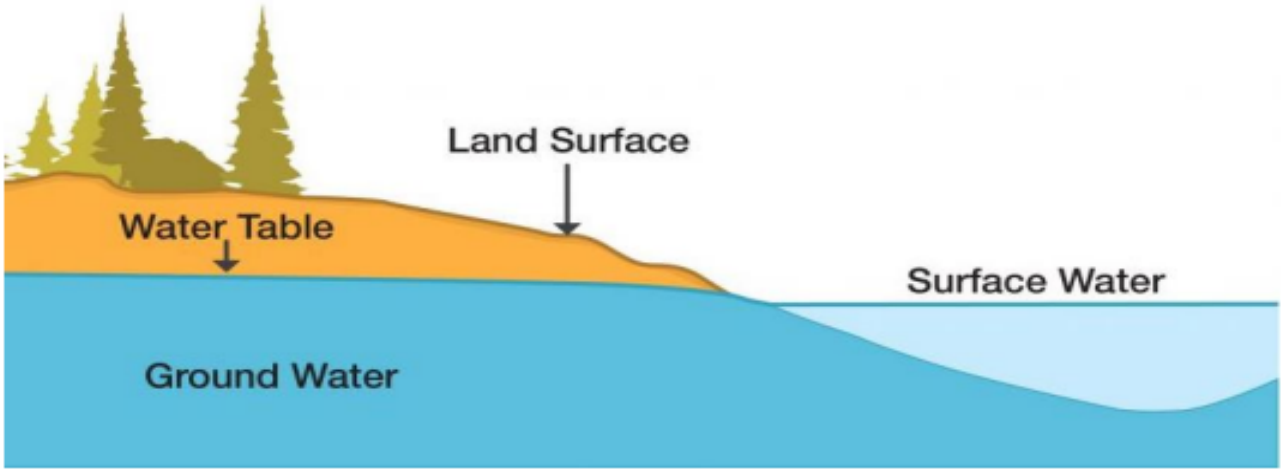
Module 4

Quantity of water*: Sources of water, Per capita demand, drinking water standards, Public* ***Water Supply System:*** *Necessity and Basic lay out, Conventional* ***water treatment process****: Screening, Plain Sedimentation, Sedimentation aided with Coagulation, Filtration and Disinfection (working principles only)*

Sources of water

Sources from which water is available for water supply schemes can conveniently be classified into the following two categories according to their proximity to the ground surface, viz.,

1. Surface source
2. Underground source



In this type of source, surface runoff is available for water supply schemes. Usual forms of surface sources are as follows:

1. Lakes and streams
2. Ponds
3. Rivers
4. Storage reservoirs

Lakes and streams

• A natural lake represents a large body of water within the land with an impervious bed. Hence, it may be used as a source of water supply schemes for nearby localities.

• Similar is the case with streams which are formed by surface runoff. It is found that the flow of water in streams is quite ample in the rainy season. But it becomes less in the hot season and sometimes the stream may even become absolutely dry.

• The catchment area of lakes and streams is very small and hence, the quantity of water available from them is also very low. Hence, lakes and streams are not considered as principal sources of water supply schemes for large cities. However, they can be adopted as sources of water supply schemes for hilly areas and small towns.

• The water which is available from lakes and streams is generally free from undesirable impurities and can therefore be safely used for drinking purposes.

Ponds

• A pond is a man-made body of standing water smaller than a lake. Thus, ponds are formed due to excessive digging of ground for the construction of roads, houses, etc and they are filled up with water in the rainy season.

• The quantity of water in a pond is very small and it contains many impurities.

• A pond cannot be adopted as a source of water supply and its water can only be used for washing clothes or animals only.

Rivers

• Since the dawn of civilization, ancient man settled on the banks of rivers, drank river water, ate fish caught from river water and sailed down rivers to find unknown lands.

• Large rivers constitute the principal source of water supply schemes for many cities.

• Some rivers are perennial while others are non-perennial.

➢ The perennial rivers are snow-fed and hence, water flows in such rivers for all the seasons.

