UNIT 4

WATER SUPPLY ENGINEERING

"Water is life, and clean water means health."

Audrey Hepburn

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Learning Objectives

At the end of this lesson you shall be able to

- Understand the objectives and planning of water supply schemes
- Know the various sources of water
- Understand the quality of water
- Explain the different stages of treatment of water
- Understand the necessity of disinfection of water
- State the purpose of water softening
- Explain the distribution system of water

4.1 Introduction

The essential elements for the existence of human beings are air, water, food, shelter, clothing, etc. Out of the above, water is the second element. Water is required for the satisfactory physiological functioning of living organisms, as a circulatory fluid to maintain temperature, to carry nourishing food and to remove the waste products from the body.

It is necessary that, water must be good and it should be free from impurities, toxic chemical compounds and pathogens. Therefore, in order to ensure the availability of sufficient quantity of good quality of water, it is essential to plan and build suitable water supply schemes.

4.1.1 Objectives of Public Water Supply Schemes

Following are the objectives of public water supply scheme:

1. To supply safe, wholesome water to the people so as to keep the diseases away and thereby promoting better health.
2. To maintain better sanitation and beautification of surroundings.
3. To ensure safety against fire, by supplying sufficient quantity of water.
4. To provide industrialisation and modernisation of the society and thereby ensuring better living standards.
5. To promote wealth and welfare for the entire community.

4.1.2 Planning of Water Supply Scheme

The water supply scheme for a city is prepared by the combination of field observation and office work. Following are the points of importance in any water supply scheme.

1. **Population**

   From the available data of census of the last two decades, the future population may be predicted by any suitable method. Based on the future expansion, the water requirement for the scheme is decided.

2. **Per Capita water demand**

   The rate of consumption of water per capita should be decided by taking all the possible uses of water as domestic, industrial, public, trade, fire demand, etc. The rate when multiplied by the population gives total quantity of water required for water supply schemes.

3. **Sources of Water supply**

   The success of a water supply scheme entirely depends upon a good source of supply of water. The source should provide adequate and good quality of water throughout the year.

4. **Quality of water**

   The quality of available water decides the line of treatment of water. The cost of treatment depends on its quality. If the water is pure, lesser will be the cost of treatment

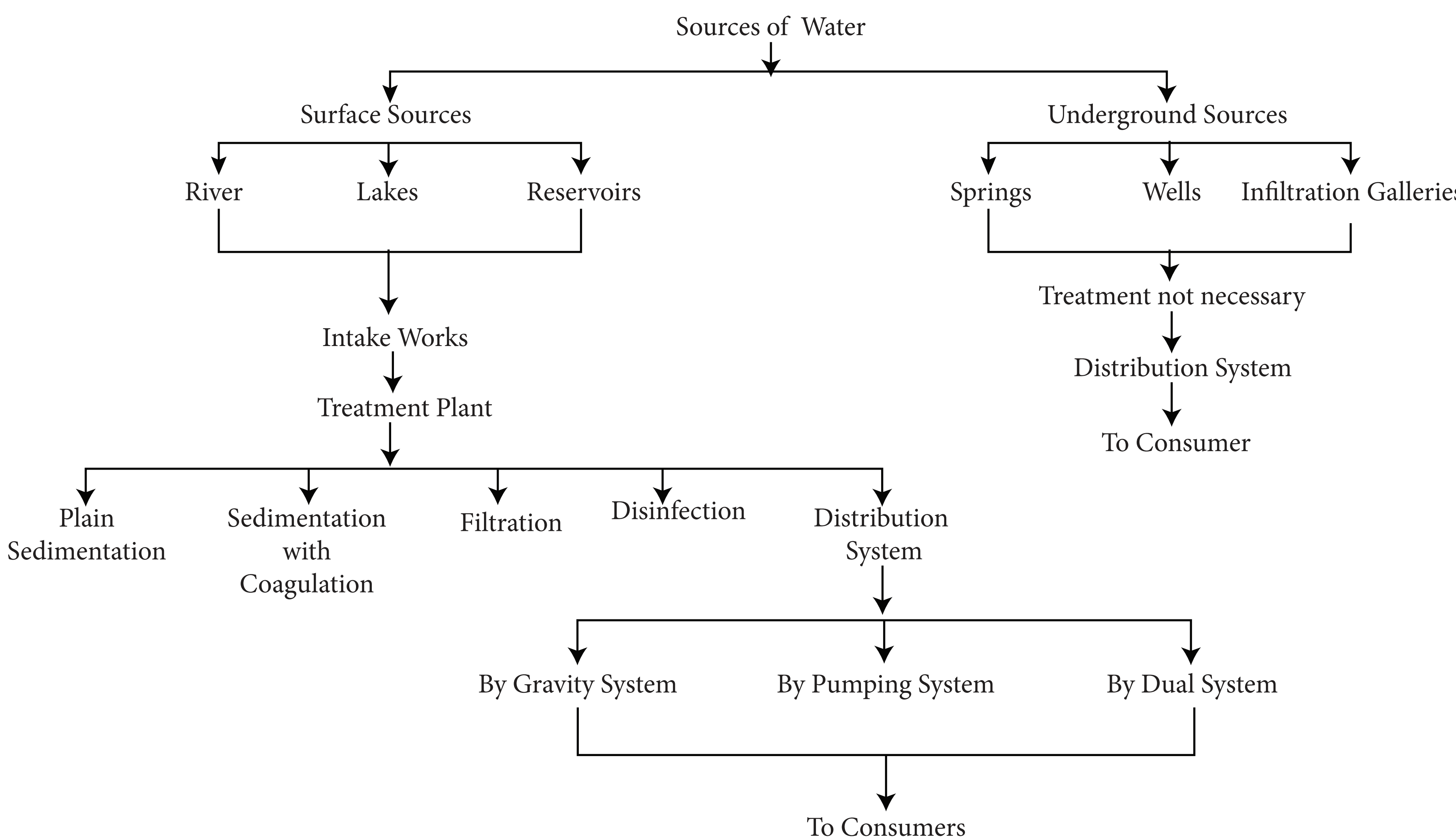
5. **Financial aspects**

   Based on the fund availability, the scheme should be adjusted and it should be as economical as possible.

6. **Topography of the area**

   The topographical map of the area should be prepared. Low lying area, plain area, ridges, high density of population area should be marked on the map and analysed to ensure a simple and cheap water supply scheme.

Flow Chart of a Water Supply Scheme



7. **Development of the town**

The trends of the future development of the town or city should be predicted and properly adjusted while planning the water supply scheme.

4.1.3 Water Demands

The first step in the design of a water supply project is the determination of water demand. This includes the quantity of water that will be required for various purposes with the provision for the estimated requirements of future. Next a reliable source of water must be located.

Following are the various types of demand,

1. Domestic demand
2. Industrial and commercial demand
3. Public demand
4. Fire demand
5. Loss and waste

1. **Domestic demand**

The domestic demand includes the water required in the houses for drinking, cooking, bathing, washing, sanitary purposes, private uses, gardening, etc. In Indian towns or cities, the domestic consumption of water under normal condition is 135 litres/day/capita as per IS: 1172-1993. This amount is about 50% of total consumption.

2. **Industrial and Commercial Demand**

This includes water required for hotels, factories, business centres, diary, sugar refineries, stores, offices, etc. The Consumption will vary greatly with the character of the city. This amounts to 20-25% of the total consumption.

3. **Public Demand**

This includes water required for flushing sewers, sprinkling streets, fountains, ornamental displays, swimming pools, public buildings, temples etc. This amounts to about 10% of the total consumption.

