PHYSICO-CHEMICAL AND BIOLOGICAL PROPERTIES OF WATER

Physical properties of water

Physical appearance : water is a colorless, odorless and tasteless liquid.

Boiling point : Boiling point is defined as the temperature at which the vapour pressure of water becomes equal to the pressure surrounding the liquid. Boiling point of water is 100 degree centigrade.

Freezing point : The temperature at which a substance changes state from liquid to solid. The freezing point of water is 0 degree celsius or 32 degree fahrenheit.

Specific heat : water has a specific heat capacity of 4.2 joules per gram at 25 degrees centigrade. This is due to the extensive hydrogen bonding between water molecules. A higher specific heat of a substance means that a large amount of heat is required to raise the temperature of the substance. Water covers around 70% of Earth's surface and its high specific heat plays a very important role as it absorbs a lot of heat

without a significant rise in temperature. High specific heat also help plants and animals in maintaining body temperature.

Density of water: The density of water is 997 kilogram per metre cube

Viscosity of water: The viscosity of water is 1.0016 millipascals second at 20 degree centigrade. Water has low viscosity and therefore can easily flow.

Surface tension of water : Surface tension is the tendency of the fluid to shrink in a minimum surface area.

Water has high surface tension that is about 72 mN/m at room temperature.

Refractive index of water: Refractive index of water is 1.3330 at 20 degree centigrade.

Compressibility of water: Compressibility is defined as the function of temperature and pressure. For water the compressibility at zero degree celsius is 5.1×10^{-10} Pa^{-1} and 4.44×10^{-10} Pa^{-1} at 45 degree centigrade.

Dielectric constant of water: It is the measure of how easily the material is polarised by electric field. The dielectric constant for water is very high which is 78.6. This constant plays an important role in water being a universal solvent.

Chemical properties of water

Amphoteric nature: amphoteric nature of water means that it can behave both

as an acid and base. Due to presence of hydrogen, water can behave as an acid in a chemical reaction. The oxygen atom present in water molecule has two lone pairs, one of which could be used to form a bond with an hydrogen (H^+) and therefore water molecule acts as a base in a chemical reaction.

Redox reactions: As water can be reduced and oxidized, it is useful in redox reactions. One very significant reaction occurs in photosynthesis, Where water molecule is oxidized in the presence of light.

pH: the pH of water is 7 at 25^0Celsius. Water with a pH less than 7 is

considered acidic for example the water received during acid rain. pH more than 7 is basic. The pH of surface water usually ranges between 6.5 and 8.5. Water with low pH often contains high amount of heavy metals as it is able to leach heavy metals from environment.

Self ionization: liquid water undergoes some ionization to form hydronium ion and Hydroxide ions.

Dissolved oxygen (DO) It is the amount of oxygen present in water. The water body receives the oxygen from atmosphere and aquatic plants. Running water has usually more oxygen than standing water. All aquatic plants

need dissolved oxygen for their survival. Sometimes due to addition of excess organic matter in water bodies, DO level goes down. Water bodies with the high organic nutrients particularly nitrogen, Phosphorus, iron etc. cause luxuriant growth of algae (algal Bloom). This results in decreased oxygen level resulting in death of aquatic animals. Dissolved oxygen is usually reported in milligrams per litre (mg/L). It is also measured in parts per million (PPM). There are several modern techniques for measurement of dissolved oxygen such as electrochemical or optical sensor technique.

Chemical oxygen demand (COD):

chemical oxygen demand (COD) analysis is a measurement of oxygen depletion capacity of a water sample contaminated with organic waste matter. Specifically it measures the equivalent amount of oxygen required to chemically oxidize organic compounds in water. COD is used as a general indicator of water quality and it is an integral part of all water quality management programs.

Method to determine COD

This is a chemical procedure. It involves a two-hour digestion at high temperature under acidic conditions using potassium dichromate as an oxidant for oxidizing any organic matter

present in water sample. Here silver sulphate is used as a catalyst. Following the digestion, the extent of oxidation is measured through indirect measurement of oxygen demand biochemical oxygen demand via electrons consumed in the reduction of Cr^{6+} to Cr^{3+}. This can be done by titration or spectrophotometry.

Biochemical oxygen demand (BOD): represents the amount of oxygen consumed by bacteria and other microorganisms while they decompose organic matter under aerobic (oxygen present) conditions at a specific temperature.

