve:

- ✓ Reflux valve is commonly known as Check valve and Non-Return Valve (NRV).
- ✓ Water tends to flow from higher pressure to lower pressure.
- ✓ Mains pressure is kept higher to suffice water distribution in a house.

- ✓ These valves are very useful in preventing back flow of water to the pump.

Pressure Relief Valve:

- ✓ A relief valve or pressure relief valve (PRV) is a type of safety valve used to control or limit the pressure in a system.
- ✓ A pressure Relief Valve is a safety device designed to protect a pressurized vessel or system during an overpressure event.



Air Relief Valve:

- ✓ Air Release Valves, or Air Relief Valve function to release air pockets that collect at each high point of a full pressured pipeline.
- ✓ An air release valve can open against internal pressure, because the internal lever mechanism multiplies the float force to be greater than the internal pressure.

➢ 

Drain or Scour or Blow Off Valve:

- ✓ Drain Valve is also called as Blow –off Valve and Scour Valve.
- ✓ These are ordinary valves but used for a specific purpose of scouring or emptying or cleaning the main and water storage tank.
- ✓ Scour valve or blow off or drain valve are provided at the dead-end of the pipeline function to remove the sand silt, etc from pipeline.

ANALYSIS OF COMPLEX NETWORKS:

- ➢ In distribution system for any closed network of pipes, the following conditions must be fulfilled.
- ➢ The entering flow must be equal to the leaving flow. ie. Law of continuity must be satisfied.
- ➢ The algebraic sum of the pressure drops around a closed loop must be zero.
- ➢ There are various methods for the analysis of flow in a pipe network.
    - ✓ Circle method
    - ✓ Equivalent method

- ✓ Electrical Analogy method
- ✓ Hardy cross method.

PROBLEMS

1. Design a pipe section AB as a part of distribution network with the data given below.

Length of pipe section AB = 900 m

Piezometric reading of pressure at A = 10 m

Piezometric reading of pressure at A = 8 m

C = 100

Q = 2 MLD

Solution:

Using Hazen William's formula,

$V = 0.85 \text{ X } C \text{ X } m^{0.63} \text{ X } i^{0.54}$

$Q / \pi d^2/4 = 0.85 \text{ X } C \text{ X } (d/4)^{0.63} \text{ X } (h_f/L)^{0.54}$

