MICROBIOLOGY COURSE MATERIAL

Semester - IV

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CC9: UNIT-6: WATER POTABILITY

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
CC-9: Unit - 6
SEMESTER – IV

❖ Introduction:

Drinking water is also known as potable water that is safe to drink or to use for food preparation. Typically in developed countries, tap water meets drinking water quality standards, even though only a small proportion is actually consumed or used in food preparation. Potable water is the one that is considered safe to drink. Non-potable water is untreated water from lakes, rivers, groundwater, natural springs, and untested ground wells. Water is important because it is needed for life to exist. Some uses of water include agricultural, industrial, household, recreational and environmental activities.

❖ Types of water source:

Three main sources of water are groundwater, surface water and rainwater. In arid regions where seawater is accessible (such as in the Middle East), desalination (the removal of salts from water) is used to generate drinking water.
There are two broad sources of water:

1. Surface Water is found in streams, lakes, rivers, wetlands and reservoirs.
2. Groundwater lies under the surface of the land, where it travels through and fills openings in the rocks. The rocks that store and transmit groundwater are called aquifers. Groundwater, which makes up around 22% of the water we use, is the water beneath the earth's surface filling cracks and other openings in beds of rock and sand.

There are several steps in the treatment process of potable water. These include:

(1) Collection; (2) Screening and Straining; (3) Chemical Addition; (4) Coagulation and Flocculation; (5) Sedimentation and Clarification; (6) Filtration; (7) Disinfection; (8) Storage; (9) and Distribution.

❖ Household Water Treatment

Even though EPA regulates and sets standards for public drinking water, many countries use a home water treatment unit to:

- Remove specific contaminants
- Take extra precautions because a household member has a compromised immune system
- Improve the taste of drinking water

Household water treatment systems are composed of two categories: point-of-use and point-of-entry. Point-of-entry systems are typically installed after the water meter and treat most of the water entering a residence. Point-of-use systems are systems that treat water in batches and deliver water to a tap, such as a kitchen or bathroom sink or an auxiliary faucet mounted next to a tap. The most common types of household water treatment systems consist of:

- Filtration Systems: A water filter is a device which removes impurities from water by means of a physical barrier, chemical, and/or biological process.
- Water Softeners: A water softener is a device that reduces the hardness of the water. Mostly sodium or potassium ions are used to replace calcium and magnesium ions that create "hardness".
- Distillation Systems: Distillation is a process in which impure water is boiled and the steam is collected and condensed in a separate container, leaving many of the solid contaminants behind.
- Disinfection: Disinfection is a physical or chemical process in which pathogenic microorganisms are deactivated or killed. Examples of chemical disinfectants are chlorine, chlorine dioxide, and ozone. Examples of physical disinfectants include ultraviolet light, electronic radiation, and heat.

