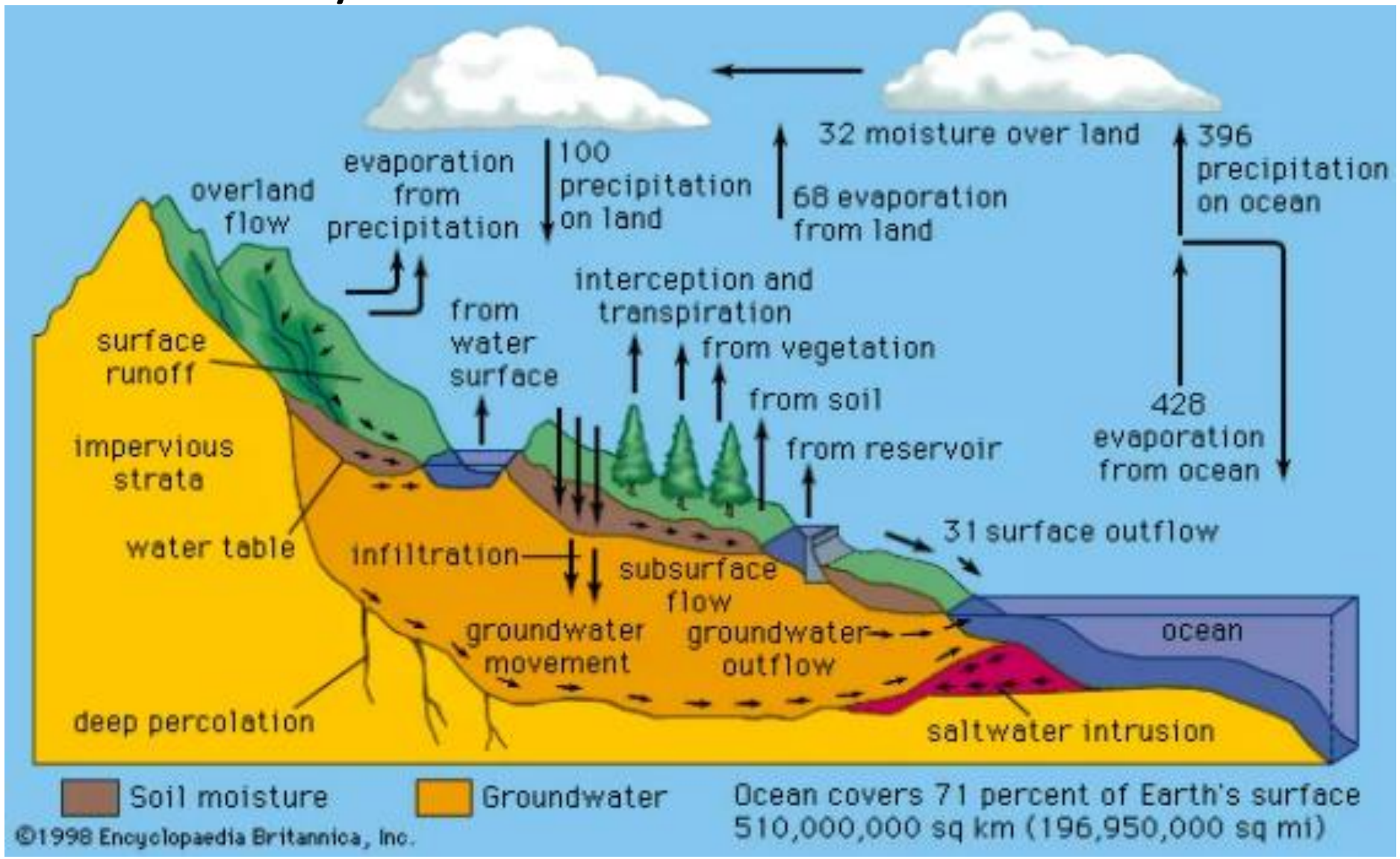
Drinking Water Purification

The Water Cycle



Raw Water Sources and Types of Treatment

Water Sources:

- Ground water *(Deep wells/Shallow wells)*
- Surface water *(Lakes /Rivers)*
- Ocean water *(Desalination Reverse osmosis)*
- Spring water

Sources of Freshwater

Where does the water that we use come from? As stated above, saltwater is not suitable for human use. (The high salt concentration makes it unsuitable for most human applications, and removal of the salt is costly.) Water found in the forms of ice and vapor are not readily accessible for human use. This leaves only about 0.3% of the water on the Earth as liquid freshwater.The vast majority (approximately 98.5%) of the Earth's freshwater is contained in underground supplies known as **groundwater.** The remaining freshwater sources, including rivers and lakes, are collectively known as **surface water.** The amount of water that we use from groundwater and surface water varies from region to region. Generally, groundwater is cleaner and requires less treatment, but surface water is easier to obtain.

Objectives of Treatment

Why is it necessary to treat freshwater before we drink it or use it for other applications? The answer is that our water supplies are not pure, i.e., these supplies contain other species that may make the water unsuitable for human use. H_2O is certainly the largest and most important component of any water source, but this molecule is hardly the only chemical present in the water supply. It may be surprising to learn that water treatment does not eliminate all of the impurities from water. In fact, the treatment process itself contributes additional impurities to the water. However, the impurities added during the treatment process generally help to make water more suitable for human use.

suspended particles typically have diameters in the range of 1-100 nm); however, the distinction between a suspension and a solution on the basis of particle size is not well-defined. Experimentally, the differenece between the two types of mixtures is seen using the Tyndall effect, in which light is scattered by the suspended particles in a suspension (i.e., the solution appears cloudy), but is not scattered in a homogenous solution. Examples of suspended particles in water samples may include:

- bacteria
- floating debris (*e.g.*, twigs, bits of leaves, and trash)
- sand and dirt

The types and amounts of these species in a given water sample depend on the source of the sample, and what sort of treatment the water has undergone. Some of these dissolved species, such as O_2 gas, are unavoidable and do not detract from our ability to use the water. Other species, such as F^-, are desirable and are often added during the water-treatment process. Many of the species dissolved in water, however, are harmful for humans to drink, or otherwise render the water unsuitable for human use (*e.g.*, Ca^{2+} is responsible for "hard water", which can leave insoluble scum on appliances and industrial boilers). These products must be removed via water-treatment facilities.

Water Treatment Processes

Water can not be consumed in its natural state due to possible presence of:

- Floating objects *(Screening)*
- Algae *(Straining or Fine Screen)*
- Excessive Fe, Mn or Hardness *(Precipitation)*
- Suspended Solids *(Sedimentation)*
- Dissolved gases *(Aeration)*
- Taste, Odor or Color *(Adsorption or Aeration)*
- Organic or bacteriological pollution *(Disinfection)*

1. Collection of Water

The **water** is collected from the **sources** like a lake, river, or reservoir. The **water** is to be **transported from** this source to the **water treatment plant** for the water treatment process. This is **included** in the **collection of water**.

Generally, water treatment plants are **built** near the **water source** itself.

Screens

Objectives:

- Removal of coarse solids (pieces of woods, plastics, papers, rags, leaves, roots, etc.)
- Protection of pump, valves, pipe lines, impellers

Classification Based on:

- Opening size: *Coarse, Medium, Fine*
- Configuration: *Bar screens, Mesh screens*
- Cleaning Method: *Manual, Mechanical, Raked, Water jet*
- Screen surface: *Fixed, Moving*

2. Screening

Screening is done to remove the **floating matter** from the water during the **water treatment** process. **Surface water contains** a large number of **suspended particles** that increase the **unnecessary** load on the **treatment plant** units.

Screening is mostly done at the **intake point itself**. The large-sized **suspended particles** like **dried leaves**, **fallen twigs**, and **other floating debris**.