Method to determine BOD of water: BOD determination requires taking two measurements. The sample water is taken and the dissolved oxygen(DO) level in water is determined immediately. Next the sample is incubated for 5 days and then the dissolved oxygen or DO value is again determined. The difference between the initial value and final value gives the amount of oxygen required by microorganisms to oxidize the organic compounds present in sample water.

Higher BOD indicates lower water quality. Lower BOD indicates good water quality.

BOD bottle: BOD bottle or incubation bottle is the main apparatuse used for

biochemical oxygen demand test. BOD bottle is used for incubating dilute samples under 20^0C of temperature. They are made from Boro silicate glass for

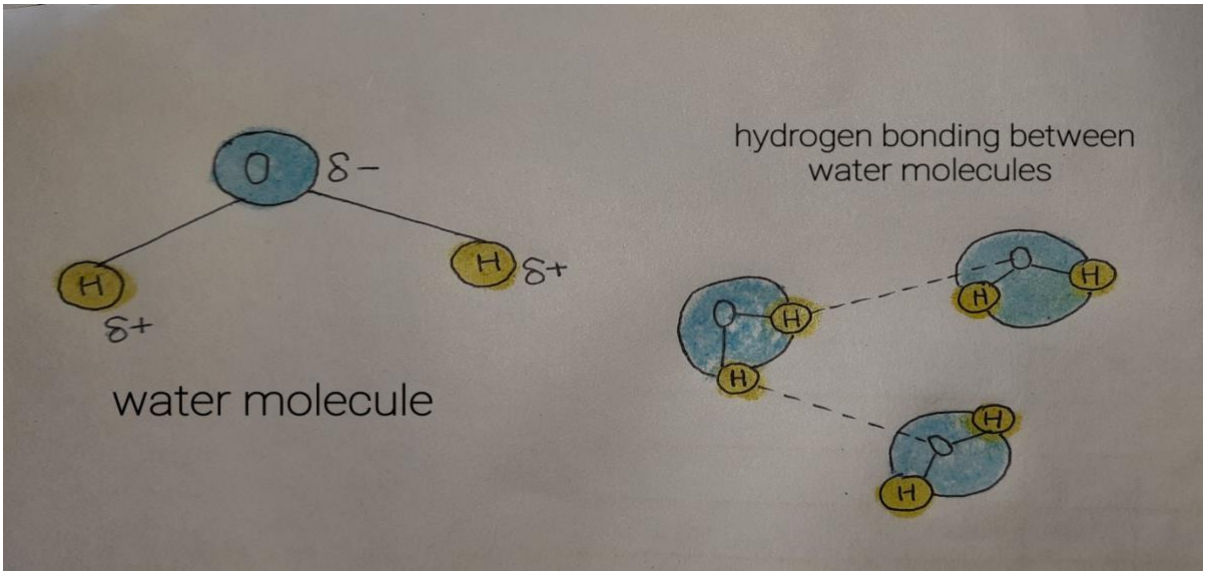
higher chemical resistance and have a 300 ml capacity.

BOD bottle

Biological properties of water

- About 60 to 75% of human body weight is composed of water.
- Even if 4% of that water gets lost dehydration occurs.
- A loss of 15% of body water can lead to death.
- All life forms depend on water.

Molecular structure:



water is a simple molecule composed of two small positively charged hydrogen atoms and a large negatively charged oxygen atom. Water is an inorganic transparent, tasteless, odorless and nearly colourless chemical substance. 71% of Earth's surface (mainly in oceans and seas) is covered by water.

Groundwater equal = 1.7 %

Glaciers and ice caps (Antarctica and Greenland) = 1.7%

Air, cloud and precipitation = 0.001%

1.Water is universal solvent:

water is a polar molecule. Due to this, it interacts very well with other polar molecules. This includes interaction of one water molecule with other molecules of water. The positive hydrogen of one water, bonds with negative oxygen of other water molecule. These bonds are responsible for the Cohesive forces between water molecules.

These forces help the plants in ascent of sap. It helps in maintaining the water column in xylem elements. Cohesion also contributes towards high boiling

point of water. Due to this property it helps in regulating body temperature.

2.Microbial contamination of water

Contamination of water by the presence of microbes stands to be a major cause of concern for human civilisation. Many types of harmful microbes are naturally present in water.

Below a brief listing of such microbes is given:

Bacteria for example Cholera, Shigella, Typhus, Salmonella etc.

