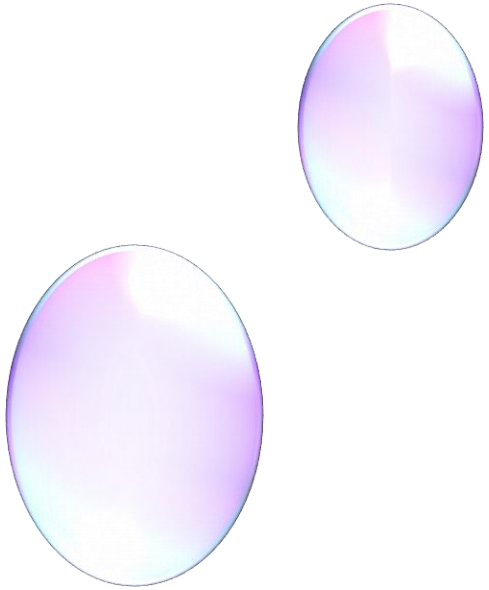
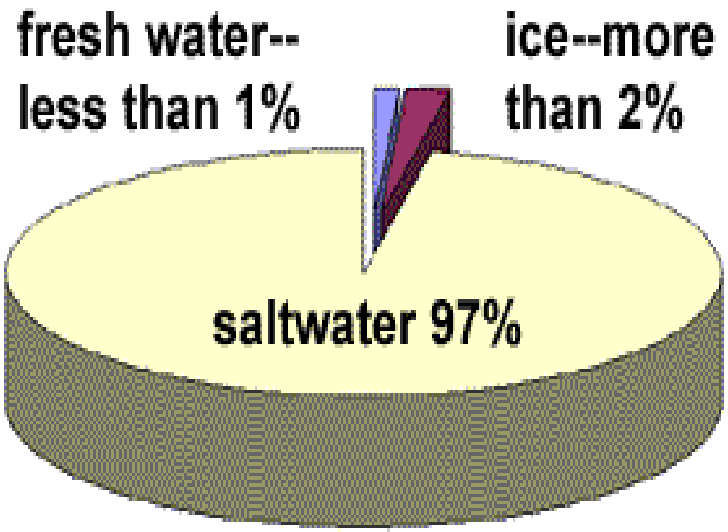
Water Analysis



Water

"Water is abundant on earth yet it's precious"



Major Problems in Water

- Alkalinity
- Hardness
- Salinity

Hard Water

What's hard water?

Practically speaking, presence of:

- Calcium (Ca^{2+}) ions
- Magnesium (Mg^{2+}) ions

Hardness as calcium carbonate

	mg/L (ppm)
Soft	0-17
Moderately hard (Medium)	60-120
Hard	120-180
Very hard	180 & over

Hardness of Water

- **"The soap consuming capacity of water is known as hardness of water."**

OR

- **"Property of water which prevents lather formation of soap"**

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

Sodium Sterate (Soluble-Soap) | Hardness in water | Calcium Sterate (Scum)

Note: The Calcium and Magnesium ions reacts with sodium salts of soap to form insoluble scum, which do not have detergent value. Soap are sodium salts of long chain fatty acids.

Types of Hardness

- There are two types of hardness
  - (a) Temporary or Carbonate Hardness
  - (b) Permanent or non-Carbonate Hardness

Temporary or Carbonate Hardness

- The hardness of water which can be removed by simple boiling.
- Temporary Hardness is caused by the presence of dissolved bicarbonate of calcium and magnesium.

$$Ca(HCO_3)_2 \xrightarrow{\text{Heat}} CaCO_3 + H_2O + CO_2$$

Calcium bicarbonate — Calcium Carbonate

$$Mg(HCO_3)_2 \xrightarrow{\text{Heat}} Mg(OH)_2 + 2CO_2$$

Magnesium Bicarbonate — Magnesium hydroxide

Permanent Hardness

The hardness of water which cannot be removed by simple boiling is called permanent hardness.

It is due to the presence of chlorides, sulfates of calcium and Magnesium.

Note: This hardness can be removed by some external methods i.e. Zeolite Method, Ion Exchange Method, Lime Soda Process etc.

Draw backs (or) Disadvantages of Hard Water

Domestic Use

1. Washing
2. Bathing
3. Drinking
4. Cooking

The sticky precipitate adheres on the fabric/cloth and gives spots and streaks. Fe salts stain the cloths.