4. **Fire Demand**

It is the quantity of water required for fire fighting purposes. In India, the quantity of water required for fire prevention is taken as 1lit/capita/day. This amounts to 5 to 10% of total consumption.

5. **Loss and waste**

This includes the water loss in pipe line due to various reasons like defective pipe joints, cracks, thefts, faulty valves and fittings. This amounts to about 15% of total consumption.

4.1.4 Per Capita Demand

It is the annual average amount of daily water required by one person and includes the domestic use, Industrial and commercial use, public use, wastes, thefts etc. It may therefore be expressed as

$$\text{Per capita demand} = Q/(P*365) \text{ lits/day}$$

Where Q = Total Quantity of water required by a town per year in litres

P = population

Factors affecting the per capita Demand

The following factors affect the per capita demand

1. Climatic conditions
2. Cost of water
3. Distribution pressure
4. Habits of people
5. Industries and commerce

6. Metering
7. Quality of water
8. Sewerage system
9. Size of community
10. System of supply
11. Age of community
12. Lawn sprinkling
13. Fire demand

1. Climatic conditions

Hotter climates need more water due to more bathing, air conditioning and more lawn and street sprinkling.

2. Cost of water

More the cost of water, lesser will be the amount of consumption of water.

3. Distribution pressure

The Consumption of water increases with increase in distribution pressure due to heavy losses and wastes.

4. Habits of people

People of higher economic status and better standard of living require more water supply.

5. Industries and commerce

Water consumption is usually more when water is to cater for large industrial and commercial uses.

6. Metering

Use of water decreases when the supplies are metered.

7. Quality of water

Safe and wholesome water will always result in an increased consumption.

8. Sewerage system

The existence of sewerage system in a locality will lead to an increase in use of water for flushing of sanitary appliances.

9. Size of community

In a large city, the water demand per head may be more as lot of water is used for maintaining clean and healthy environments.

10. System of water supply

Generally Intermittent supply of water will reduce the rate of demand.

11. Age of community

Older and more stable communities use less amount of water than rapidly developing communities where new homes are being constructed and owners are planting new lawns.

12. Lawn Sprinkling

Enforcement of lawn sprinkling regulations can reduce peak demands significantly.

13. Fire demand

The frequency of occurrence of fire and its size, largely contribute to the demands considerably.

4.2 Sources of Water

The source of water is selected such that it may be able to fulfil all the demands. The following points should be considered while selecting the sources of water for a water supply scheme.

1. Location

The source should be as near as possible to the town or city to minimise the cost of conveyance.

2. Elevation of Intake point

The reduced level (R. L) of the point should be higher than that of the supply

Famous hot springs in India

DO YOU KNOW?

Some of the famous hot springs of Himachal Pradesh are:

- Manikaran **Hot Springs**. Located in Parvati of Kullu District, Manikaran is known for sulphur **hot**water **springs**. ...
- Kheerganga **Hot Springs**.
- Tattapani **Hot Springs**.
- Vashisht **Hot Springs**

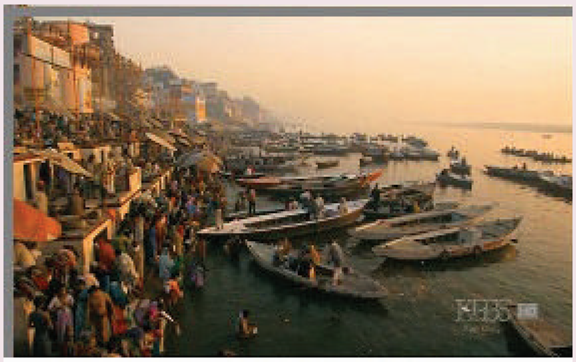
zone so that the water can flow by gravity. Otherwise, pumping unit will increase the cost of the scheme.

3. Quantity of water

The source should be such that the required quantity of water may be available throughout the year to meet the water demand.

Sources of water

Arabian Sea, Kerala



Ganges River in India

Chillika Lake in India

All Indian Village Pond

4. **Quality of water**

The cost of the treatment depends on the quality of water. Bad quality water requires excessive treatment and increases the cost. But the good quality requires less treatment and decreases the cost of the scheme.

The sources from which water is obtained for water supply can be classified into two types

1. Surface sources
2. Sub surface sources

4.2.1 Surface sources

The primary source of water is rain. When rain falls on the ground, a certain portion percolates into the ground and the balance portion remains on the ground as surface water. The usual forms of surface sources are as follows:

i. Ponds
ii. Lakes and streams
iii. Storage reservoirs
iv. Rivers
v. Sea

4.2.2 Sub surface sources

These sources obtain their supply from percolation of precipitation. It is comparatively safer, free from suspended impurities and are reliable. It is due to the fact that water get strained during their passage through the porous underground strata. This water contains more dissolved mineral and gases. The bacterial content is usually low. In General, sub surface source water is good in quality. But they may require some treatment to improve their chemical characteristics.

The usual forms of subsurface sources are as follows:

i. Springs
ii. Wells
iii. Infiltration galleries
iv. Infiltration wells

Well

Activity 1

Identify the sources of water in your school and home. Brief two points of each.

4.3 Quality of Water

The water required for water supplies should be pure. It should be free from pathogens, toxic chemicals, etc., in order to provide good quality. The water should be pre-treated before distribution to the consumers.

Wholesome water

Water which does not contain harmful impurities and which are good or harmless to health is termed as wholesome water. It is bacteriologically pure but chemically not pure.

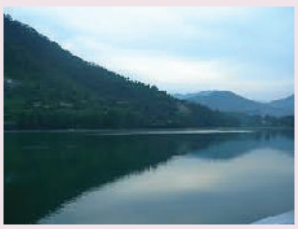
Distilled water

Distilled water is safe water as it is bacteriologically and chemically pure. But it is unpleasant to drink.

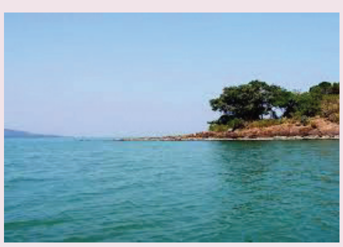
DO YOU KNOW?

World largest Lake

Wular Lake, located in the state of Jammu and Kashmir, is often referred to as the largest **freshwater lake** in India. Wular is a natural lake that is a major part of the Jhelum River basin.



The Sambhar **Salt Lake**, **India's largest** inland **salt lake**, is located 96 km southwest of the city of Jaipur (Northwest **India**) and 64 km northeast of Ajmer along National Highway 8 in Rajasthan. it surrounds the historical Sambhar **Lake** Town.



4.3.1 Impurities in water and its classification

Impurities in water may be classified as below

a. Physical Impurities
b. Chemical Impurities
c. Bacteriological Impurities

a. Physical Impurities

They are due to the presence of inorganic substances like clay, pebbles, sand, silt, algae, fungi, bacteria, etc., in water in finely divided condition. Physical impurities give taste, odour, colour and turbidity to water.

b. Chemical Impurities

They may be either organic or inorganic and is present in either suspended or dissolved form. The suspended organic chemical impurities are due to the presence of vegetables or animals in water. The dissolved inorganic chemical impurities are caused by the melting of minerals and gases in water.

c. Bacteriological Impurities

The Bacteriological Impurities are caused in water by the presence of bacteria. The bacterias may be harmful or harmless. Harmless bacterias are called non-pathogens. Pathogens are dangerous and are mainly responsible for water borne diseases.