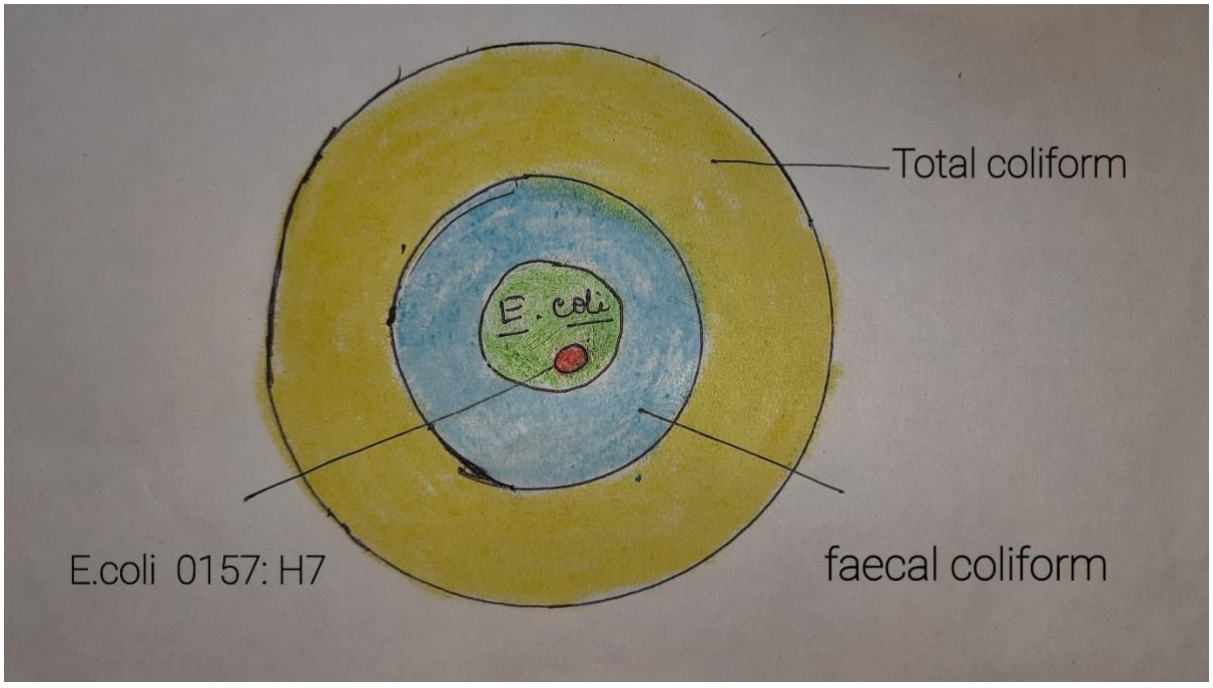
Virus eg. Hepatitis, Polio, encephalitis, meningitis etc.

Protozoans eg Amoeba, giardia etc.

Helminths eg. Roundworms,Guinea worm, hookworms.

Total coliform bacteria testing

Total coliform bacteria test is the main indicator of water potability (suitability



of water as being safe for drinking and food preparation).

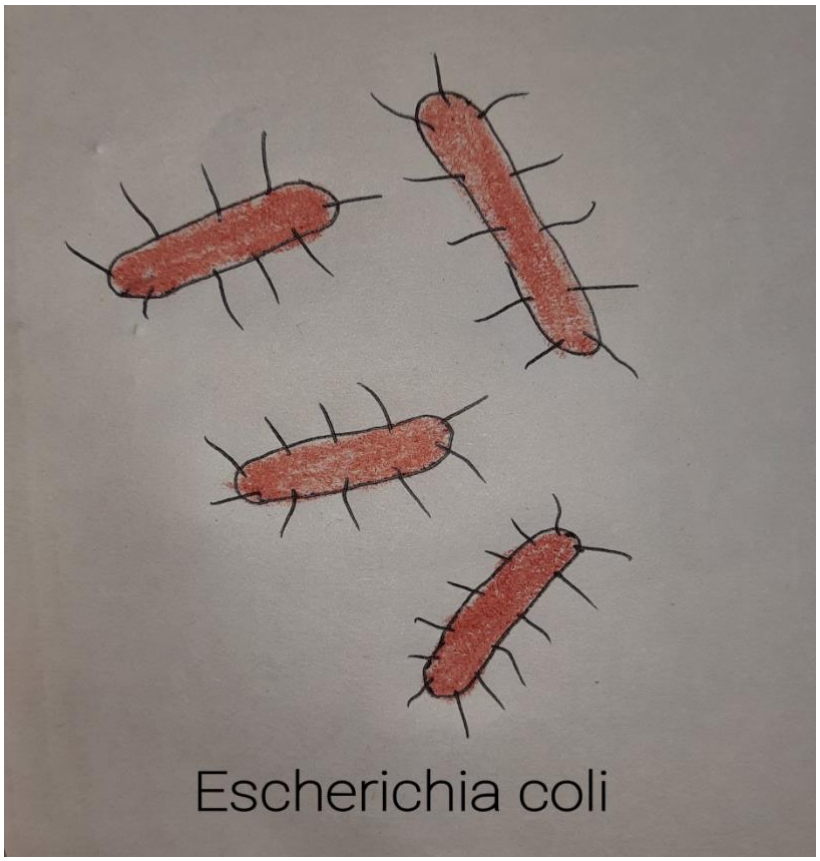
Coliforms are Bacteria that are always present in the digestive tracts of animals and human beings, and are found in their waste.