Two types of screens are used for screening:

Coarse Screens/ Bar screens

Bar grills are installed and **water** is allowed to pass through them in this **process**. 25 mm bars are installed at **75 to 100 mm center to center distance**. This traps **particles** of large size as the **water flows** through them.

Mostly the **bars** are kept in an **inclined position** so that they can be **cleaned easily** with racks to remove the **trapped particles**.

2. Fine Screens/ Automatic Strainers

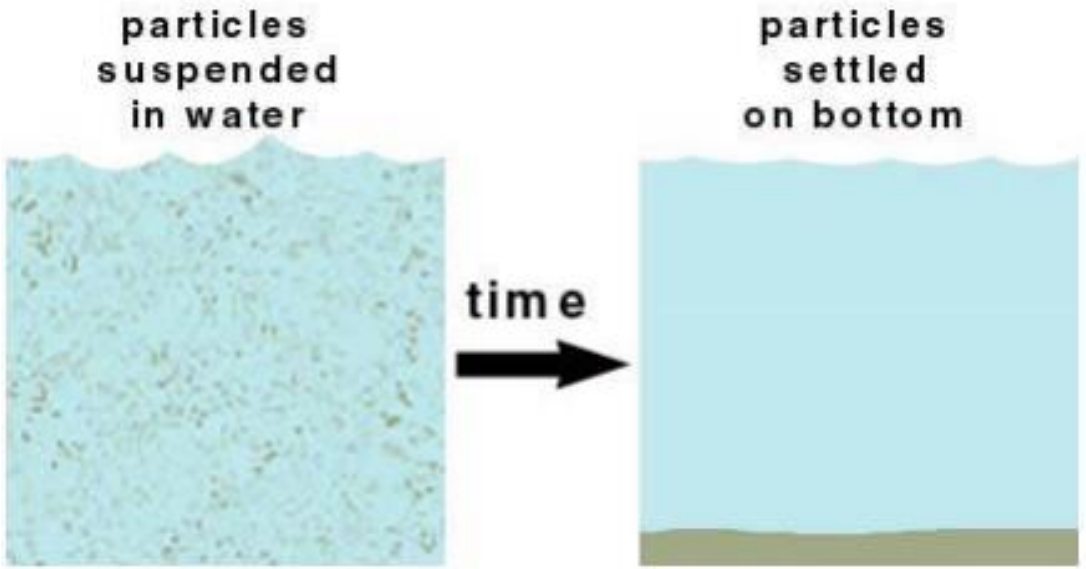
An **automatic device** is fitted in the **screens** so that the **trapped materials** can be removed on their own. Such type of **screens** is called **automatic strainers**.