Produces sticky scum on the bath tub and the body

Bad to the digestive system and calcium oxalate formation is possible in urinary tracts

Requires more fuel and time. Certains food don't cook soft and also gives unpleasant taste

Industrial Use

1. Textile Industry : wastage of soap
2. Sugar Industry : difficulty in crystallization of sugar
3. Dyeing Industry : imperfect shades or uneven spots
4. Paper Industry
5. Pharmaceutical Industry
6. In Steam generation in Boilers

Degree of hardness

Degree of Hardness is expressed in terms of equivalents of $CaCO_3$ because –

- $CaCO_3$ is most insoluble salt in water.
- The equivalent weight of $CaCO_3$ is 50(Mol. Wt. 100), which cause ease (=easy)
  in calculations.

Therefore the calculation of the degree of hardness is given by-

$$Degree\ of\ \ hardness\ or\ CaCO_3\ equivalent = \frac{[Mass\ or\ Strength\ of\ \ hardness\ \ producing\ \ subs\tan ce\ in\ mg/l] \times 50}{Equivalent\ weight\ of\ \ hardness\ \ producing\ \ subs\tan ce}$$

Units of Hardness

Parts per million (ppm) or milligram per liter (mg/l)

1ppm=1 part of $CaCO_3$ equivalence hardness causing substance present in 10^6 parts of water

Degrees French (*°Fr*)

1^o Fr = 1 part of $CaCO_3$ eq per 10^5 parts of water

Degree Clarke (*°Cl*)

1^o Clarke= 1part of $CaCO_3$ equivalent hardness in 70000 parts of water

[1ppm = 1 mg/liter = 0.1°Fr = 0.07 °Cl]

Alkalinity

- **What is alkalinity?**
  - Alkalinity of a water is the measure of its capacity to neutralize acids i.e. to absorb hydrogen ions without significant change in pH.
- **Parameters which causes the alkalinity**
  - Alkalinity is caused by the presence of hydroxide ions, carbonates and bicarbonates.
  - At pH <8.3 , only bicarbonates are found to occur , because at lower pH all carbonates are converted into bicarbonates by the action of **CO_2** and **H_2O.**
  - $CO_2 + H_2O + CaCO_3 \longrightarrow Ca(HCO_3)_2$

Alkalinity

- If its pH falls below 4.5 since the all are converted into carbonic acid.
- As far as natural water concern, algae in natural water usually found to be rich in carbonates.
- By the photosynthesis the algae provides CO_2 and the carbonates are converted into the bicarbonates and hence the algae rises the pH of water to above 8.3.
- At pH 8.3 or more carbonates as well as bicarbonates both may exist
- Hydroxide are however found to exist at much higher values of pH say about 10 to 11.

Alkalinity

Total alkalinity in water may consist of,

I. Only hydroxide
II. Only carbonates
III. Hydroxide and carbonates
IV. Carbonates and bicarbonates
V. Only bicarbonates

- First four possibilities will exist when the pH of water is more than **8.3** and fifth possibility will exist only when the pH is in between **4.5 to 8.3.**
- It is assumed that hydroxide and bicarbonate alkalinity cannot be present together in the same sample , although this may not be 100% true always.

Environmental Significance

- Alkalinity in water has a little public health significance
- Highly alkaline waters are usually not pleasant to taste.
- Sometimes chemically treated waters are alkaline so standards are sometimes established on that chemically treated waters
- The principal objection of alkalinity in water is the reactions that occur between alkalinity and certain cations in waters. The resultant precipitates can corrode the pipes and other accessories of water distribution system.