➢ The non-perennial type of rivers dries in summer either wholly or partly and in monsoon, heavy flood visits them. For such types of rivers, it is desirable to store the excess water of flood in monsoons by constructing dams across such
rivers. This stored water may then be used in summer.

• The quality of surface water obtained from rivers is not reliable. It contains silt and suspended impurities, disease bacteria, harmful impurities, etc. The presence of all such undesirable elements in river water requires an exhaustive treatment of water before it can be made fit for drinking purposes.

Storage reservoirs

An artificial lake formed by the construction of a dam across a valley is termed a storage reservoir. It essentially consists of the following three parts

- A dam to hold water
- A spillway to allow the excess water to flow and
- A gate chamber containing necessary valves for regulating the flow of water

At present, this is the chief source of water supply schemes for very big cities. The multipurpose reservoirs also make provisions for other uses in addition to water supply such as irrigation and power generation.

Underground sources

In this type of source, the water that has percolated into the ground is brought to the surface. The difference between the terms infiltration and percolation should be noted.

➢ Infiltration - the entrance of rainwater or melted snow into the ground

➢ Percolation - the movement of water after entrance

It is observed that the surface of the earth consists of alternate courses of pervious and impervious strata. The pervious layers are those through which water can easily pass while it is not possible for water to go through an impervious layer. The previous layers are known as aquifers or water-bearing strata. If an aquifer consists of sand and gravel strata, it gives a good supply of drinking water. The aquifer of limestone strata can supply a good amount of drinking water, provided there is the presence of cracks or fissures in it.

Following are the four forms in which underground sources are found

1. Infiltration galleries
2. Infiltration wells
3. Springs
4. Wells

Per Capita Demand

Per capita demand of water is **the ratio of a community's average annual water consumption to its total population for 365 days**

$$Per\ capita\ demand = \frac{Total\ consumption\ of\ water\ in\ liters}{Population \times 365}$$

It's calculated in liters per person per day.

- Domestic use: 135 liters per capita per day
- Public use: 25 liters per capita per day
- Industrial use: 40 liters per capita per day
- Fire demand: 15 liters per capita per day
- Losses, wastages, and thefts: 55 liters per capita per day

That means the total demand is 270 litres/capita/day.

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Factors affecting per capita demand

Factors affecting per capita per demand are:

1. Climate of town.
2. Habits of people.
3. Industries and commercial places.
4. Method of charging.
5. Pressure in the distribution system.
6. Size of city or town.
7. System of supply.
8. Sanitation facilities.
9. Quality of water.
10. Cost of water.

1. Climate of town

The requirement of water in hotter places is more than in cooler places as they need more water for air conditioning, sprinkling in streets or roads, bathing etc.

2. Habits of people

Some people need less water for bathing, washing clothes and other daily activities while some people need more. Generally, rich people consume more water due to their high living standards.

3. Industries and commercial places

With more industries and commercial places in the city, more will be demand for water. Hence, per capita demand increases.

4. Method of charging

Water is charged on the basis of a metering system and a non-metering system. In the metering system, consumers will consume less water compared to the non-metering system

5. Pressure in the distribution system

There will be more consumption of water in case adequate pressure is maintained to lift the water to the upper stories of the buildings. Also, leakages will be more.

6. Size of city or town

If the size of the city or town is large, then more water will be consumed. This is all due to population, big cities have more population than small cities. Per capita demand increases with an increase in population.

7. System of supply- If the water supply is intermittent, less water is consumed due to decreases in losses and wasteful use.

8. Sanitation facilities

In areas where underground sanitation facilities are available, more water is needed for efficient drainage through pipes, channels and sewers.

9. Quality of water- Per capita demand will increase if the quality of water is good.

10. Cost of water-The per capita demand will be more if the cost of water is less and vice versa

Drinking water standards

Following are some important drinking water quality standards in India.