3. Microstainers

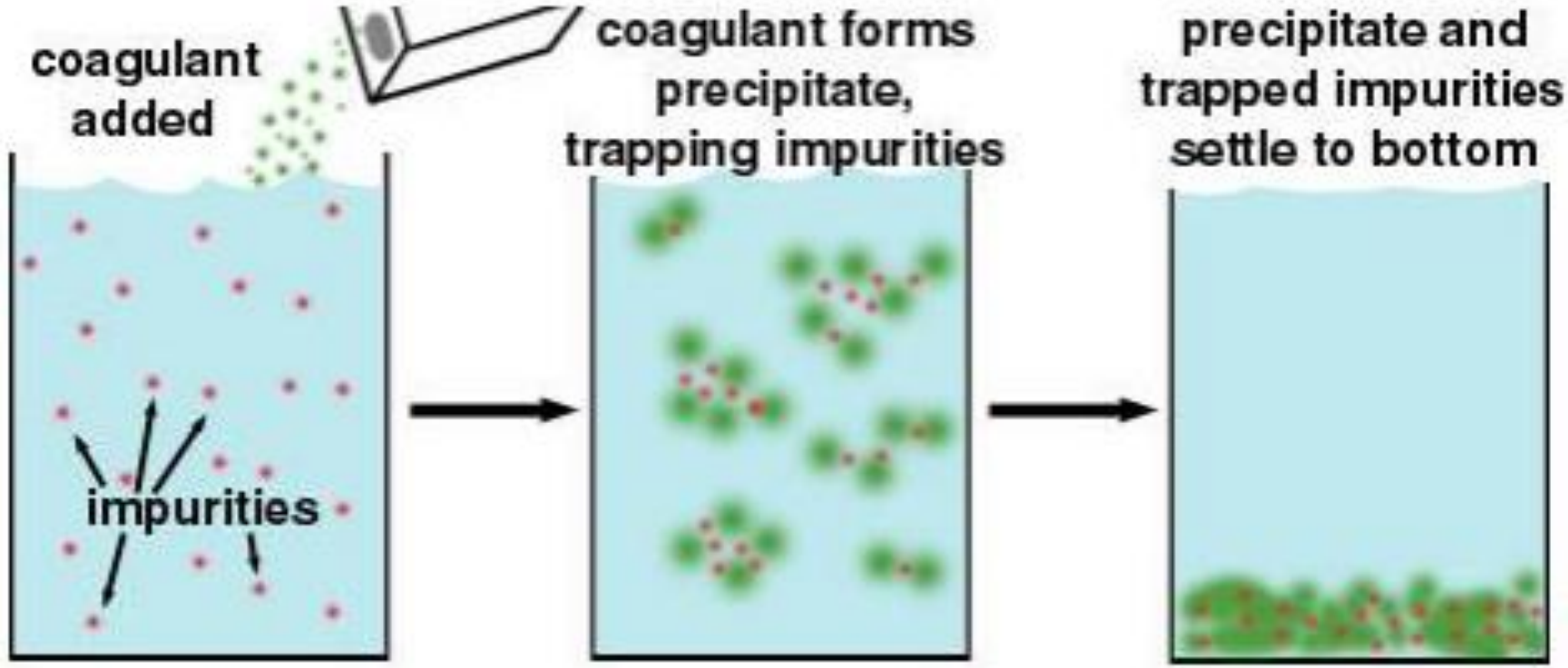
A **stainless steel** wire is used to make the cloth **designed** specially and it is **mounted** on t periphery of the **revolving** drum afterward. It has an **arrangement** for **backwashing** too. This **ensures** that it does not get **clogged**.

Sedimentation

Other suspended (insoluble) particles, such as sand and dirt, are small enough to pass easily through the screens. These particles must be removed from the water by another process known as **sedimentation** (Figure 5). When water is allowed to sit, heavy suspended particles (*e.g.*, sand) will settle to the bottom over time because they are denser than water. The water, now free of the suspended impurities, can be collected from the top without disturbing the layer of sediment at the bottom (which is eventually discarded).



Sometimes the insoluble particles are too small to settle out quickly enough to use sedimentation alone. Two processes, known as **flocculation** and **coagulation**, are used to create larger particles that will settle quickly to the bottom. In flocculation, small particles with non-rigid surfaces are made to agglomerate by mixing the water (and thus bringing the particles into contact with one another so that the surfaces can become stuck together). When the agglomeration of the particles gets large enough, the aggregate can settle in still water by sedimentation. Other suspended particles do not agglomerate well by flocculation. To remove these particles from the water, coagulation must be used. Coagulation is the process of gathering particles into a cluster or clot, often achieved by the addition of special chemicals known as **coagulants.** The most common coagulant used in water-treatment facilities is **aluminum sulfate** (alum, $Al_2(SO_4)_3$). ~~Other Al and Fe salts, including poly-~~


coagulant added
impurities
coagulant forms precipitate, trapping impurities
precipitate and trapped impurities settle to bottom

4. Clarification or Sedimentation with Coagulation

The **sedimentation** with coagulation is termed **clarification**. It is required to **increase** the efficiency of sedimentation as **stated above** during the **water treatment process**. Plain sedimentation **consumed** too much **time**.

How does clarification work?

The **colloidal particles** suspended in the water have a **negative** or positive charge **around** them. **Coagulants neutralize** this charge and **allow** these particles to **coagulate**.