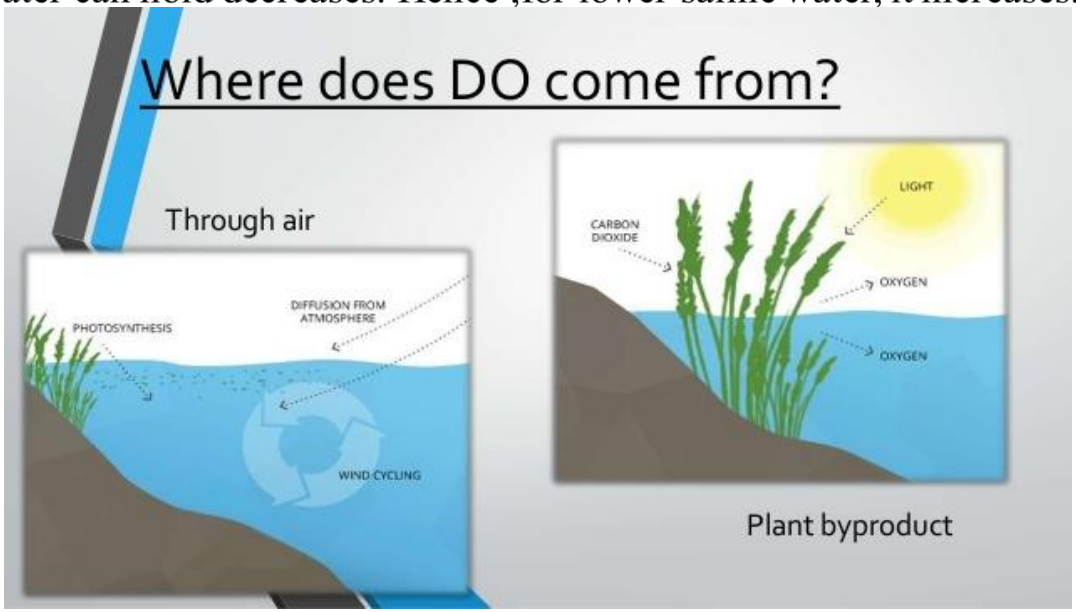
Dissolved oxygen

What is dissolved oxygen?

- Dissolved Oxygen is the amount of gaseous oxygen (O_2) present in the water in its dissolved state.
- DO is the most important indicator of the health of a water body and its capacity to support a balanced aquatic ecosystem of plants and animals.
- A higher dissolved oxygen level indicates a better water quality.
- If dissolved oxygen levels are too low, some fish and other organisms may not be able to survive.

How it is available?

- Mostly the dissolved oxygen in water comes from oxygen in the air.
- Also it comes from the photosynthesis process done by aquatic plants.
- Water temperature and the volume of moving water affects dissolved oxygen levels. Oxygen dissolves easier in cooler water than warmer water.
- Salinity is also an important factor in determining the amount of oxygen a body of water can hold. As the amount of dissolved salts in the water increases, the amount of oxygen the water can hold decreases. Hence ,for lower saline water, it increases.



Dissolved Oxygen Measurement Methods

There are three methods available for measuring dissolved oxygen concentrations in water:-

- Titration Method
- Colorimetric Method
- Optical or electrochemical Sensor.

Dissolved Oxygen Levels

- The quality of water, at any temperature, can be determined by the amount of oxygen present.
- At 20° C, dissolved oxygen content of 8 to 9 ppm O2 at sea level is considered to be water of good quality.
- As the dissolved oxygen level reaches 4.5 ppm oxygen, it is considered moderately polluted and below that concentration, it is highly polluted.

- BOD, the Biochemical Oxygen Demand, is a measure of the amount of oxygen consumed by the biodegradable organic wastes and ammonia in a given amount of water over a time period; normally 5 days at 20° C. The greater the amount of oxygen demanding wastes, the higher is the BOD.

ppm BOD	Quality of water
<1	Almost pure water
5	Doubtful Purity
20	Unacceptable Purity

BOD

- Biochemical oxygen demand (BOD) is the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period.

- The term also refers to a chemical procedure for determining this amount. This is not a precise quantitative test, although it is widely used as an indication of the organic quality of water.[1]

- The BOD value is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20 °C and is often used as a robust surrogate of the degree of organic pollution of water.

COD

- COD (Chemical Oxygen Demand) is the amount of oxygen required to degenerate all pollutants in a chemical way (by adding oxidising agents and heating). In general with chemical destruction you can remove more pollutants than with the biological way.

- . It is expressed in milligrams per liter (mg/L) also referred to as ppm (parts per million), which indicates the mass of oxygen consumed per liter of solution.

Quiz

- What is hardness of water?
- How do you remove temporary hardness?
- What are the units of hardness of water?
- What is $CaCO_3$ equivalent?
- Why $CaCO_3$ is taken as standard in calculating hardness of water?
- Explain the terms DO, BOD, COD

FAQ

- **Why does soap do not give lather with hard water?**
- **What do you understand by hardness of water? What are the different units of hardness of water? Write relationship between them?**
- **Explain the terms DO, BOD, COD**

Recap

1. **Major Problems in Water**

- Hardness
- Alkalinity
- Salinity

2. Hardness

(Soap consuming Capacity of water)

- Temporary Hardness (Can be removed by boiling)
- Permanent Hardness (Can-not remove by boiling)

3._ $Degree\ of\ \ hardness\ or\ CaCO_3\ equivalent = \frac{[Mass\ or\ Strength\ of\ \ hardness\ \ producing\ \ subs\tan ce\ ] \times 100}{Molecular\ \ weight\ of\ \ hardness\ \ producing\ \ subs\tan ce}$

4. Units of Hardness

1ppm → 1mg/lit → 0.1 °Fr → 0.07°Cl