21/8/25

Unit - III

Water Pollutions

Rain water PH 5.5

① Physical and chemical properties of water, water quality standards and parameters, PH, TDS, BOD, COD, hardness, Alkanity, turbidity. — 10m

* ② Hardness of water. / Temporary and Permanent hardness. Methods to convert hard water into soft water. — 10m

* ③ Eutropication and its effects. — 5m

④ Industrial waste water treatment. — 5m

① Physical, chemical, and biological properties of water.

① physical

Temperature
Colour
taste
Odour
Turbidity
dissolved salts

② chemical

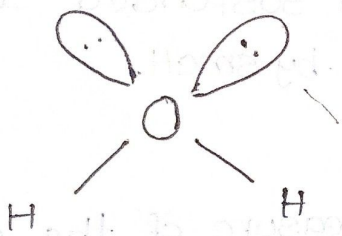
PH, EC (Electrical conductivity), salinity,

(chemically oxygen demand)
DO (dissolved oxygens), COD, BOD, (Biological oxygen demand),

(3) Biological

Microbial contamenation, Total coliforms.

water (H_2O)



Hybridisation :- sp^3

Shape :- V-shape / Angular / Bent

Bond Angle :- 104.5°

Bond length :- 95.7 Pm

Dipole moment :- $\mu = 1.83$ debye

Bond Energy of O-H = 450 kJ/mole

(1) Zeolight / Permulite

~~Na~~ $Na_2, Al_2, Si_2, O_8, xH_2O$

(2) D.O Level = 4-6 Ppm

① Physical characteristics:-

a) Temperature physical characteristics of water (temperature, colour, taste, odour and etc) are determined by senses of touch, sight, smell and taste.

e.g. For example:- Temperature by touch, colour, floating debris, turbidity and suspended solids by sight, and taste and odour by smell.

a) Temperature:

1) Temperature is a measure of the average kinetic energy of water molecules. It is measured on a linear scale of degress celsius or degrees Fahrenheit.

2) Temperature in water bodies generally follows mean daily air temperature. It influences: amount of oxygen that can be dissolved in water rate of photosynthesis by algae and other aquatic plants.

b) Colour:

1) Colour in water is primarily a concern of water quality.

2) Colour is reduced or removed from water through the use of coagulation, setting and filtration techiques.

c) Taste and odor:

1) Taste and odour are human perceptions of water quality.

2) Relatively simple compounds produce sour and salty tastes. However, sweet- and

bitter tastes are produced by more complex organic compounds.

3) odor is produced by gas production due to the decomposition of organic matter or by substances added to the waste water.

d) Turbidity

"Turbidity is a measure of the light-transmitting properties of water and is comprised of suspended and colloidal material".

1) It is important for health and ~~ese~~ aesthetic reasons.

2) Turbidity provides an estimate of total suspended solids (TSS) concentration.

② Chemical Properties

There are few chemical constituents of water that can lead to health problems with even a single exposure. The major chemical properties of the water are discussed below.

a) PH

1) pH is a measure of how acidic or basic (alkaline) the water is.

2) The pH scale is logarithmic and ranges from 0 (very acidic) to 14 (very alkaline).

b) Electrical conductivity:

1) The conductivity of water is its ability to conduct an electric current by the breakdown of dissolved solids into positively and negatively charged ions.

2) The major positively charged ions are sodium (Na^{+1}), calcium (Ca^{+2}), Potassium (K^{+1}) and magnesium (Mg^{+2}).

3) The major negatively charged ions in water include chloride (Cl^{-}), sulphate (SO_4^{-2}), carbonate (CO_3^{-2}), and bicarbonate (HCO^{-3}).

c) salinity

"salinity is a measure of the quantity of salts in the water. Because dissolved ions increase salinity as well as conductivity, the two measures are related".

d) Alkalinity

The alkalinity of natural water is generally due to the presence of bicarbonates formed in reactions in the soils".

1) It may also be attributed to the presence of carbonates and hydroxides.

e) Dissolved oxygen:

"Dissolved oxygen is the amount of gaseous oxygen (O_2) dissolved in an aqueous solution".

f) Biochemical oxygen Demand (BOD):

Biochemical oxygen demand is the amount of dissolved oxygen required by aerobic biological organisms to degrade the organic material present in a water body at certain temperature over a specific time period.

g) Chemical oxygen Demand (COD):

"Chemical oxygen Demand (COD) determines the quantity of oxygen required to

oxidize the organic matter present in water body under specific conditions of oxidizing agent temperature and time".

(2) Methods to convert temporary hard water into soft water:

The process of removing soluble salts of calcium and magnesium from hard water is known as softening of water.

Methods of softening temporary hard water:

There are two different methods of softening temporary hard water as,

1. Boiling Method
2. Clark's method.

1. Boiling of water (physical method):

Boiling decomposes calcium and magnesium hydrogen carbonates to their respective carbonates, water and carbon dioxide gas. The calcium and magnesium ions are removed as from water as insoluble carbonates and then deposited as solids at the bottom of boilers. This method cannot be used on large scale.