Steps in Clarification in Water Treatment Process-

- **Addition** of measured amount of **chemicals** to the **water**
- Thorough **mixing** of water
- **Formation** of **precipitates** in water
- Formation of **flocs** which is formed by **coagulation initiated** by the precipitates
- **Sedimentation**

Aeration

Some of the methods used to remove this objectionable colour, odour, and taste are:

1. Aeration

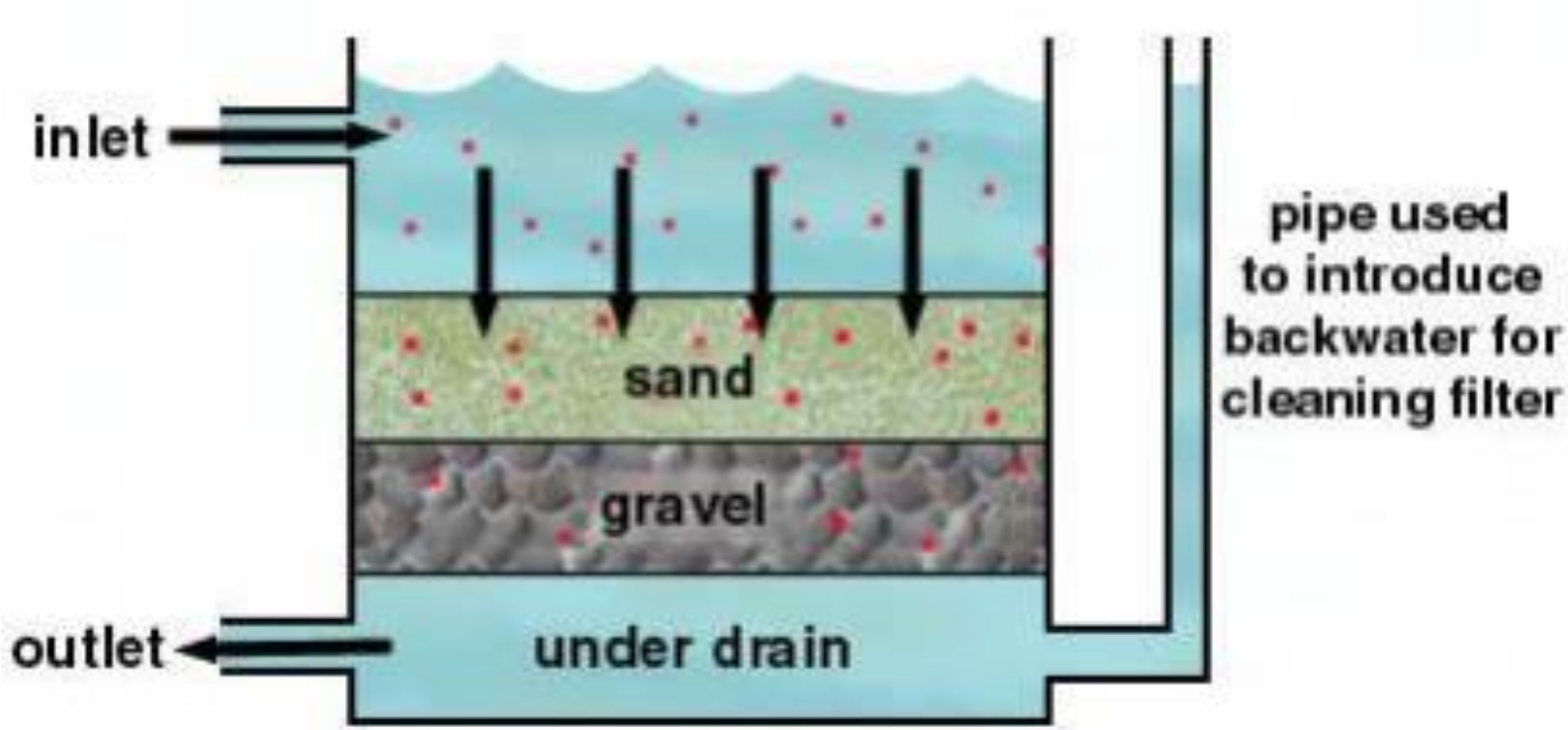
In aeration, air and water are mixed intimately.

