UNIT - I / WATER AND ITS TREATMENT

1.2 INTRODUCTION

1.2.1 SOURCES OF WATER

1.2.2 WATER QUALITY PARAMETERS

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Water is the most important compound essential for the survival of all living organisms. About 80% of the earth's surface is covered by water. Besides being a supporter of life, water plays a unique role in industries. Water is used in the power generation industry for the production of the electric current through steam generation. It is also used as a coolant in nuclear power plants and chemicals plants. Water is widely used in other fields such as production of steel, atomic energy, textiles, irrigation, etc.

The process of removing of all types of impurities from water and making it fit for domestic or industrial purposes is called water technology or water treatment.

1.2.1 SOURCES OF WATER

The main sources of water are

- Rain Water
- Surface water
- Underground water
- Sea water

Impurities in Water

The common impurities present in natural waters may be classified as follows.

1. **Dissolved minerals** – mostly comprise of carbonates, bicarbonates, sulphates and chlorides of calcium, magnesium, sodium and potassium.
2. **Dissolved gases** – mostly air and carbon dioxide.
3. **Suspended matter** – mostly mineral matter, giving turbid or muddy water. Organic matter may also be present.
4. **Microscopic matter** – consists mostly of plant and bacterial life giving colour, taste and odour.

In general, the removal of impurities from water of classes 1, 2 and 3 form the chief problem for industrial usage, and 3 and 4 for municipal supplies.

1.2.2 WATER QUALITY PARAMETERS

The demand for pure water is growing day by day and it is very important to decide the quality of water. Water quality determines the ‘goodness’ of water for particular purposes. The water used for domestic and industrial purposes should be free from toxic substances and pathogenic organisms. The following are some of the parameters which determine the quality of water.

S.No.	Water Quality Parameters	Maximum acceptable limit
1.	Colour	15 TCU (True colour unit).
2.	Odour	Odourless
3.	Turbidity	less than 5 NTU (Nephthalometric turbidity unit)
4.	pH	6.5 – 8.5.
5.	Hardness	350 ppm.
6.	Alkalinity	300ppm.
7.	TDS	300mg/L.
8.	COD	250mg/L
9.	BOD	30mg/L
10.	Fluoride	0.7ppm
11.	Arsenic	0.01mg/L

1. Colour:

- Pure water should be absolutely colourless. Therefore any types of colour appearance in water indicates water pollution.
- Natural water is often coloured due to the degradation of organic matter or untreated discharge from textile, dying, wood pulp, leather industries.
- If colour is due to suspended material, it is called as apparent colour. Colour given by dissolved material that remains even after removal of suspended material is called true colour or real colour.
- The guideline value (maximum acceptable level) for colour of drinking water is 15 TCU (True colour unit).

2. **Taste and odour:**

- Pure water is always tasteless and odourless. Therefore if any types of taste and odour is present, it indicates water pollution.
- Bitter taste – due to presence of iron, aluminium, manganese, sulphate or excess lime.
- Soapy taste – presence of large quantities of sodium bicarbonate.
- Brackish taste – presence of unusual amount of dissolved salts.
- Palatable taste – presence of dissolved gases(CO_2) and minerals (like nitrates)
- Disagreeable odour – due to the presence of living organisms and decaying vegetable matter.

3. Turbidity:

- Turbidity is a measure of the ability of light to pass through water. It is due the presence of finely divided, insoluble impurities that are suspended in water. Turbidity is measured in Nephelometric Turbidity Units (NTU's).
- Suspended Solids usually enter the water as a result of soil erosion. Turbidity measurements also take into account algae and plankton present in the water.
- High turbidity affects submerged plants by preventing sufficient light from reaching them for photosynthesis.
- High turbidity also has the capacity to significantly increase water temperature.
- Drinking water should have turbidity less than 5 NTU (Nephthalometric turbidity unit)

4. Total dissolved solid (TDS):

- If water is filtered to remove suspended solid, the remaining solid in water indicates total dissolved solid.
- Dissolved solid may be organic (animal or plants waste) or inorganic compounds (carbonate, sulphate, bicarbonate etc.). These compounds give variety of effects like hardness, taste, odour etc. depending on nature of dissolved solid.
- If the dissolved solid in water exceeds 300 mg/lit, it adversely affects living organisms as well as industrial products.