1. Turbidity
2. Colour
3. pH
4. Taste and odour
5. Hardness
6. Total Suspended Solids (TSS)
7. Total Dissolved Solids (TDS)
8. Alkalinity
9. Chlorides
10. Nitrogen
11. Fluoride

Public Water Supply System

A public water supply system is a critical infrastructure that provides clean and safe drinking water to communities and households. It is essential for public health, sanitation, and the overall well-being of society.

Necessity of a Public Water Supply System

1. Public Health: Access to clean and safe drinking water is crucial for preventing waterborne diseases. Contaminated water can harbour harmful microorganisms, such as bacteria, viruses, and parasites, which can lead to serious health issues. A well-maintained public water supply system ensures that the water is treated and disinfected to remove or reduce these contaminants.

2. Sanitation: A public water supply system supports various sanitation practices, including the flushing of toilets, personal hygiene, and cleaning. It plays a vital role in preventing the spread of diseases and maintaining overall hygiene.

3. Economic Development: Reliable access to clean water is essential for economic development. It supports industries, agriculture, and commercial activities that rely on water as a primary resource. Businesses and industries require a dependable water supply for their operations.

4. Fire Protection: Public water supply systems provide the necessary water pressure and volume to support firefighting efforts, which is crucial for saving lives and property during emergencies.

Basic Layout of a Public Water Supply System

A public water supply system consists of several key components and processes. The exact layout and components can vary depending on the size and needs of the community,

but here is a basic overview:

1. Water Source: The system begins with a water source, which can be a natural water body such as a river, lake, or groundwater from wells. In some cases, reservoirs are used to store water.

2. Intake Structure: At the water source, there is usually an intake structure that draws water from the source. This may include screens to remove debris and fish screens to protect aquatic life.

3. Treatment Plant: Water from the source is transported to a treatment plant, where it undergoes several processes to remove impurities. Treatment typically includes coagulation, flocculation, sedimentation, filtration, and disinfection (commonly using chlorine or ozone) to ensure the water is safe to drink.

4. Storage Reservoirs: Treated water is often stored in reservoirs before distribution. These reservoirs help ensure a continuous and reliable water supply, even during high demand or emergencies.

5. Distribution Network: The distribution system includes a network of pipes, pumps, and storage tanks that transport water to homes, businesses, and other consumers. Pressure is maintained to ensure adequate flow, and various valves control water flow and pressure.

6. Water Meters: Water meters are installed at individual connections to measure the amount of water used by consumers. This helps in billing and tracking water consumption.

7. Emergency Backup Systems: Public water supply systems often incorporate backup generators, redundant water sources, and emergency plans to maintain service during power outages or other disruptions.

8. Monitoring and Maintenance: Continuous monitoring and maintenance are critical to ensure the quality and safety of the water supply. This includes water quality testing, leak detection, and infrastructure repair and replacement.

Conventional Water Treatment Process

Water treatment is the process of removing pollutants from raw water to produce safe water for human use.

Water Screening-Water Screening is the first unit operation in all water treatment plants. The screen is the device used to retain solids found in the influent water to the treatment plant. The main purpose of screening is to remove solid materials that could:

- Cause damage to other process equipment.
- Cause reduction in efficiency of the whole system
- Contaminate waterways

The materials that are removed using screens are called screenings.

Working Principle of Screening:

1. Raw Water Intake: Water from the source (river, lake, or groundwater) is drawn into the water treatment facility through an intake structure. The raw water typically contains large debris and sediments.
2. Screening Chamber: The raw water enters the screening chamber, where it passes through the bar screens or gratings. The screens have openings of a specified size that allow water to flow through while trapping larger particles and debris.
3. Debris Accumulation: Debris like leaves, twigs, plastics, and other solids become trapped on the screens as the water flows through.
4. Cleaning Process: To prevent clogging and maintain efficient screening, a rake mechanism is periodically or continuously moved across the screen's surface. The rake collects the trapped debris and moves it to a designated area for disposal.
5. Treated Water Outlet: After screening, the cleaned water continues to the next stages of the water treatment process, such as coagulation, flocculation, sedimentation, and filtration

Plain Sedimentation-To allow heavier suspended solids to settle naturally under gravity.