It **mostly removes** the taste because of dissolved gases. It also **increases** the content of dissolved oxygen in the **water**.

Filtration

Often, the particles generated by the precipitation reactions described above are too small to settle efficiently by sedimentation. One strategy that is frequently employed to remove these solids is **gravity filtration** (Figure 7).In this process, water containing solid impurities (*e.g.*, precipitates from water softening) is passed through a porous medium, typically layers of sand and gravel. The force of gravity is used to push the water through the medium. The small water molecules pass through the holes between sand and gravel pieces. However, the solids (from precipitation) get stuck in the holes, and are thus retained in the porous medium. The water that passes through the bottom of the filter no longer contains those solid impurities.

Gravity filters at water-treatment plants have a pipe feeding into the under drain, the bottom layer where the clean water is collected. By adding water to the filter through this pipe, clean water can be forced upward through the filter to remove the solids that have collected in the filter. This process is used to clean the filter.


inlet
sand
gravel
outlet
under drain
pipe used
to introduce
backwater for
cleaning filter

Disinfection

After **filtration**, the next step of the **water treatment process** is disinfection. Disinfection includes the **inactivation** of pathogenic bacteria and other **microorganisms** that can cause diseases. This step is **essential** to control **water-borne diseases**.

A **disinfectant** is added in this step to **filtered water**. Skilled operators are **required** to carry out the process of **disinfection** so as to maintain the **appropriate dosage**.

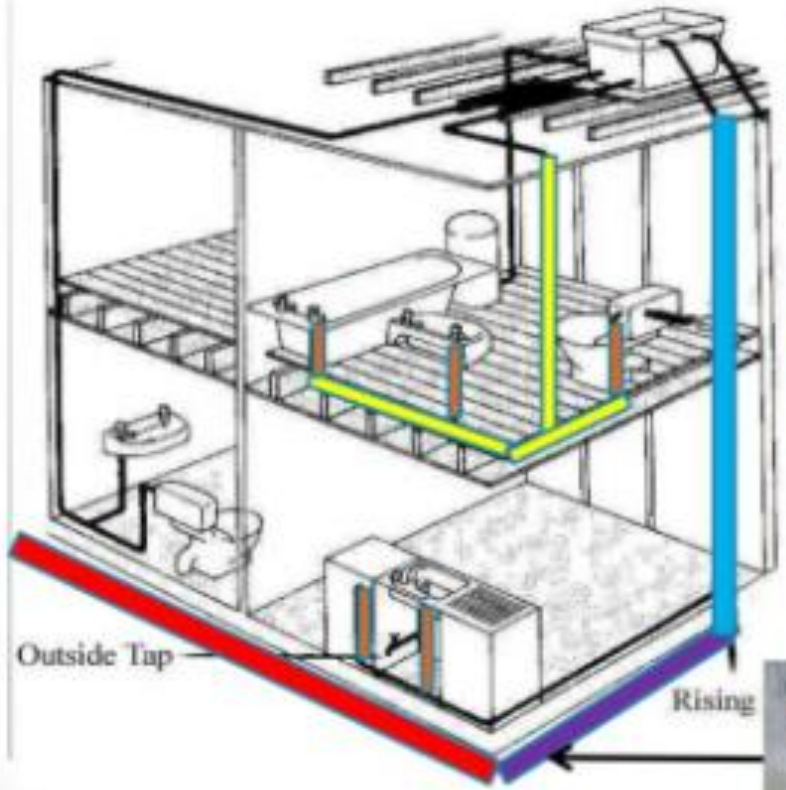
The most commonly used disinfection method is chlorination.

Negative side of chlorination

- By-product formation such as;
  - $CHCl_3$
  - $CHCl_2Br$
  - $CHClBr_2$
  - $CHBr_3$
- These are proven for cancer causing specially in bladder.