5. pH

pH is a measure of the acidity or alkalinity of water. It is usually measured by using a colorimetric test - litmus paper changes colour with increased acidity or alkalinity. pH is given by the formula,

$$pH = -\log_{10}[H^+]$$

pH varies naturally within streams as a result of photosynthesis. Death of most aquatic fauna may result from extremely acid or alkaline water. The pH scale ranges from 0 to 14.

Acidic range: 0 to 6.9

Neutral: 7

Alkaline range: 7.1 to 14

A pH range of 6.5 – 8 is optimal for freshwater. A range of 8 – 9 is optimal for estuarine and sea water. Range of pH for consumable water is 6.5 – 7.5.

6. Hardness:

- Hardness is the characteristic property of water which "prevents the lathering of soap".
- This is due to the presence of certain salts of calcium, magnesium and other heavy metals dissolved in water.

How to detect hardness?

When a sample of water is treated with soap solution, if it does not produce lather, but forms a white scum or precipitate, the water contains hardness.

This is due to the formation of insoluble soaps of calcium and magnesium.

$$C_{17}H_{35}COONa + CaCl_2 \longrightarrow (C_{17}H_{35}COO)_2Ca \downarrow + 2\ NaCl$$

(sodium stearate) (hardness causing substance) Calcium stearate (insoluble soap)

TYPES OF HARDNESS

- Hardness is classified into two types based on dissolved salts present in water.

They are: Temporary Hardness (or) Carbonate Hardness (CH)

Permanent Hardness (or) Non-Carbonate Hardness (NCH)

TEMPORARY HARDNESS

Temporary Hardness is due to the presence of dissolved bicarbonates of calcium and magnesium. Thus the salts responsible for temporary hardness are $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$. Temporary hardness is otherwise known as Carbonate Hardness (or) Alkaline Hardness.

Temporary Hardness can be removed by following two processes:

- Boiling of water
- Adding lime

The above two processes convert the bicarbonates into insoluble carbonates and hydroxides, these are removed by filtering.

PERMANENT HARDNESS

Permanent hardness is due to the presence of dissolved chlorides and sulphates of calcium and magnesium. The salts responsible for permanent hardness are $CaCl_2$, $MgCl_2$, $CaSO_4$ and $MgSO_4$. Permanent hardness cannot be removed by boiling. It can be removed by the following two processes:

- Lime – soda process
- Zeolite process

Permanent Hardness is otherwise known as Non-Carbonate Hardness (NCH) (or) Non – alkaline Hardness.

TOTAL HARDNESS

Total hardness = Temporary Hardness + Permanent Hardness

Classification Of water based on hardness

On the basis of hardness, water can be classified into two types:

- Hard Water and Soft Water

HARD WATER

Water which does not produce lather easily with soap solution, but forms a white precipitate, is called **hard water**. **It contains dissolved salts of calcium and magnesium**.

SOFT WATER

Water which lathers easily with soap solution, is called **soft water**. I**t does not contain dissolved calcium and magnesium salts.**

7. Alkalinity

Alkalinity is a measurement of dissolved alkaline substances in water (higher than 7.0 pH). It is generally termed as basicity of water. It tells us the water's ability to neutralize acid. It is due to the presence of soluble hydroxide, carbonate and bicarbonate ions. It also may be due to the dissolution of phosphates, limestone, and borates in water sources.

There are three primary types:

1. Hydroxide alkalinity – due to (OH^-) ions
2. Carbonate alkalinity - due to (CO_3^-) ions

3. Bicarbonate alkalinity - due to (HCO_3^-) ions

Significance

Higher alkalinity levels in surface waters will buffer acid rain and other acid wastes and prevent pH changes that are harmful to aquatic life.

8. Chemical Oxygen Demand (COD)

Chemistry Oxygen Demand is the amount of oxygen required to oxidise the organic matter and oxidisable inorganic matter present in a water sample under acidic conditions. The oxidation depends on various factors like pH, Temperature & reaction time.

Significance of COD:

1. It is a measure of both the biologically oxidisable & biologically inert organic matter.
2. Higher COD levels mean a greater amount of oxidisable organic material in the sample, which will reduce dissolved oxygen (DO) levels. A reduction in DO can lead to anaerobic conditions, which is deleterious to higher aquatic life forms.

9. Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand is the quantity of oxygen required by the microorganisms for the biological oxidation of organic matter present in waste water under standard experimental conditions. It is calculated over five days at a specific temperature of 20°C.