(A) **Total coliforms** include bacteria that are found in the soil, in water that has been influenced by surface water and in human or animal waste.

(B) **Fecal coliforms** are the entire group of the bacteria that exist in the gut and faeces of warm blooded animals. faecal coliforms are typical indicators of contamination of water by human and animal waste.

(C) Escherichia coli (E.coli)

E.coli is the main species in faecal



coliforms. It is Gram Negative, facultative anaerobic, rod shop coliform bacteria. It is usually

found in lower intestine of warm blooded animals.

E.coli 0157: H7 is a shiga-toxin producing E.coli. it is a Enterohemorrhagic bacterial strain that is an important food and water borne pathogen that causes diarrhoea, hemorrhagic colitis and hemolytic-uremic syndrome (HUS) in humans.

Coliform test techniques

Two techniques are generally used to detect the presence of coliforms in water.

(a) **Multiple fermentation tube or most probable number (MPN)**

In this technique measured amount of water samples are placed in test

tubes containing culture media. The test tubes are incubated for standard time at standard temperature.

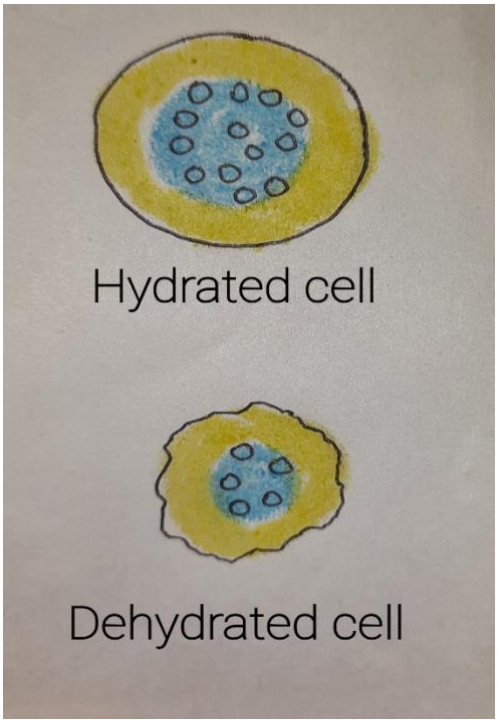
(b) **Membrane filter technique**

In this technique, a measured amount of sample is passed through a filter that retains bacteria. The filter is then transferred to a culture medium and incubated.

PCR method:

This method can detect coliform bacteria using lac Z gene (gene B-galactoseidase) and E coli bacteria using the Lam B gene that codes the maltose transport protein.

3. Cell turgidity



The turgid state of the cell is maintained by water. It helps maintain cell shape and size.

4. Cell membrane functions

Cell membrane is composed of lipid-bilayer and several extrinsic and

intrinsic proteins. the Lipid bilayer is made up of phospholipid molecules. Polar end of each molecule faces outward and is hydrophilic in nature. It interacts with the water molecules present outside. The nonpolar tail of each phospholipid molecule is hydrophobic in nature. This end repels water molecules.

5. Chemical reactions

Photosynthesis, the most important reaction taking place in plants requires water.

Almost all chemical reactions in plants and animals require water. Water buffers the cells from harmful effects of acids and bases.

6. Phloem transport

In the phloem of plants, food is transported in the form of sucrose a water-soluble disaccharide.

THANKS

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