4.3.2 Test on Water

The Analysis of water is carried out in order to establish its quality. Following

Tests	Properties/ Impurities
1. Physical tests	i. Turbidity ii. Colour iii. Taste iv. Odour
2. Chemical tests	i. Total solids ii. Hardness iii. PH value iv. Chloride v. Residual chlorine vi. Iron and Manganese
3. Bacteriological tests	i. Total count test ii. E-coli test

tests are carried out to determine the physical, chemical and bacteriological impurities present in water.

1. Physical tests
2. Chemical tests
3. Bacteriological tests

The list of tests and properties/ Impurities determined in the test are tabulated below:

1. Physical Tests

i. Turbidity

Turbidity is caused by the presence of finely divided, suspended and colloidal matters like clay, loam and sand or micro-organisms. It is more during floods. It is a measure of its resistance to the passage of light through it. It is expressed in parts per million(ppm) or milligram per litre(mg/l). The standard unit of turbidity is the turbidity produced by one part of finely divided silica (Fuller's earth) in a million parts of distilled water. For drinking water, the permissible turbidity is 5 to 10ppm. It is measured by Jackson Turbidimeter.

ii. Colour

Dissolved organic matter from decaying vegetation or some inorganic materials such as coloured soils, etc., may import colour to the water. The test for true colour should be taken up only removing all the suspended particles by centrifuging. The sample is then compared for colour with standard colour solutions or colour discs.

The unit of colour is the colour produced by one milligram of platinum cobalt in a litre of distilled water. The colour of public water supply should not exceed 20 mg/s. The colour is measured by Tintometer.

iii. Taste and Odour

The dissolved organic materials or the inorganic salts or the dissolved gases may impart tastes and odours to the water. Taste and odour are generally combined together. Tastes may be sweet, bitter, salty brackish and irritating. Odours may be fishy, earthy, grassy, mouldy, vegetable, etc. The odour is identified by using osmoscope.

2. Chemical Tests

i. Total solids

The total solids consist of dissolved and suspended solids. The total solids present in water can be determined by evaporating a sample of water and weighing the dry residue left. The suspended solids can be found by filtering water sample and weighing the residue left on the filter paper. The difference between the total solids and suspended solids will give the dissolved solids. The amount of total solids should preferably be less than 500 ppm and should never exceed 1000 ppm in any case.

ii. Hardness

It is the property of water which prevents the lathering of soap. It is due to the presence of bi carbonates of calcium and magnesium and is termed as temporary hardness or carbonate hardness. It can be removed either by boiling or by adding lime to water. The permanent hardness or non carbonate hardness is due to sulphates and chlorides of calcium and magnesium. It cannot be removed by boiling. It requires water softening.

iii. pH value

The pH value of water indicates the logarithm of reciprocal of hydrogen ion concentration present in water. It is thus an indicator of the acidity or alkalinity of water. The pure water consists of positively charged(H^+)Hydrogen ions combined equally with negatively charged Hydroxyl (OH^-) ions. The water is said to be acidic when H^+ ions are excess than OH^- ions and the pH value ranges from 0 to 7. The water is said to be alkaline when OH− ion exceeds H+ ion and the pH value ranges between 7 to 14.

iv. Chloride

Chlorides are generally present in water in the form of Sodium chloride E.g.: Common Salt. The amount of chloride present in the water is determined by titrating the sample of water with Silver Nitrate solution taking Potassium Chromate as buffer. The end point is the appearance of red colour. The permissible limit of chloride for drinking water is 250 mg/l.

v. Residual chlorine

The free chlorine which remains as residue in treated water after the contact period is called residual chlorine. It can be determined by two methods.

a. Starch Iodide method
b. Orthotolidine Arsenite method

vi. Iron and Manganese

They usually occur together. They should be less than 0.3 ppm in portable water. They produce rust spots on fabrics (clothes) and plumbing fixtures. They are determined by chlorometric principle. Iron is determined by persulphate method. They impart reddish brown colour to water.

3. Bacteriological Tests

The following tests are normally done for bacteriological examination of water

i. Total count test
ii. E-Coli test

i. Total count test

In this test, bacterias are cultivated on specially prepared culture medium of agar containing nutrients for bacteria. The diluted sample is incubated at 20°C for 48 hours or 37°C for 24 hours. The bacterias grow and multiply and form colonies or clusters. The bacterias thus formed are counted and the results are computed for 1cc. For portable water, the total count should not exceed 100 per cc.

ii. E-Coli test

It is also called as B-Coli test. In this method, the sample of water is filtered through a sterilized membrane containing microscopic pores of size 5 to 10 millimicron to retain bacterias. The membrane with retained bacterias is incubated for 20 hours at 37°C along with

DO YOU KNOW?

Largest water treatment plant in the world

Nearly one billion gallons of water are **processed** on an average day at the James W. Jardine Water Purification Plant in Chicago, Illinois, the largest water treatment plant in the world. This plant and the South Water Purification Plant serve nearly 5 million consumers in the City of Chicago and 118 outlying suburbs.

(1 gallon = 3.78541 litres)

Activity 2

Visit any treatment plant / pumping station available in your locality and submit a report for the functioning of the units.

nutrients. After this period, the membrane is taken out and the colonies of bacterias are counted by means of microscope. This method is called membrane filter technique.

4.4 Treatment of Water

Objectives of water Treatment

The following are the objectives of water treatment

i. To remove the dissolved gases and colour from the water

ii. To remove the unpleasant and objectionable taste from the water

iii. To kill all the pathogens from the water

iv. To remove corrosive materials from the water

v. To make water fit for domestic and industrial purpose.

Flow Diagram of a Treatment plant **(Refer Page 72)**

Sequence of units

1. Intake point
2. Pump house
3. Plain Sedimentation tank
4. Coagulation tank
5. Filtration unit
6. Chlorination unit
7. Water softening plant
8. Overhead reservoir

4.4.1 Functions and locations of Treatment Units

The function of each unit is stated briefly

1. Intake point

The function of this unit is to collect water in the intake well so that the water can be supplied throughout the year.

2. Pump House

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

3. Plain Sedimentation Tank

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

4. Coagulation Tank

The function of this unit is to remove the lighter suspended particles by the application of some coagulants(chemicals). In this tank, some recommended coagulant is mixed with the water and the water is allowed to flow at a very low velocity through the coagulation tank. The coagulant makes the lighter particles to gain settleable size and ultimately settle down at the bottom of the tank. But some colloidal particles still remain in suspension.