Significance of BOD:

1. It represents the quantity of oxygen which is consumed in the course of aerobic processes of decomposition of organic materials, caused by microorganisms.
2. The BOD therefore provides information on the biologically-convertible proportion of the organic content of a sample of water.
3. BOD of water is essentially important for understanding the polluting potential of the water.
4. The more the BOD levels in a water body, the more polluting potential it has. It is used as an index in sewage or wastewater treatment plants.

10.Fluoride

Fluoride is a naturally-occurring mineral, present in in soil, food. groundwater and oceans. It helps prevent cavities in children and adults by making the outer surface of your teeth (enamel) more resistant to the acid attacks that cause tooth decay.

It is also produced synthetically for use in drinking water, toothpaste, mouthwashes and various chemical products.

Significance of fluoride

- Fluoride comes from fluorine, which is a common, natural, and abundant element.
- Adding fluoride to the water supply reduces the incidence of tooth decay.
- Fluoride protects teeth from decay by demineralization and remineralisation.
- Too much fluoride can lead to dental fluorosis or skeletal fluorosis, which can damage bones and joints.
- A fluoride content of 0.7 ppm is now considered best for dental health. A concentration that is above 4.0 ppm could be hazardous.

11.Arsenic

Arsenic is an element that occurs naturally in rocks and soil and is used for a variety of purposes within industry and agriculture. It is also a by-product of copper smelting, mining, and coal burning. Arsenic can combine with other elements to make chemicals used to preserve wood and to kill insects on cotton and other agricultural crops.

Arsenic in water:

Arsenic can enter the water supply from natural deposits in the earth or from industrial and agricultural pollution. Some industries release thousands of pounds of arsenic into the environment every year. Once released, arsenic remains in the environment for a long time. Arsenic is removed from the air by rain, snow, and gradual settling. Once on the ground or in surface water, arsenic can slowly enter ground water.

Arsenic toxicity:

- Long-term exposure to arsenic from drinking-water and food can cause cancer and skin lesions. It has also been associated with cardiovascular disease and diabetes.
- Exposure to high levels of arsenic may cause stomach pain, vomiting, diarrhea and impaired nerve function.
- Exposure to high enough amounts of arsenic can be fatal.

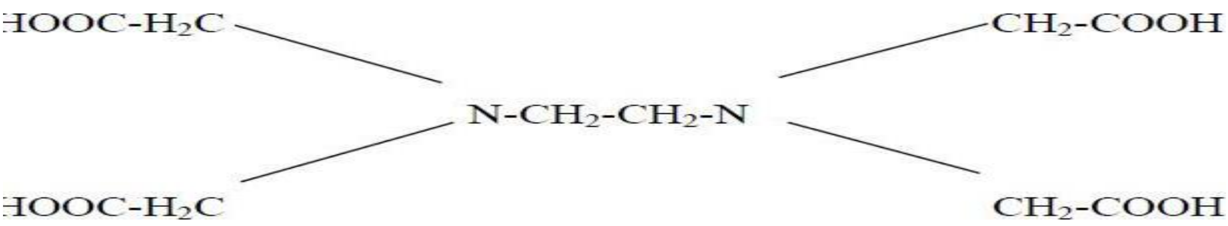
DETERMINATION OF HARDNESS OF WATER BY EDTA METHOD

It is complexometric titration method in which disodium salt of EDTA is used as achelating agent or complexing agent

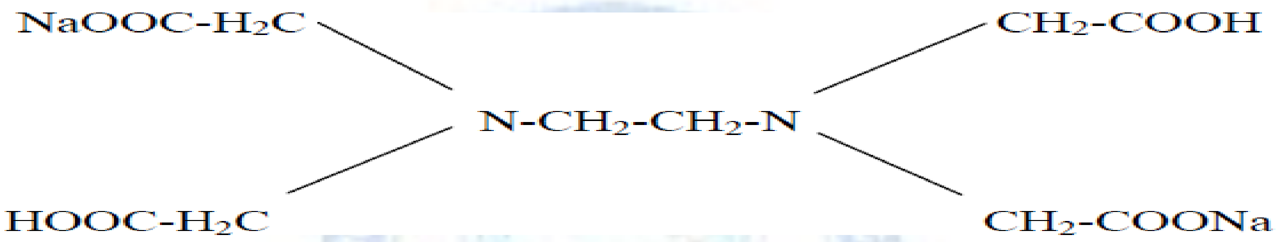
EDTA –Ethylene diamine tetra acetic acid – insoluble in water.