$h_f = h_1 - h_2 = 10 - 8 = 2$

$h_f/L = 2/900 = 1/450$

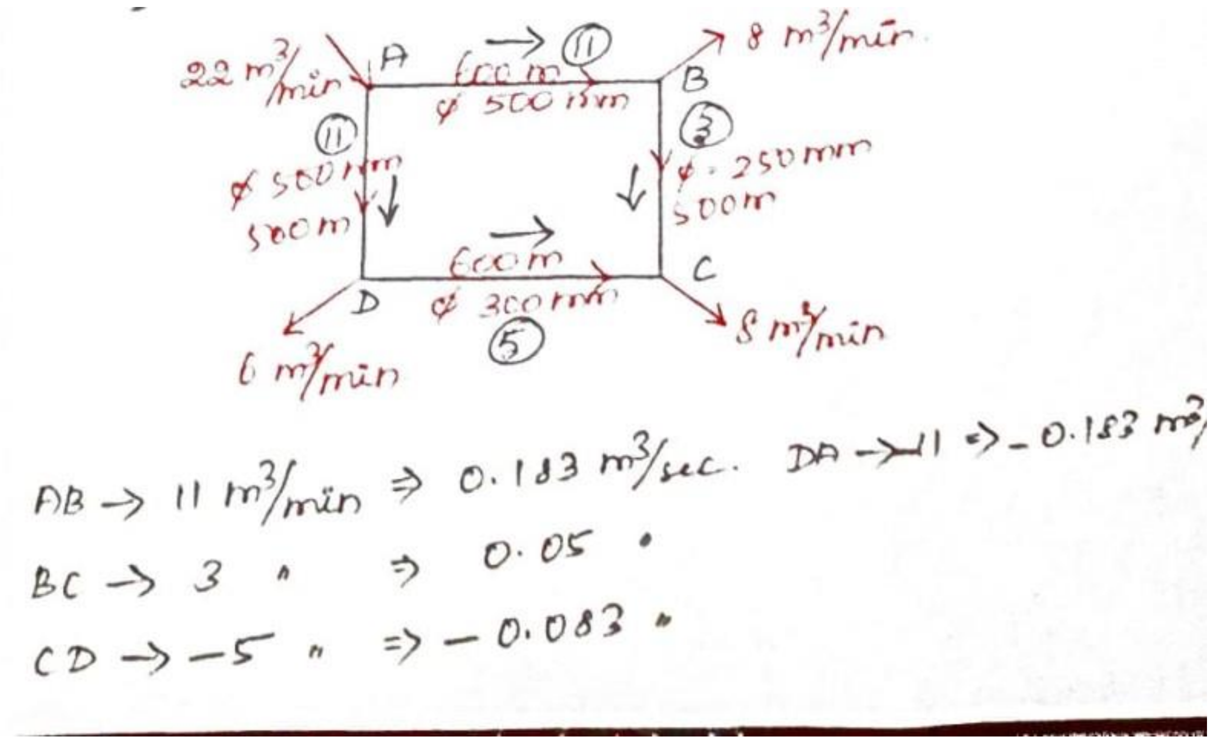
$0.023 / \pi d^2/4 = 0.85 \text{ X } 100 \text{ X } (d/4)^{0.63} \text{ X } (1/450)^{0.54}$

d = 233 mm or 230 mm.

Equivalent Pipe Method:

For the purpose of analysis, entire network of pipes is considered to be

- ✓ Pipes in series (Assume Discharge)
- ✓ Pipes in parallel (Assume Head Loss)



PIPE	L (m)	d	Q_a or Q (m/s)	$d^{4.87}$	K = L/470 $d^{4.87}$	H or H_L = K $Q_a^{1.85}$	H_L/Q_a
AB	600	0.5	0.183	0.034		1.62	8.85
BC	500	0.25	0.05	0.0011	910.03	3.56	71.2
CD	600	0.3	-0.083	0.0028	449.5	-4.49	54.09
DA	500	0.5	-0.183	0.034	31.28	-1.35	7.37

$$q = \frac{-H}{1.85\, H/Q_a}$$

$$= \frac{-(-0.66)}{1.85 \times 141.51}$$

$= 0.00252\ m^3/sec$ or $0.003\ m^3/sec$

Hence Corrected flow rates are :

Q in AB = 0.183 + 0.003 = 0.186 m^3/sec

Q in BC = 0.05 + 0.003 = 0.053 m^3/sec

Q in CD = - 0.083 + 0.003 = - 0.08 m^3/sec

Q in DA = - 0.183 + 0.003 = - 0.18 m^3/sec.

GRAPHICAL METHOD:

Using Nomograph,

PIPE	L (m)	D (mm)	Q or Q_a l/s	S	H or H_L = S X L	H_L / Q_a
AB	600	500	183	0.0025	1.5	0.008
BC	500	250	50	0.007	3.5	0.07
CD	600	300	-83	0.0072	-4.32	0.052
DA	500	500	-183	.0025	-1.25	0.006

$$q = \frac{H}{1.85\ H/Q} = \frac{-(-0.57)}{1.85 \times 0.137} = 2.24 \text{ l/s.}$$

Hence corrected flow rates are,

Q in AB = 183 + 2.24 = 185.24 l/s

Q in BC = 50 + 2.24 = 52.24 l/s

Q in CD = -83 + 2.24 = -80.76 l/s

Q in DA = -183 + 2.24 = -180.76 l/s.