CY 150
CHEMISTRY

MODULE 4
WATER TECHNOLOGY

REFERENCES

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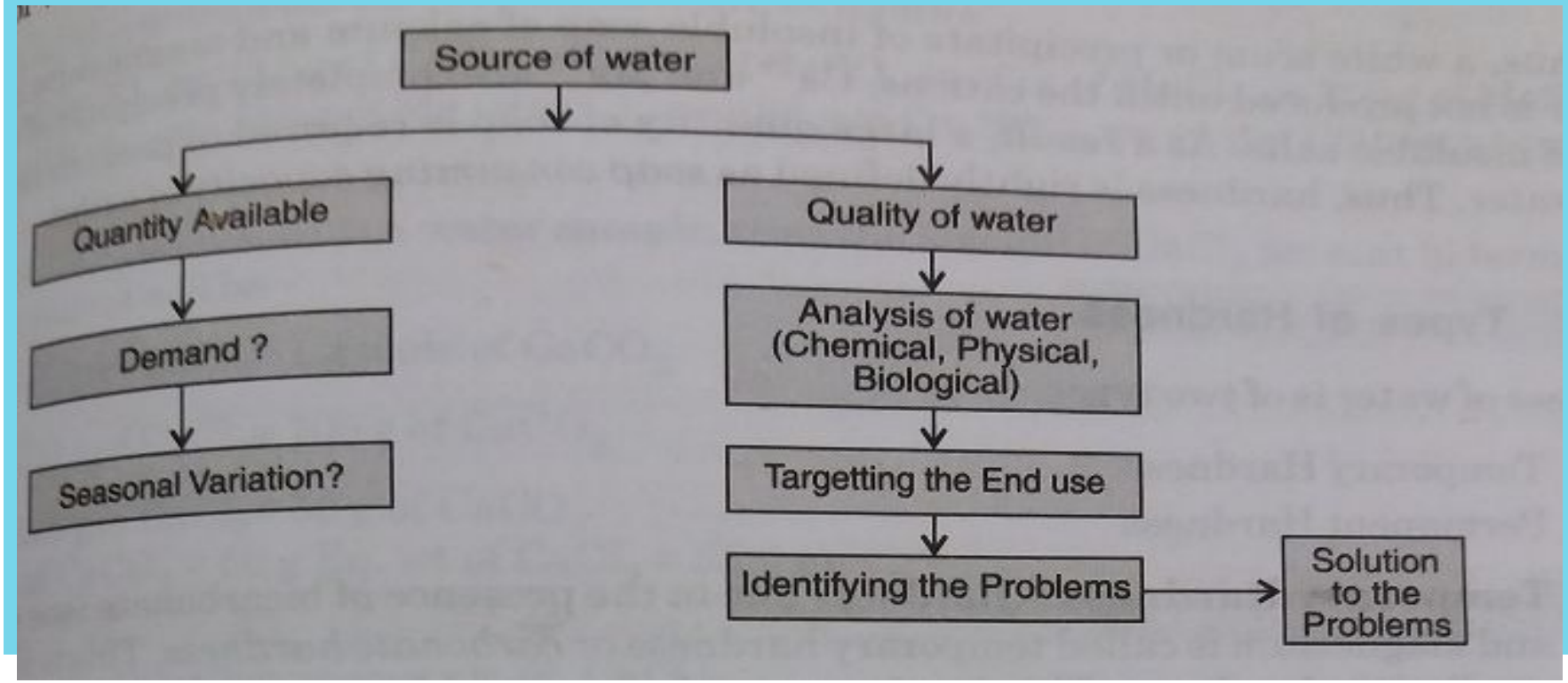
Introduction

Water is **essential for** existence of most animal, bird and plant **lives**.

Water is **non-poisonous**, eco friendly, **free of cost**, abundant,and available throughout the world.



Distirbution of Water

Oceans – 97.23%
Ice Caps and Glaciers – 2.14 %
Ground Water – 0.61%
Fresh water Lakes – 0.01%
Other – 0.01%