5. Filtration unit

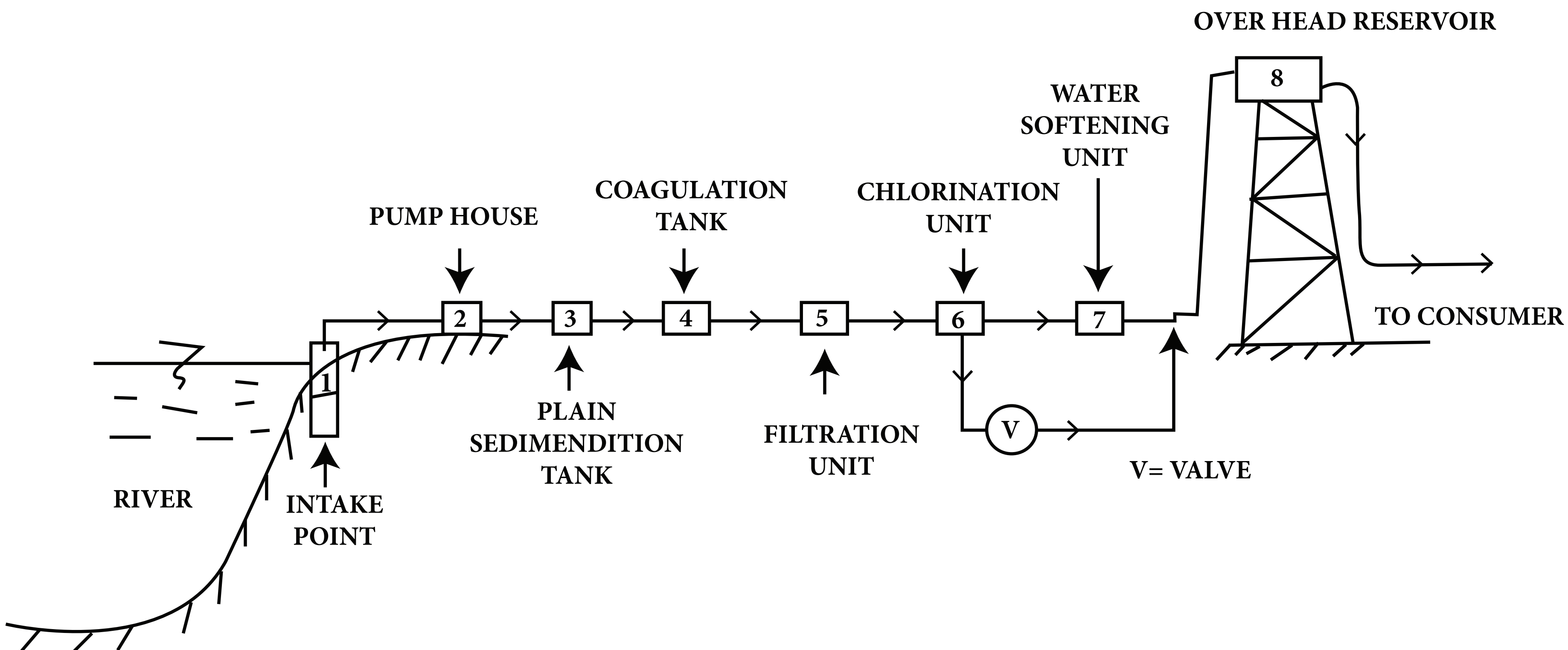
The function of this unit is to remove the finer colloidal particles and some bacteria by filtering media of sand and gravel. But some bacteria still remain in water.

6. Chlorination unit

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

7. Water softening tank

The function of this unit is to remove the hardness of water to make it



Flow Diagram of Treatment Plant

fit for commercial purpose. This unit is not always necessary.

8. **Overhead Reservoir**

The function of this unit is to store the purified water after the treatment is complete. The water from the reservoir is supplied to the consumers by gravity or pumping.

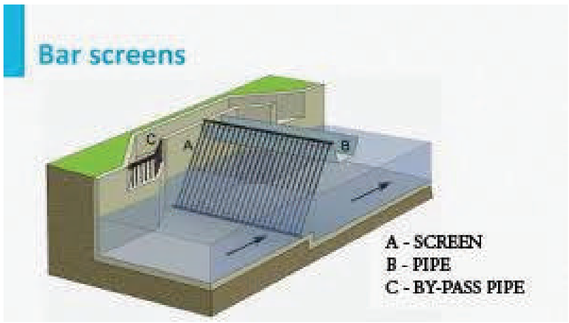
Location of Treatment units

The following points are to be considered while locating the plants for treatment of water

1. All plants should be located in such a sequence that water may flow from one process to the other automatically.
2. Elevation of different processes should ensure gravity flow from one to another.
3. All the processing units should require minimum area. For future expansion, adequate space should be available.
4. All the processing units should be nearer to the area of distribution for better working and efficient maintenance.
5. The site of treatment plant installation should be neat and clean and should be well protected.
6. A well equipped laboratory should be available at the treatment plant to have regular checking of the quality.
7. Space for the disposal of sludge from settling tanks and wash water from filters should be provided.

4.4.2 Screening

Water, when derived from the surface sources may contain floating matters. Most of the big and visible objects such as trees, branches, sticks, vegetation, fishes, dead and floating animals, etc., can be removed by screening. (e.g.) Bar screens. Bar screens may be of two types.



Bar screens

1. Coarse screens
2. Fine screens

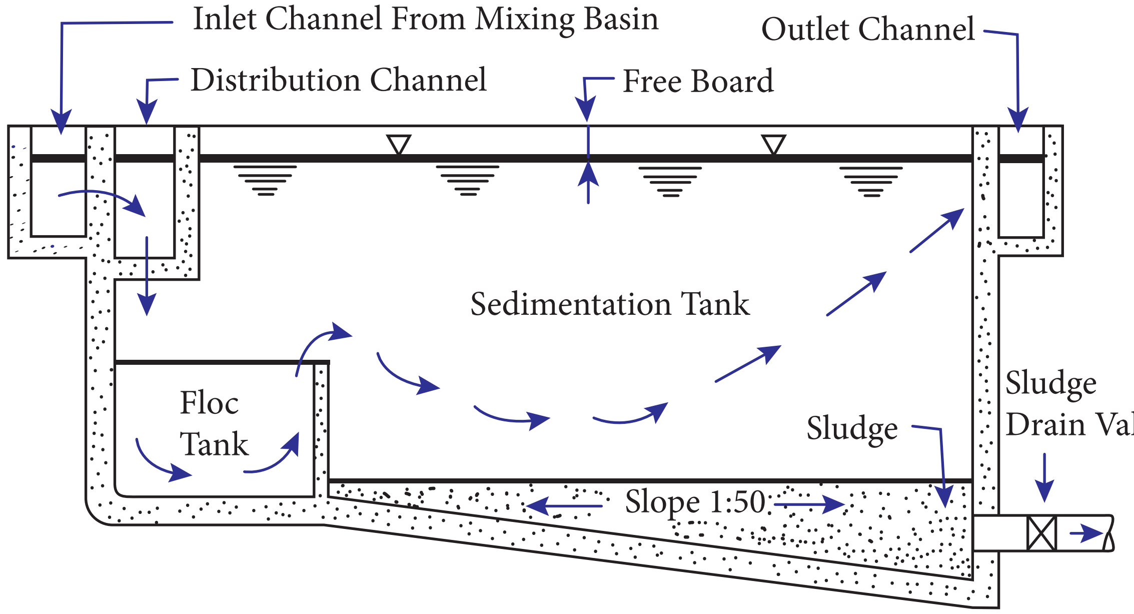
4.4.3 Sedimentation

It is the process of causing heavier solid particles in suspension both organic and inorganic, to settle by retaining the water in a huge tank called sedimentation tank.

Theory of Sedimentation

The particles heavier than water tend to settle down due to the force of gravity. Impurities in water are held in suspension due to the turbulence of the moving water. When this turbulence is checked and the velocity of flow is reduced, the suspended particles tend to settle down at the bottom of the tank. The settling velocity depends upon

1. The horizontal velocity of flow.
2. The shape and size of the particle.
3. The specific gravity of the particle.
4. The temperature of water.

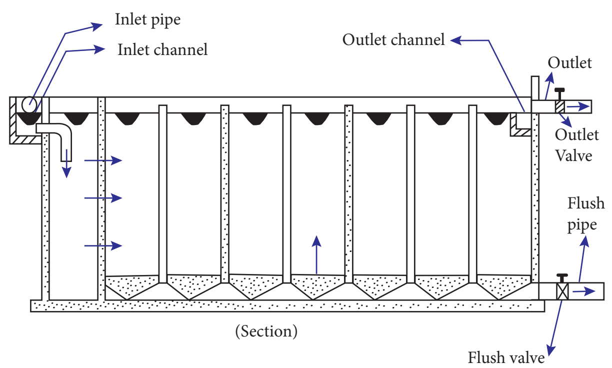


Sedimentation with coagulation

Types of Sedimentation

There are two types of sedimentation. They are

1. Plain sedimentation
2. Sedimentation with coagulation



Plain sedimentation

1. Plain sedimentation

In this, the raw water is retained for sometime in a huge tank for the suspended particles to settle down by the action of gravity.