External gravity tank

Water Supply and Distribution System



SERVICE PIPE

DISTRIBUTION PIPE / SUPPLY PIPE

RISER

FIXTURE BRANCH

FIXTURE SUPPLY PIPE

Connecting pipes:

- **Service Pipe**

  The pipe from the water main or other source of portable water supply to the water distribution system of the building served.

- **Distribution Pipe / Supply Pipe**

  A pipe within the structure or on the premises which conveys water from the water service pipe or meter to the point of utilization.

- **Riser**

  A water supply pipe that extends one fully story or more to convey water to branches or to a group of fixtures.

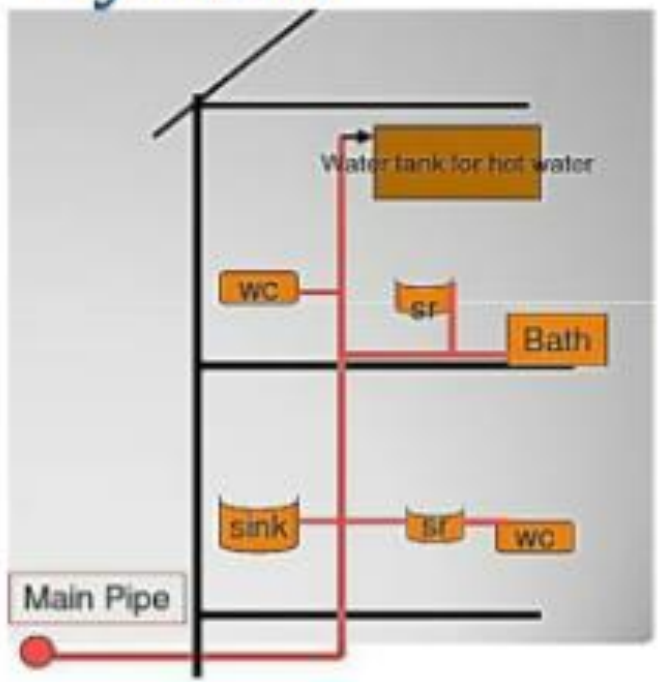
- **Fixture Branch**

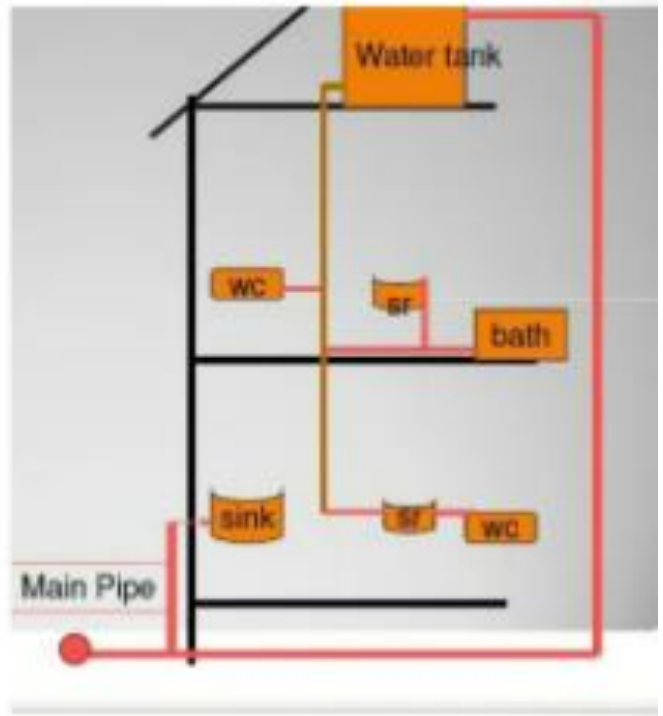
  The water supply pipe between the fixture supply pipe and the water distributing pipe.

- **Fixture Supply Pipe**

  A water supply pipe connecting the fixture with the fixture branch.

Direct System & Indirect System





Indirect System