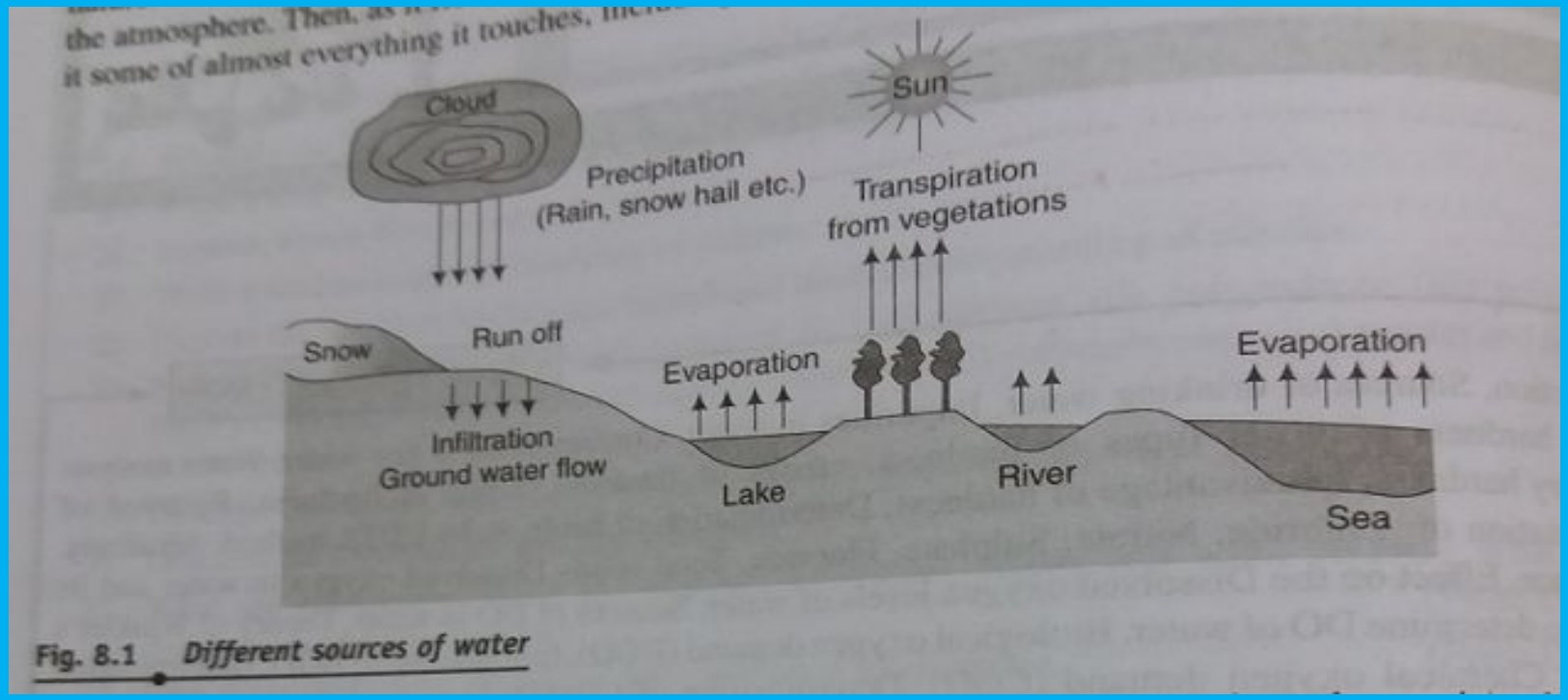


Fig. 8.1 *Different sources of water*

Sources of Drinking Water

Deep ground water, Shallow ground water, Upland lakes and reservoirs, Rivers, Canals and Low Land reservoirs

Water Quality Parameters – Desired Quality

Physical Characteristics

1.Colour – Colourless

2. Smell – Odourless

3. Turbidity – No turbidity

Chemical Characteristics

Hardness, alkainity - pH, chlorides, nitrates, sulphates, fluorides, dissolved solids (TDS), dissolved gases – DO, BOD, COD - **Invisible**

Biological Characteristics

Pathogens – aerobic and anaerobic bacteria, protozoa, fungi, virus, weeds, algae, DO, BOD, COD

Hardness

- presence of salts of **calcium and magnesium** and other heavy metals
-**prevents lather formation**, hair growth, crop growth etc. and creates boiler troubles

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

Sodium Stearate (Sodium Soap) — Hardness — Calcium Stearate (Insoluble)

$2C_{17}H_{35}COONa + MgSO_4 \rightarrow (C_{17}H_{35}COO)_2Mg\downarrow + Na_2SO_4$

Magnesium Stearate (Insoluble)

Water which does not produce lather with soap solution readily, but forms a white curdy precipitate, is called **Hard Water**.

So water which lathers easily on shaking with soap solution is called **Soft Water**.

(ii) *Non-alkaline* ... sulphates, chlorides and nitrat... Permanent hardness is not destroyed by boiling... Depending on the need for the purpose, they are softened by...

Causes of Hardness of Water The cause for hardness of water is due to the presence of dissolved salts like chlorides, sulphates, bicarbonates of calcium and magnesium.

The presence of chlorides and sulphates of calcium, magnesium make water hard. This water is known as permanent hard water.

Hardness is that characteristic which prevents the lathering of soap. If such salts are present in water, then water does not lather with soap solution. The reason is that these salts precipitate soap (Sodium salt of stearic palmitic acid) and thus prevent lathering.

$$CaCl_2 + 2Na\text{-}St \rightarrow Ca\text{-}St + 2NaCl$$
$$MgCl_2 + 2Na\text{-}St \rightarrow Mg\text{-}St + 2NaCl$$
$$MgSO_4 + 2Na\text{-}St \rightarrow MgSO_4 + Na_2SO_4$$

1 mg/L = 1 mg of $CaCO_3$ equivalent hardness in 10^6 mg of water or = 1 ppm.

Disadvantages of Hardness of Water The disadvantages of using hard water for domestic and industrial purposes are plenty.