Disodium salt of EDTA – soluble in water – so used for water analysis.

Structure of EDTA



Structure of Disodium salt EDTA



Principle

(Ca, Mg) ions + EBT → unstable wine red complex of Ca & Mg ions with EBT(at pH 8 – 10)

$$Ca^{2+} / Mg^{2+} + \underset{\text{Indicator (Blue colour)}}{EBT} \rightarrow \underset{\text{Unstable complex (Wine red)}}{[Ca / Mg - EBT]}$$

Unstable wine red complex of Ca & Mg ions with EBT + EDTA → colourless stable complex of Ca &Mg with EDTA + free indicator(steel blue)

$$\underset{\text{Unstable complex (Wine red)}}{[Ca / Mg - EBT]} + EDTA \xrightarrow{pH=8-10} \underset{\text{Stable complex (Colorless)}}{[Ca / Mg - EDTA]} + \underset{\text{(Steel blue)}}{EBT}$$

Preparation of solutions

EDTA solution – 4g EDTA in 1 litre of water

Std. hardwater – 1g $CaCO_3$ dissolved in minimum quantity of dil. HCl and made upto 1 litre with distilled water.

EBT indicator – 0.5g EBT in 100mlof ethyl alcohol

Ammoniacal buffer – 67.5g NH_4Cl + 570ml liquor ammonia, made up to 1 litre.

Procedure

1.Standardization of EDTA

Burette – EDTA solution

Pipette – 50ml std. hard water

Indicator – EBT(2-3 drops)

Buffer – Ammoniacal buffer (5 mL)

End point – wine red to steel blue

Titrevalue = V1 ml

2. **Estimation of total hardness**

Burette – EDTA solution

Pipette – 50 ml sample hard water

Indicator – EBT(2-3 drops)

Buffer – Ammoniacal buffer (5 mL)

End point – wine red to steel blue

Titrevalue = V2 ml

3. **Estimation of permanent hardness**

100ml sample hard water is boiled for 15 minutes and temporary hardness is removed.

Burette – EDTA solution

Pipette – 50ml boiled, cooled & filtered sample hard water

Indicator – EBT (2-3 drops)

Buffer – Ammoniacal buffer (5 mL)

End point – wine red to steel blue

Titrevalue = V3 ml

Calculations

1. Standardization of EDTA

1 ml of std. hard water = 1 mg of $CaCO_3$ equivalent hardness

50 ml of std. hard water = 50 mg of $CaCO_3$ equivalent hardness

50 ml of std. hard water consumes = V_1 ml of EDTA

[V_1 ml of EDTA = 50 mg of $CaCO_3$ equivalent hardness]

1 ml of EDTA = $\mathbf{50/V_1}$ mg of $CaCO_3$ equivalent hardness

2. Estimation of total hardness of water sample

50 ml of std. hard water consumes = V_2 ml of EDTA [V_2 x 1ml of EDTA]

= $V_2 \times \mathbf{50/V_1}$ mg of $CaCO_3$ hardness

1000 ml of water sample = $\dfrac{\dfrac{V_2 \times 50}{V_1}}{50} \times 1000$

Total hardness = $1000 \times \dfrac{V_2}{V_1}$ ppm

3. Estimation of permanent hardness of water sample

50 ml of boiled water consumes = V_3 ml of EDTA [V_3 x 1ml of EDTA]

= $V_3 \times \mathbf{50/V_1}$ mg of $CaCO_3$ hardness

Permanent hardness = $1000 \times \dfrac{V_3}{V_1}$ ppm

4. **Determination of Temporary hardness**

Total hardness = Temporary hardness + permanent hardness

Hence, Temporary hardness = Total hardness – permanent hardness

$= 1000 \times \dfrac{V_2}{V_1} - 1000 \times \dfrac{V_3}{V_1}$

$= \dfrac{(V_2 - V_3)}{V_1}$ 1000mg of $CaCO_3$ equivalent hardness

Temporary hardness $= \dfrac{(V_2 - V_3)}{V_1}\, 1000$ ppm

Advantages of EDTA method

This method is preferable because of,

- Greater accuracy
- Convenience
- More rapid procedure