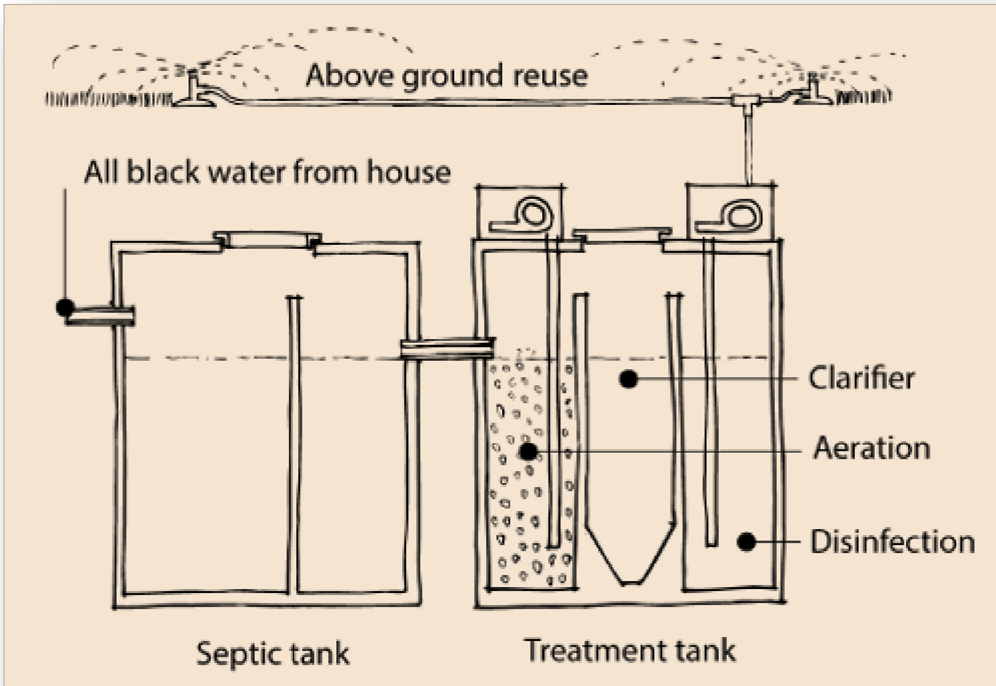


Figure 1: Diagrammatic view of a Household Water Treatment Plant

Water is vital for everyday life and serves as an essential element for our health, hygiene and the productivity of our community. The water treatment process may vary slightly at different locations, depending on the technology of the plant and the water it needs to process, but the basic principles are largely the same.

1. **Pre-Treatment (Screening):** Pumps bring "raw" or untreated water, often from lakes or rivers, into the purification plant through screens that exclude fish, weeds, branches and large pieces of debris. Screening may not be necessary for groundwater. The plant may aerate the water at this point to increase the oxygen content and thus help remove problematic odors and tastes.

2. **Coagulation/Flocculation:** During coagulation, liquid aluminium sulfate (alum) and/or polymer are added to untreated water (raw water). When mixed with the water, this causes the tiny particles of dirt present to stick together or coagulate. These groups of dirt particles then join to form larger, heavier particles called flocs, which are easier to remove by settling or filtration. The purpose of these two steps is to clear water of the small particles that makes it turbid or cloudy.

Turbidity renders the water hard to disinfect. The water is rapidly agitated to disperse coagulant chemicals throughout it. The small particles, including many bacteria, begin to form large clumps called flocs or floccules. In flocculation, the water is mixed gently so that these clumps combine and precipitate out further.

3. **Sedimentation:** As the water and the floc particles progress through the treatment process, they move into sedimentation tanks. Here, the water moves slowly, causing the heavy floc particles to settle to the bottom. The floc that collects at the bottom of the tank is called sludge, and is piped to drying lagoons. In direct filtration, the sedimentation step is not included, and the floc is removed by filtration only. The water and flocs are pumped into sedimentation basins. Here, the flocs settle beneath the water so that they can be removed. About 85 to 90 percent of the suspended particles responsible for turbidity are removed at this point, including large amounts, but not all, of the bacteria.

4. **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. In filtration, the water flows through a multilayer medium such as quartz sand, activated carbon or anthracite coal in order to remove up to 99.5 percent of the solid materials remaining in it, whether flocs, microbes or minerals. This step usually is the last one in the process of removing solids from the water.

5. **Disinfection:** Water is disinfected before it enters the distribution system to ensure that any disease-causing microorganisms are destroyed. Chlorine is used because it is a very effective disinfectant, and residual concentrations can be maintained to guard against possible microbial contamination in the water distribution system. Disinfection kills off disease-bearing organisms in the water. Although chlorine is still one of the most common disinfectants, ultraviolet radiation and ozone gas are becoming more widespread. Chlorine is increasing in cost and has some known toxic effects on humans and fish. In addition, some disease-carrying microbes like *Giardia* and *Cryptosporidium* resist chlorine.

6. **Sludge Drying:** Solids that are collected and settled out of the water by sedimentation and filtration are removed to drying lagoons.

7. **Fluoridation:** Water fluoridation happens where community water supplies are treated with a concentration of the free fluoride ion. This is adjusted to an optimum level to reduce dental decay. We're required to fluoridate in accordance with the NSW Fluoridation of Public Water Supplies Act 1957.

8. **pH Correction:** Lime is added to filtered water to adjust the pH and stabilize the naturally soft water. This minimizes corrosion in the distribution system, and within customers' plumbing.

9. **Corrosion & Scale Control:** The pH of the water is adjusted so that it neither corrodes nor deposits too much scale in pipes. Excessive amounts of scale can disrupt plumbing systems, but small quantities help pipes to function at their best. However, no amount of corrosion in the water distribution system is desirable. As well as causing leaks and other damage, corrosion releases pipe metals like lead and copper that jeopardize human health.