2. Sedimentation with coagulation

In this, certain chemical compound called coagulant is added to water to assist sedimentation. The coagulant react with impurities in water and convert them into settleable solids.

4.4.4 Filtration

Filtration is the process of passing the water through the filter beds. Filtration removes colour, odour, turbidity and pathogenic bacterias from water.

Theory of filtration

The filtration involves the following actions

1. Mechanical straining
2. Sedimentation and absorption
3. Biological metabolism
4. Electrolytic changes

1. Mechanical straining

The filtering media contains a number of voids between the sand grains. When water is passed through these voids, the suspended particles which are bigger in size than the voids are retained on the surface of the sand bed. This action is called mechanical straining which removes the suspended particles.

2. Sedimentation and Absorption

The voids between the sand grains act as minute sedimentation basins. The colloidal matters arrested in these voids is in a gelatinous mass. Therefore, it attracts other finer particles by absorption.

3. Biological Metabolism

It is the growth and life process of living cells. When bacterias are caught in the voids of sand grains, the surface layer gets coated with a biological film. This film contains large colonies of living bacterias. They feed on the organic impurities present in water. They convert such impurities into simple harmless compounds by biochemical action. This results in the filtration of water.

4. Electrolytic Changes

The sand particles of filter media and ionized matter in water carry electrical charges of opposite nature. Hence, they attract each other and neutralize the charge of each other. This results in the alteration of chemical characteristics of water.

Types of filters

The filters are mainly classified as

1. Slow sand filters
2. Rapid sand filters
3. Pressure filters

The terms rapid and pressure represent high rate of filtration and slow indicate low rate of filtration.

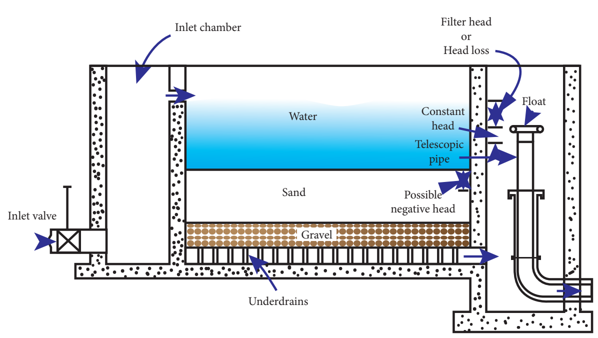
1. Slow sand filters

A slow sand filter is a water tight tank of 2.5 to 3.5 m in depth. It has a sand bed of 1 to 1.5 m thick, supported by a 0.3 to 0.75 m thick layer of graded gravel or broken stone (25 to 50 mm size), laid in layers. Beneath this, an under-drainage system consisting of open-jointed drains is laid over a concrete bed sloping towards a central longitudinal drain. The filtration is effected by gravity.

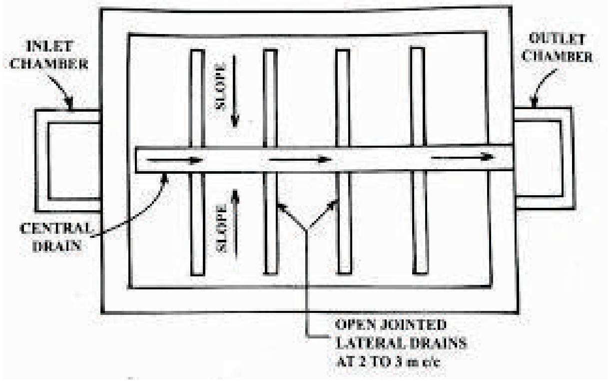
The rate of filtration is 100 to 200 lits/m^2/hour. It's bacterial efficiency is 98 to 99%. The filter bed is cleaned by scraping. This type of filter is unsuitable for waters having turbidity more than 50 ppm.

A typical plan and longitudinal section of a slow sand filter is shown in fig. It consists of the following essential parts.

i. Enclosure tank
ii. Filter media
iii. Base material
iv. Under-drainage system
v. Inlet and outlet arrangement
vi. Other appurtenances



Section of Slow Sand Filter



Plan of Slow Sand Filter

Working

The treated water from the sedimentation tank is allowed into the inlet chamber. It is uniformly distributed over the sand bed to a depth of 1 to 1.5 m without any disturbance. The water percolates through the filter media and gets filtered. Now the water enters the base material and comes out as filtered water. It gets collected in the laterals and discharged into the central main covered drain. Then it is finally discharged into the filtered water well. The standard rate of filtration (100 to 200 litres/m^2/hour) is continued until the difference between the water levels in the filter and the outlet chamber is slightly less than the depth of water above the sand or the loss of head reaches 0.7 to 1.2 m.