Working Principle:

•Raw water is allowed to flow slowly into a sedimentation tank.

•As the flow velocity reduces, heavier particles like sand, silt, and grit settle at the bottom of the tank due to gravity.

•The clean water at the top of the tank is collected and sent to the next stage.

Key Features:

•Tanks are designed to provide sufficient time for particles to settle (called detention time).

•Sludge collected at the bottom of the tank is periodically removed.

Sedimentation Aided with Coagulation

Purpose: To improve the removal of fine particles and suspended solids that do not settle easily in plain sedimentation.

Working Principle:

A coagulant (e.g., Alum, Ferric Chloride) is added to water in the coagulation tank.

Coagulants neutralize the charges on fine suspended particles, allowing them to clump together into larger particles called **flocs**.

This process is called **flocculation**, and it occurs by gentle mixing to form bigger, heavier flocs.

The flocs settle more quickly in the sedimentation tank, improving clarity of water.

Adding chemical or natural coagulants to the water can quicken the sedimentation process.

Common types of chemical coagulants are:

- Aluminium sulphate
- Polyaluminium chloride (also known as PAC or liquid alum)
- Ferric sulphate

Some examples of natural coagulants are:

- Prickly pear cactus
- Moringa seeds
- Broad beans
- Fava beans.

Coagulation- Coagulation is often the first step in water treatment. During coagulation, chemicals with a positive charge are added to the water. The positive charge neutralizes the negative charge of dirt and other dissolved particles in the water. When this occurs, the particles bind with the chemicals to form slightly larger particles.

Flocculation- Flocculation follows the coagulation step. Flocculation is the gentle mixing of the water to form larger, heavier particles called flocs. Often, water treatment plants will add additional chemicals during this step to help the flocs form. Common chemicals used in this step include specific types of salts, aluminium, or iron

Filtration

To remove remaining suspended solids, microorganisms, and fine particles after sedimentation.

Working Principle:

•Water passes through a filter bed made up of layers of sand, gravel, and sometimes activated carbon.

•Suspended solids and impurities get trapped within the void spaces of the filter media.

•Clean water is collected at the bottom and passed to the disinfection stage.

Types of Filtration:

1. Slow Sand Filtration:
    - •Water flows slowly through a bed of fine sand.
    - •Effective in removing bacteria, suspended solids, and algae.
2. Rapid Sand Filtration:
    - •Water flows rapidly through layers of graded sand and gravel.
    - •Requires periodic backwashing to clean the filter.
3. Pressure Filtration:
    - •Water passes through filters under pressure, typically used in industrial applications.

Filter Media:

•Fine Sand (Top Layer): Traps fine particles.

•Coarse Sand/Gravel (Lower Layers): Provides support and filtration of larger particles.

•Activated Carbon: Removes odors, colors, and dissolved organic compounds.

Disinfection-To destroy harmful microorganisms (bacteria, viruses, and protozoa) to make water safe for drinking.

Working Principle:

•A disinfectant is added to water to kill or inactivate pathogens.

•The most common disinfectant is **Chlorine** due to its effectiveness and low cost.

•Alternatives like Ozone and Ultraviolet (UV) light are also used for disinfection.

Methods of Disinfection:

1. **Chlorination**:
    1. Chlorine reacts with water to form hypochlorous acid (HOCl), which penetrates bacterial cells and disrupts their functions.
    2. Advantages: Cost-effective and provides residual disinfection.
    3. Disadvantages: Can produce harmful by-products (trihalomethanes).
2. **Ozonation**:
    1. Ozone (O3) gas is bubbled through water, killing microorganisms by oxidation.
    2. Advantages: Fast and effective; no residual taste or odor.
    3. Disadvantages: Expensive and requires specialized equipment.
3. **UV Disinfection**:
    1. Water is exposed to ultraviolet light, which damages the DNA of microorganisms, rendering them inactive.
    2. Advantages: Chemical-free and highly effective against viruses and protozoa.
    3. Disadvantages: No residual disinfection.