10. **Chlorination:** Chlorination is the process of adding chlorine to drinking water to disinfect it and kill germs. Different processes can be used to achieve safe levels of chlorine in drinking water. Chlorine is available as compressed elemental gas, sodium hypochlorite solution (NaOCl) or solid calcium hypochlorite ($Ca(OCl)_2$.

11. **Taste & Odor Control:** Unpleasant tastes and odors remaining in the water, such as those from algae, often do not pose any health hazards. Yet consumers prefer to do without them. So water purification plants often remove tastes and odors through additional chemical treatment, ozonation or filtration. At this stage, some municipalities also require the addition of fluoride to the water for dental health.

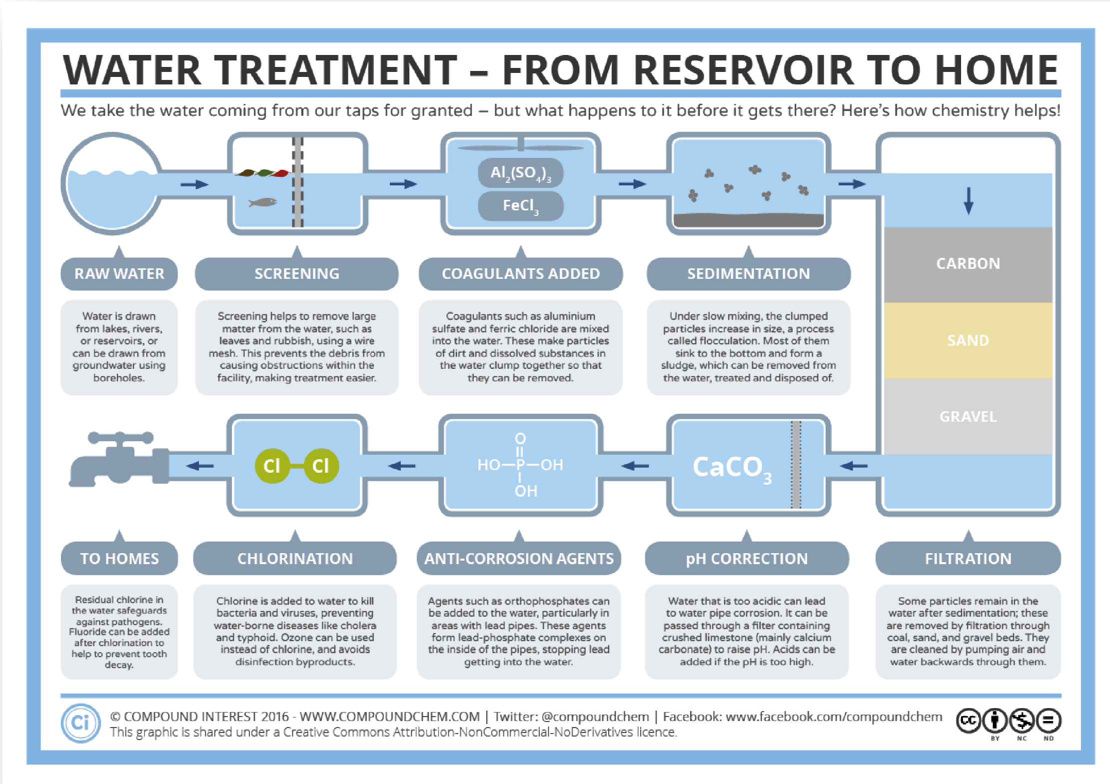


Figure 2: Schematic view of the Water Treatment Process

❖ Methods to detect potability of water samples:

The following points highlight the top two techniques used for determining the potability of water. The techniques are:

1. Coliform Test Technique
2. Membrane Filter Technique.

1) Coliform Test Technique (Multiple-Tube Fermentation Test):

Coliform-test-technique (or MTFT) is a standard method followed all over the world to determine whether the water is potable or faecally polluted. The technique involves three successive steps, namely, presumptive test, confirmed test, and completed test. In the presumptive test, lactose broth tubes are inoculated with three different water volumes to give an estimate of the most probable number (MPN) of coli forms in water. Tubes which are positive for gas production are inoculated into brilliant green lactose bile broth in the confirmed test, and positive tubes are used to calculate the most probable number (MPN) value. Presence of coliform bacteria in water samples are established in completed tests. A general scheme of coliform-test technique is presented in Fig. 31.2.