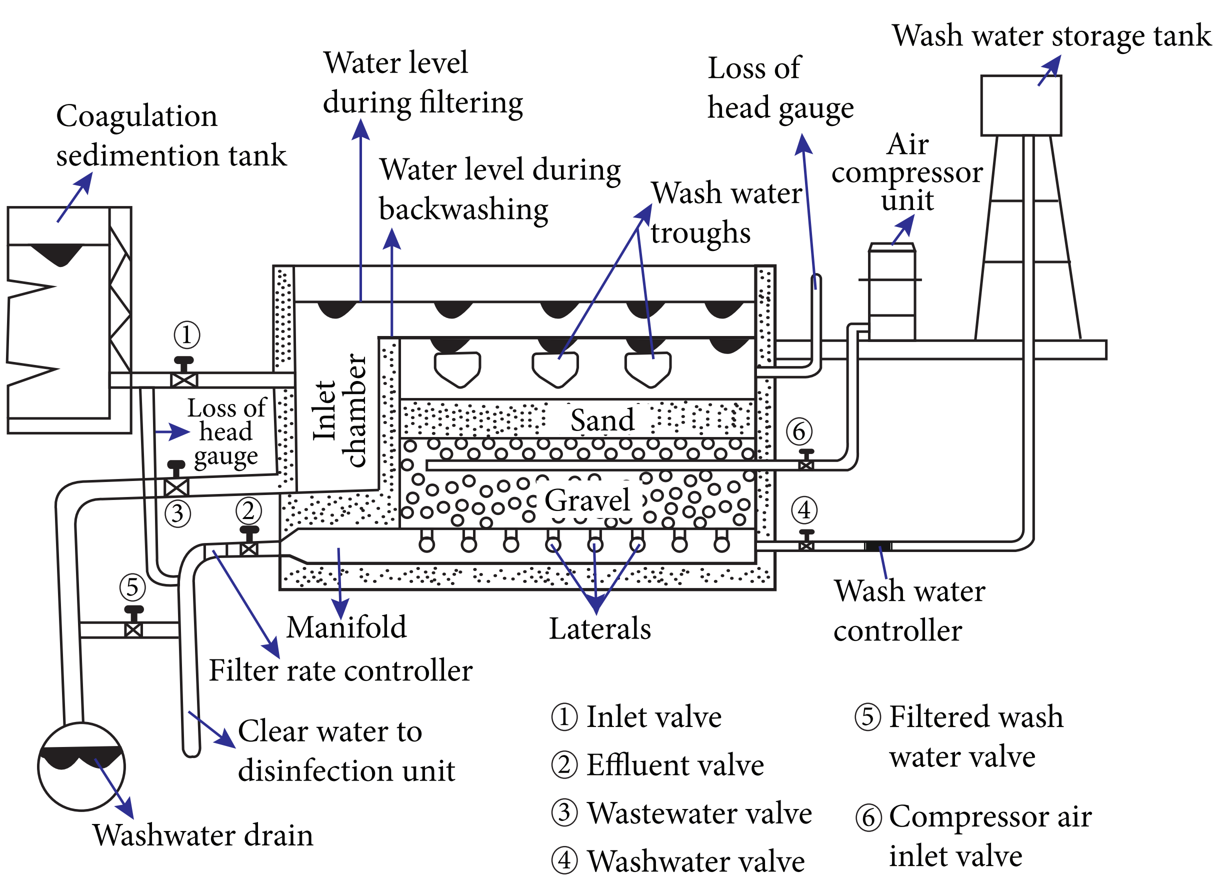
Cleaning

During working of the filter if the loss of head reaches the permissible limit, the filtration is stopped. About 20 to 30 mm sand is scraped from the top of the filter bed. The top surface is finally raked, roughened, cleaned and washed with pure water till the sand depth reduces to 0.4 m or so. Then more clean sand is added to have a minimum sand depth of about 0.45 m. The interval of cleaning may vary from 1 to 3 months.

After every cleaning, the initial filling is done by admitting filtered water from the bottom till it rises about 0.8 m above the sand. Then the fresh water is allowed to enter from the top.

2. Rapid sand filters

In rapid sand filters, the yield is about 30 times the yield given by slow sand filters for the same filter area. This is achieved by increasing the size of sand. They are also known as mechanical sand filters.



Longitudinal section of a rapid sand filter

A rapid sand filter is an open water tight chamber, 3 to 3.5 m deep. It has coarse sand filter media, 0.6 to 0.75 m thick, laid on 0.45 m thick graded gravel. The under-drainage system is supported by concrete floor. The under-drainage system consists manifold with strainers mounted on top and laterals. Laterals have perforations on sides. The filtration is effected by gravity.

The rate of filtration is about 3000 to 6000 litres/m^2/hour. Its bacterial efficiency is 80 to 90%. It removes turbidity upto 30 to 40 ppm.

A typical longitudinal section of a rapid sand filter is shown in fig. The following are its essential parts

i. Enclosure tank
ii. Filter media
iii. Base material
iv. Under-drainage system
v. Appurtenances

Action during filtration

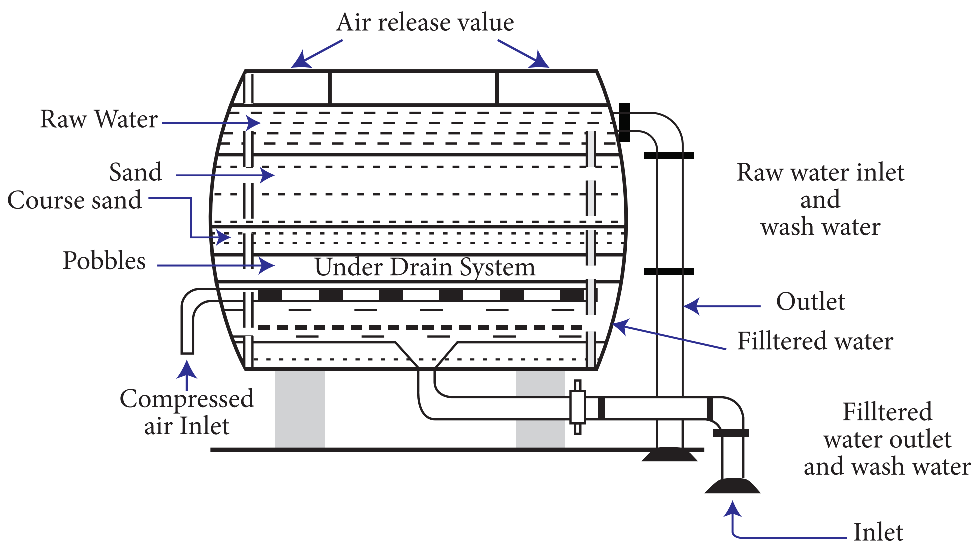
Inlet valve is opened and water from coagulated sedimentation tank is allowed to enter the filter. Effluent valve is opened to carry filtered water to clear water reservoir. During this time all other valves remains closed. Only inlet and effluent valves are opened.

Action during backwashing

Backwashing is done when the loss of head reaches the maximum permissible limit of 2.5 to 3.5 m. The filter is drained out leaving a very small depth of water standing above the filter bed. Now, the compressed air is sent under pressure through the under drainage system for about 2 to 3 minutes. This agitates the mass of water. The agitated water loosens the dirt from the surface of sand grains. Then, an upward flow of water from a high level tank is sent through the bed. This causes the sand bed to expand, agitate the sand grains and wash off the surface deposits. The deposits are carried by wash water troughs and disposes through wash water drains. During backwashing the valve positions are the inlet and effluent are closed, and the valves of wash water trough and wash water drains remains open.

3. Pressure Filters

They consist of closed watertight cylindrical metal tanks of 1.5 to 3 m diameter and length or height 3.5 to 8 m. It contains filter media as of rapid sand filter. The raw water mixed with a dose of coagulant is



Horizontal pressure filter (sectional view) pumped into the filter under a pressure of 200 to 700 kN/m^2. After filtration, water comes out under high pressure. The rate of filtration is 6000 to 15000 litres/m^2/hour. They are of horizontal or vertical type. They are more suitable for industries, private estates, etc. They are less efficient than slow and rapid sand filters. Inspection windows are provided at the top. A horizontal type of filter is shown in fig.

Working

The coagulated water under pressure is directly admitted to the pressure filter through inlet valve. The filtered water comes out through the outlet valve. It is collected in the central drain and conveyed to filtered water storage tank. During normal working, only the valves for raw water and filtered water are kept open.

The cleaning of the filter may be carried out by backwashing like rapid sand filter. The compressed air may be used to agitate sand grains. For cleaning, inlet and outlet valves are closed. The wash water valve and wash water gutter valve are opened. The cleaning is done more frequently.

4.5 Disinfection of Water

Disinfection of water is the process of removal of pathogenic bacteria from water by chemical or other means.

The chemicals used for killing disease producing bacterias are known as disinfectants.

4.5.1 Necessity of Disinfection

The filtered water may contain some harmful impurities such as disease producing bacterias, dissolved inorganic salts, colour, odour, taste, iron and manganese. The bacterially contaminated water will spread various diseases and their epidemics causing disaster to public life. Hence, disinfection is most essential. Further disinfection not only kills the existing bacterias from water, but also prevents its contamination during its transit from the treatment plant to place for its consumption.

4.5.2 Methods of Disinfection

There are two methods of disinfection of water. They are:

(i) Chlorination

(ii) Minor methods

(i) Chlorination

Chlorine has been universally recognized as the most ideal disinfectant in treatment of water on a large scale.

The treatment by chlorination is cheap and reliable. It produces desired effects and lasts long. It is also easy to measure and handle. Chlorination is the treatment of water with chlorine or its compounds for the disinfection of water.

Chlorination not only disinfects, but also removes colour, odour, unpleasant taste and prevents the growth of weeds in water.

(ii) Minor methods

1. Boiling
2. Excess lime treatment
3. Iodine and bromine treatment
4. Ozone treatment
5. Potassium permanganate treatment
6. Silver treatment
7. Ultra-violet rays treatment

The most commonly adopted two minor methods of disinfection of water are discussed below.