1. For domestic use

Washing – Presence of hardness causes wastage of soap, etc.

Drinking – Excess calcium content in drinking water may be injurious to health.

Cooking – May effect the utensils, if the water is hard. Effect the cooking process due to the presence of mineral contaminants.

Bathing – Lack of foaming soap leads to uneasiness of bathing and wastage of soap.

2. For industrial use

Paper – The presence of calcium and magnesium has impact on the properties and quality of paper and their products.

Textile – During dyeing process of cloths, the calcium and magnesium contaminants induce poor quality of shades.

Sugar – Causes hindrance to crystallization of sugar, if nitrates, sulphates of calcium and magnesium are present.

Boilers – Formation of scales corrodes the boilers. Wastages of fuel etc.

Determination of Hardness ... EDTA Method

Permanent Hardness - **Noncarbonate** Hardness – sulphates and chlorides of Ca and Mg – $CaCl_2$, $MgSO_4$ etc.

Temporary Hardness – **Carbonate** Hardness – Alkaline Hardness – bicarbonates of Ca and Mg – $Ca(HCO_3)_2$, $Mg(HCO_3)_2$

Temporary hardness can be removed by

1. By boiling the hard water
2. By adding lime (CaO - $Ca(OH)_2$) to the water

On Boiling - $Ca(HCO_3)_2 \xrightarrow{\Delta} CaCO_3 \downarrow + H_2O + CO_2$

On Adding Lime - $Mg(HCO_3)_2 + 2Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow + CaCO_3 \downarrow + CO_2$

Total Hardness = **Permanent** Hardness **+** **Temporary** Hardness

Expression of Hardness

Hardness and other complicated common units are expressed in terms of **Calcium carbonate equivalent**. Why? F.Wt.(M.Wt.) of $CaCO_3$ = 100 & **Eq. Wt** of $CaCO_3$=**50**

Calcium carbonate equivalent of any compound

$$= \frac{\text{Wt of hardness producing substance in g}}{\text{Eq Wt of hardness producing substance}} \times \text{Eq. Wt. Of } CaCO_3$$

Molecular weight of some hardness producing salts are given in the following table.

Table 1.1

S.No.	Hardness producing salt	Molecular weight
1.	Mg^{2+}	24
2.	$Mg(HCO_3)_2$	146
3.	$Mg(NO_3)_2$	148
4.	$MgCO_3$	84
5.	$MgCl_2$	95
6.	$MgSO_4$	120
7.	Ca^{2+}	40
8.	$Ca(HCO_3)_2$	162
9.	$Ca(NO_3)_2$	164
10.	$CaCO_3$	100
11.	$CaCl_2$	111
12.	$CaSO_4$	136

Illustration : If the amount of $MgSO_4$ in hard water is 60 mg/lit, then the weight equivalent to $CaCO_3 = \frac{60 \times 100}{120} = 50$ **mg / lit.**

SOLVED PROBLEMS

1) ***If a sample of water contains 50 mg of $MgCl_2$ per litre, calculate the hardness in terms of $CaCO_3$ equivalents.*** ***(BU, Nov.96)***

Given : The amount of $MgCl_2 = 50$ mg/L

Solution : Equivalent of $CaCO_3$

$$= \frac{\text{The amount of hardness producing salt} \times 100}{\text{Molecular weight of hardness producing salt}}$$

$$= \frac{50 \times 100}{95} = \mathbf{52.63\ mg/L}$$

2) ***If a sample of water contains 48 mg of Mg^{2+} ions per litre, calculate its hardness in terms of calcium carbonate equivalent.***

Given : The amount of Mg^{2+} ions $= 48$ mg/L

Solution : Atomic weight of magnesium $= 24$

$$\therefore \text{Amount equivalent to } CaCO_3 = \frac{48 \times 100}{24} = \mathbf{200\ mg/L}$$

3) ***A sample of water contains 120 mg of $MgSO_4$ per litre. Calculate the hardness in terms of $CaCO_3$ equivalent.*** ***(MKU, Apr.95)***

Given : The amount of $MgSO_4 = 120$ mg/L

Solution : Amount equivalent to $CaCO_3 = \frac{120 \times 100}{120}$

$$= \mathbf{100\ mg/L}$$

4) ***A water sample contains 204 mg of $CaSO_4$ and 73 mg of $Mg(HCO_3)_2$ per litre. What is the total hardness in terms of $CaCO_3$ equivalent?***

(AU, Model QP)

Name of the hardness producing salt	Amount (mg/L)	Molecular weight	Amount equivalent to $CaCO_3$
$CaSO_4$	204	136	$\frac{204 \times 100}{136} = 150$ mg/L
$Mg(HCO_3)_2$	73	146	$\frac{73 \times 100}{146} = 50$ mg/L

Temporary hardness due to $Mg(HCO_3)_2$ $= 50$ mg/L

Permanent hardness due to $CaSO_4$ $= 150$ mg/L

$\therefore$ Total hardness $= 50 + 150 = 200$ mg/L $= \mathbf{200\ ppm.}$