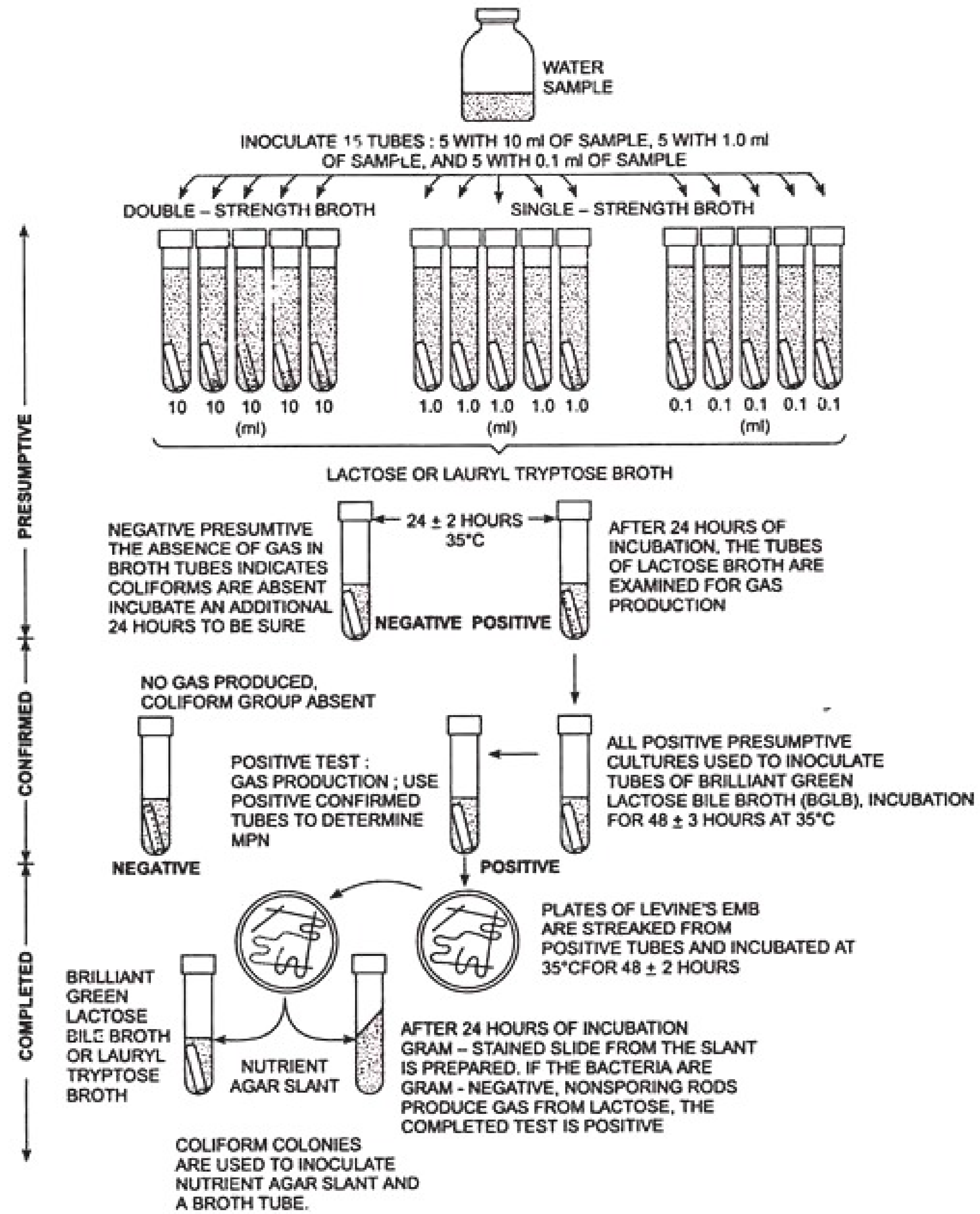


FIG. 31.2. Coliform-test-technique (or multiple-tube fermentation test) used to determine whether water is potable or faecally polluted. MPN = most probable number, EMB = eosin-methylene blue agar.