1. **Boiling**

Continuous boiling of water for a long time above a certain temperature kills the bacterias. It is the most effective method of disinfection. It is highly impracticable to boil water on large scale for public water supplies. However, during water borne epidemics, it is advisable to boil water before consumption.

2. **Excess Lime Treatment**

Addition of excess lime to water removes salts and also kills the bacterias. Use of excess lime increases the pH value of water. When the pH of water rises to about 9.5 or so, 99.93 to 100% bacterias are removed even from highly polluted waters.

After disinfection, by adopting some suitable method the excess lime is removed from water before its public supply. Further this method cannot protect water from recontamination.

Activity 3

Collect the data regarding disinfection of water in your locality.

4.6 Water Softening

Water softening is the process of reduction or removal of hardness from water.

4.6.1 Purpose of water softening

1. To reduce soap consumption
2. To reduce corrosion and incrustation of pipes and fittings
3. To improve the taste of food preparations
4. To reduce scaling in boilers
5. To minimise its interference in dyeing systems

4.6.2 Hardness of Water

It is the characteristic which prevents the lathering of soap. It is caused by the presence of certain salts of calcium and magnesium dissolved in water.

Hardness of potable water is 5 to 8 degrees. Hardness less than 5 degrees is tasteless and above 8 degrees produces undesirable effects. (One degree of harness = 14.25 ppm).

Types of Hardness

1. Temporary hardness or Carbonate hardness
2. Permanent hardness or Non-carbonate hardness

Temporary hardness is due to the presence of bicarbonates of calcium and magnesium. Permanent hardness is caused by the presence of sulphates and chlorides of calcium and magnesium.

1. **Removal of temporary hardness**

The temporary hardness can be removed by boiling or by adding lime which is called as lime process. Lime process is otherwise known as clark process.

The principle involved in this process is the neutralization of carbon-di-oxide with milk of lime.

2. **Removal of permanent hardness**

The permanent hardness can be removed by special methods of water softening. Any of the following methods can be adopted.

i. Lime-soda process
ii. Zeolite process or Base exchange process
iii. Demineralisation

4.7 Distribution System of Water

Distribution of water is the supply of safe and wholesome water to all parts of the area served at adequate pressure and quantity. Hence, the distribution system may consist of the following

1. Pipe lines of different sizes to convey water.
2. Valves for controlling the flow in the pipe lines.
3. Meters for measuring the consumption.
4. Hydrants for providing connections with water mains for releasing water during fires.
5. Service connections to the individual houses.
6. Pumps for lifting and forcing the water into the distribution pipes.
7. Service reservoirs for storing the treated water and feeding to the distribution pipes.

Requirements of Good Distribution system

A good distribution system should satisfy the following general requirements

1. It should be capable of supplying water in adequate quantities and pressure at all points of the area served.
2. It should meet the demands of water supply for fire-fighting purposes.
3. It should be thoroughly reliable.
4. It should be economical in its design, layout and construction.
5. It should be easy and simple to operate and repair.
6. It should be safe against any future pollution of water.
7. It should be water-tight so as to keep the "losses due to leakage" to the minimum.
8. It should be safe and not cause the failure of the pipelines by bursting, etc.

Different Systems of supplying water

Depending upon the situation, the water supply system may be classified as below

1. Methods of distribution
2. Systems of water supply
3. Methods of Layout of distribution pipes

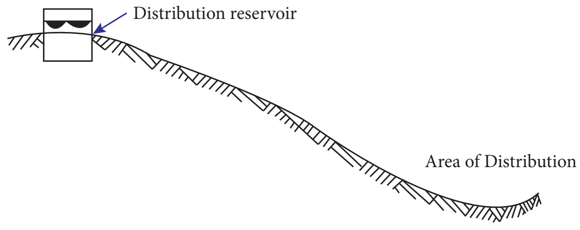
4.7.1 Methods of distribution

Depending upon the levels of water source and that of the area served, topography of the area served and other local conditions, following methods are adopted.

a. Gravity system
b. Pumping system
c. Combined pumping and gravity system

a. Gravity system

In this system as shown in fig, treated water is conveyed at atmospheric pressure through pipes by gravity. This system is adopted when the source of water supply is situated at a higher level than the area served.



Merits

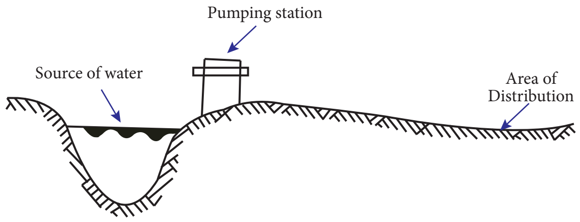
i. Most safe, reliable and economical.
ii. No pumping is required.

Demerits

i. Source of water supply should be higher than the area served.
ii. During fire-fighting, it may require motor pumping to develop required pressure.

b. Pumping system

This system is followed when the source of water supply is lower than the area served or the ground between the source and the distribution area is undulating. In this system, treated water is pumped directly into the water distribution mains. Water flows under hydraulic pressure.



Merits

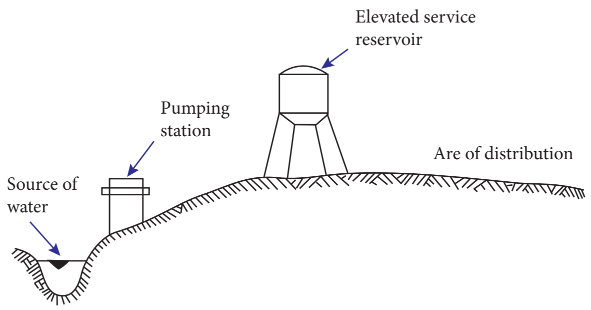
i. The source of supply can be at any level.
ii. No pumping during non-supply

Demerits

i. Requires high lift pumps.
ii. Requires constant attention at pumping stations.
iii. Unreliable as it depends entirely on power supply.
iv. Pressure in mains varies as the variation in consumption.

c. Combined pumping and gravity system

In this system water is supplied by both gravity and pumping. When the demand is less than the rate of pumping, the excess water is stored in the reservoir. When the demand is more than the rate of pumping, the water from the reservoir is supplied for consumption.



Merits

i. Most economical, efficient and reliable.
ii. Pumping can be done at uniform rate.
iii. Pumps can operate at their capacities which results in higher efficiency and economy in operation.
iv. Stored water can be used at all emergencies.

4.7.2 Systems of water supply

Based on the frequency of water supply, the following water supply systems may be followed.

a. Continuous system
b. Intermittent system

a. Continuous system

In continuous system, treated water is supplied to the consumers throughout the day.

Merits

i. Most ideal.
ii. No separate storage by the consumers is required.
iii. Adequate supply is always available for fire-fighting.
iv. Wastage is minimum.

Demerits

i. The water supply source should have adequate quantity.
ii. Wastage will be more if the consumers do not have civic sense.

b. Intermittent system

In this system, treated water is supplied to the consumers during certain fixed hours of the day. This system is used when the quantity of water is limited and the pressure in the system is low.

Merits

i. Minimum wastage due to vigilant use of consumers.
ii. Suitable if the source has only limited supply.
iii. Repairs can be easily attended during non-supply hours.
iv. Own storage of the consumers will relieve the situation during emergencies or non-supply.

Demerits

i. The consumers have to store water for use during non-supply hours.
ii. If emergencies such as fire occur during non-supply period, it causes great loss and hardship.
iii. More wastage due to open tap, etc.

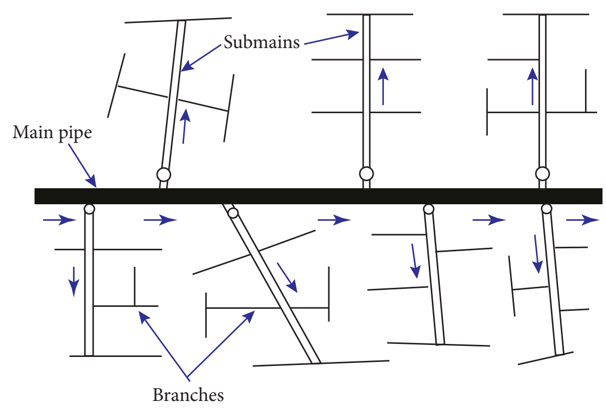
4.7.3 Methods of Layout of Distribution pipes

There are four systems of layout of pipes

1. Dead end or tree system.
2. Grid-iron system or interlaced system or reticulation system.
3. Circular or ring system.
4. Radial system.

1. Dead end or tree system

This system shown in fig, is more suitable to irregularly developed areas without any properly planned roads. This system consists of one supply main and from which many submains are taken. The submains again branch off into several branch lines. The branch lines divide into a number of service pipes.



Merits

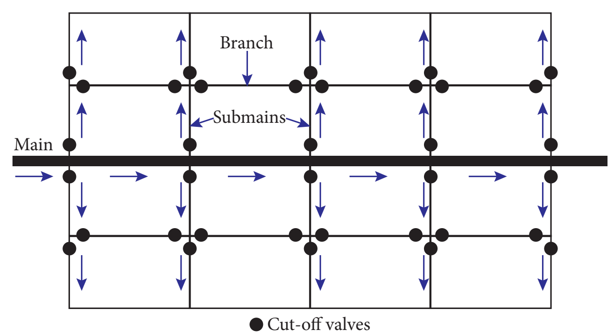
i. Cheap and simple and can be expanded, extended easily.
ii. Discharge and pressure calculations are easy, simple and accurate.
iii. Requires less number of cut off valves.
iv. Pipe lines can be laid in any pattern easily.

Demerits

i. During repairs, large portion of distribution area is affected.
ii. Water available for fire fighting will be limited.
iii. The numerous dead ends of the system prevent the free circulation of water.
iv. The stagnated water at dead ends may pollute.

2. Grid -Iron system

In this system shown in fig., the mains, submains and branches are all interconnected with each other. The dead ends are completely eliminated. This system is most suitable for well planned towns.



Merits

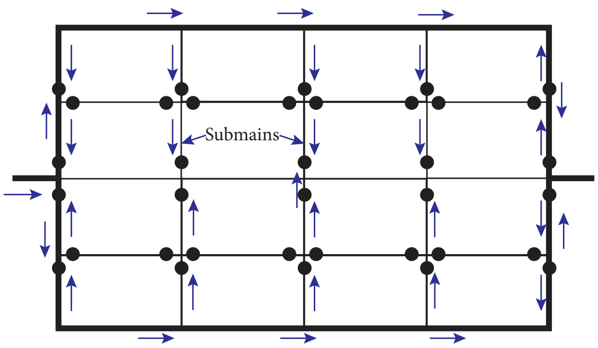
i. There is free circulation of water. No possibility of pollution due to stagnation.
ii. In case of repairs, only a very small portion of the distribution area will be affected.
iii. Water reaches all the points with minimum loss of head.

Demerits

i. Two or more valves are to be installed at every cross junction.
ii. Laying water pipes is costly.
iii. The design is difficult and costlier.

3. Circular or Ring system

In this system shown in fig, the entire distribution area is divided into square, rectangular or circular blocks. The water mains are laid on the periphery of these blocks. The submains, branches, etc., are laid along the inner roads and streets. This system is most suitable for cities having well planned roads and streets.



Merits

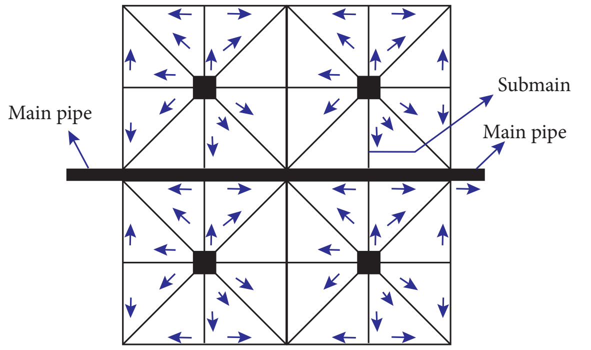
i. This system has the advantages of the previous two systems.
ii. In this systems, every point receive its supply from two directions.
iii. Design of this system is easy.

Demerits

This system has the same disadvantages as the grid-iron system.

4. Radial system

This system of layout shown in fig., is just the reverse of the ring system. The entire distribution area is divided into distributed zones. There is a central distribution reservoir in each zone. The supply pipes are laid radially away from the reservoir towards the periphery. The water from the mains flow into these reservoirs. From there it is supplied to the respective zones.



Merits

i. Provides good service quickly.
ii. Design calculations for the sizes of the pipes are simple.
iii. Best suited where the roads are laid radially.

Demerits

Requires a distribution reservoir in each zone.

MODEL QUESTIONS

Part – I

Choose the Correct answer (1 Mark)

1. The standard recommendation of the quantity of water required for domestic purpose is ________________.
   a. 270 liters per capita per day
   b. 135 liters per capita per day
   c. 180 liters per capita per day
   d. 125 liters per capita per day

2. Distilled water is safe water as it is ________________.
   a. Bacteriologic ally pure
   b. Chemically pure
   c. Bacteriologically and Chemically pure
   d. Bacteriologically pure and Chemically not pure

3. For drinking water, the permissible turbidity is ________________.
   a. 5 to 10 PPM
   b. 10 to 15 PPM
   c. 15 to 20 PPM
   d. 20 to 25 PPM

4. The Permissible limit of chloride for drinking water is ________________.
   a. 500 mg/l c. 400 mg/l
   b. 300 mg/l d. 250 mg/l

5. The rate of filtration of a slow sand filter is ________________.
   a. 100 to 200 liters/m^2/hour
   b. 500 to 1000 liters/m^2/hour
   c. 2000 to 3000 liters/m^2/hour
   d. 3000 to 6000 liters/m^2/hour

6. Hardness of portable water is ____________.
   a. 4 to 6 degrees
   b. 5 to 8 degrees
   c. 6 to 7 degrees
   d. 7 to 10 degrees

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7. The water is said to be alkaline when Ph value ranges from ________________.
   a. 0 to 7 c. 7 to 14
   b. 5 to 10 d. 8 to 15

Part – II

Answer in one or two sentences (3 Marks)

8. List the name of the tests to determine impurities in water.
9. List the various types of water demand.
10. Name the various sources of water.
11. Write any two objectives of water treatment.
12. Define Sedimentation.
13. Define Chlorination.

Part – III

Answer in brief (5 Marks)

14. What are the objectives of public water supply schemes?
15. What are the points to be considered while locating the water treatment units?
16. Define filtration and list the actions involved.
17. What are the general requirements of a good distribution systems.

Part – IV

Answer in detail (10 Marks)

18. Explain the factors affecting per capita Demand.
19. Explain the construction and working of a slow sand filter with a neat sketch.
20. Explain the construction and working of a Rapid sand filter with a neat sketch.
21. What are the different systems of supplying water and explain in detail.

Answers:
1) b 2) c 3) a 4) d 5) a 6) b 7) c