2) Membrane Filter Technique:

This technique is used for bacteriological examination of water to determine its potability was developed in Germany during World War II and, at present, is being considered advantageous over coliform test technique because of its significant advantages. In this technique, a thin membrane filter-disc is used. The filter-disc consists of cellulose derivatives and can retain all the bacteria on its surface from the water sample. The water is filtered through filter-disc and the disc is then transferred with a sterile forceps on to a thin absorbent pad that has previously been saturated with the appropriate medium (generally Endo-broth [GM-9] medium) and accommodated within a Petri dish. The Petri dish containing absorbent pad and filter-disc is incubated at 37°C for 18-24 hours. The medium diffuses through the pores of the filter-disc and provides nutrient to the bacteria. After the incubation is over, one can see colonies developing upon the filter-disc. The characteristic colonies of different bacteria could now be studied to determine water potability.

- **Advantages:**

(i) A large volume of water can be analyzed in a short period of time without much expenses.

(ii) The membrane filter-disc can be transferred from one medium to another to differentiate organisms.

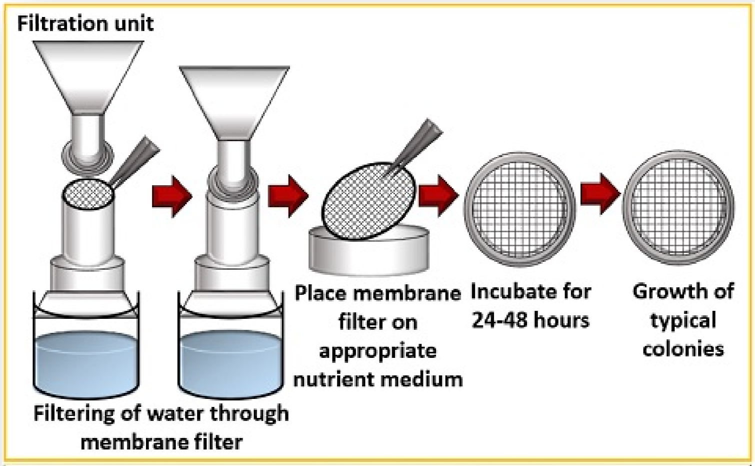
(iii) Quantitative estimations of certain bacterial types, e.g., coliforms can be done using appropriate selective media even when the bacterial types in question are present in small numbers.

(iv) This technique requires much less equipment and, therefore, can be operated direct in the field.

- **Disadvantages:**

(i) High turbidity waters limit volume sampled.

(ii) High population of background bacteria result in overgrowth.



METHOD OF MEMBRANE FILTRATION

A simplified qualitative **Presence-Absence test** has been proposed as an alternate procedure for detecting coliform bacteria in potable water. Based upon the analysis of the combined data base, it is clear that the presence-absence test is as sensitive as the current coliform methods for the examination of potable water. The Presence-Absence (P-A) test is a presumptive detection for coliforms in water. The test involves a simple modification of the multiple-tube procedure. A 100 mL test sample is inoculated into a single culture bottle. When using this simple test, the sample turns blue-green in the presence of coliform bacteria, but *E. coli* growth is confirmed by blue fluorescence under UV light. Simply use the UV light on the sample to see if *E. coli* is present.

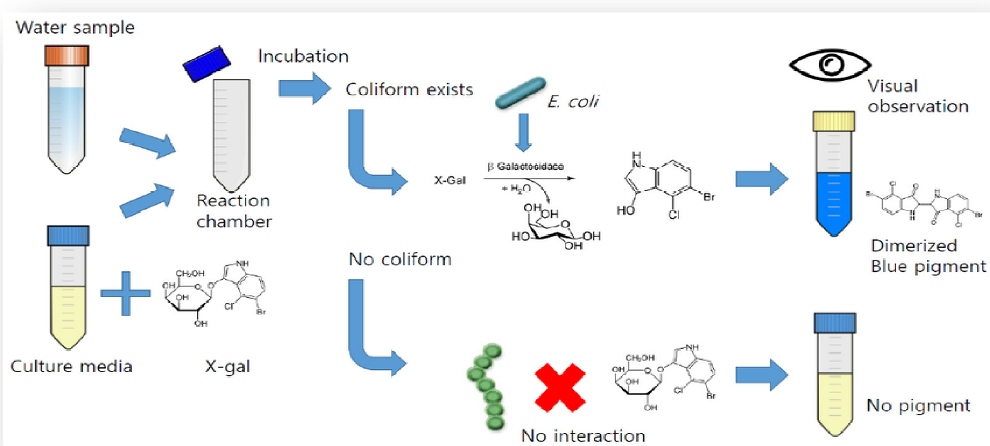


Figure 3: Schematic view of Presence-Absence Test