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

2. Clark's method (Addition of Lime):

The method of softening the temporary hard water by using Lime is known as

as Clark's method. In this method, the calculated quantity of lime is added to hard water. The lime reacts with soluble bicarborates of calcium and magnesium to produce respective insoluble carborates. In this method, excess lime should not be used because the excess lime remaining behind in water causes hardness of water.

$$Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow CaCO_3 + CaCO_3 + 2H_2O$$

$$Mg(HCO_3)_2 + 2Ca(OH)_2 \longrightarrow Mg(OH)_2 + 2CaCO_3 + 2H_2O$$

Soluble bicarborate & lime — Insoluble hydroxide & carborates

Methods of softening permanent Hard water:

There are four different methods of softening permanent hard water as,

1. Soda ash method
2. Lime soda method
3. Permutit method
4. Ion Exchange method.

1. Soda Ash method:

Soda ash is commercial name of sodium carborate (Na_2CO_3). In soda ash method, the soda ash is added to hard water. The soda ash reacts with the soluble salts of calcium and magnesium from hard water to produce insoluble carbonates. Thus, the water becomes soft.

$Na_2CO_3(aq) + CaSO_4(aq) \longrightarrow Na_2SO_4(aq) + CaCO_3(s)$

$Ca(HCO_3)_2 + Na_2CO_3 \longrightarrow CaCO_3 + 2NaHCO_3$

$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 + 2NaCl$,

$Mg(HCO_3)_2 + Na_2CO_3 \longrightarrow MgCO_3 + 2NaHCO_3$.

2. Lime soda method:

Lime soda method is combination of clark's method and ash method. In this method both temporary and permanent hardness of water is removed. The lime reacts with bicarbonates and carbonate while the soda ash reacts with chlorides and sulphate to produce insoluble carbonate. Thus, the water becomes soft.

$Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3 + 2H_2O$

$Mg(HCO_3)_2 + 2Ca(OH)_2 \longrightarrow Mg(OH)_2 + 2CaCO_3 + 2H_2O$

Four methods of lime - soda process:

- Batch cold process
- continuous cold process.
- Batch hot process
- continuous hot process.

3. Zeolite or permutit process:

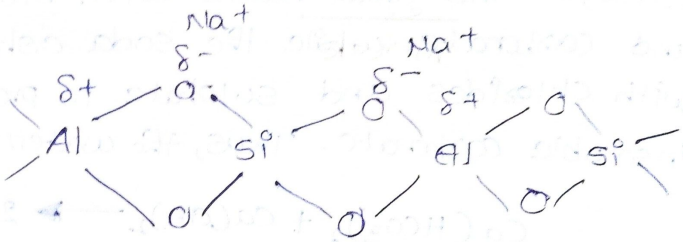
Zeolite are crystalline microporous aluminosilicates built up of three dimentional framework of $[SiO_4]^{4-}$ and $[AlO_4]^{5-}$ tetrahedra linked by sharing of oxygen atoms. The linking of these tetrahedra results in pores of the zeolite which permits the movement of water molecules and ions. Zeolite contains

weakly bonded Na+ ions in pores of the structure. They are capable of exchanging reversibly its Na^+ ions for hardness causing Ca^{2+} and Mg^{2+} ions in hard water.

Zeolites are two types

i) Natural zeolites ($Na_2O.Al_2O_3.4SiO_2.2H_2O$)
Example:- Natrolite

ii) Synthetic zeolites



Structure of zeolite.

Softening Process:

When hard water is passed through the bed of zeolite, the hardness causing Ca^{2+} and Mg^{2+} ions are retained on the zeolite bed as CaZ and MgZ and an equivalent amount of Na^+ ions are released in the purging water. The exchange reaction taking place during the softening process are.

Removal of carbonate hardness:-

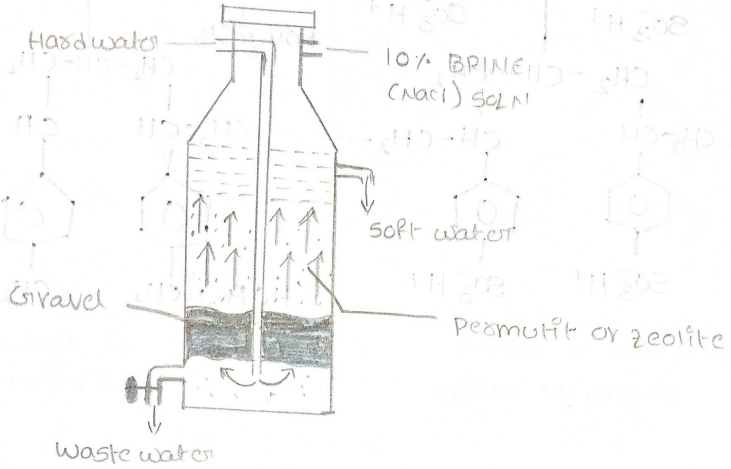
$$Na_2Z + Ca(HCO_3)_2 \longrightarrow CaZ + NaHCO_3$$

$$Na_2Z + Mg(HCO_3)_2 \longrightarrow MgZ + NaHCO_3$$

Removal of non-carbonate hardness:

$Na_2Z + CaCl_2 \longrightarrow CaZ + NaCl$

$Na_2Z + MgCl_2 \longrightarrow MgZ + NaCl$

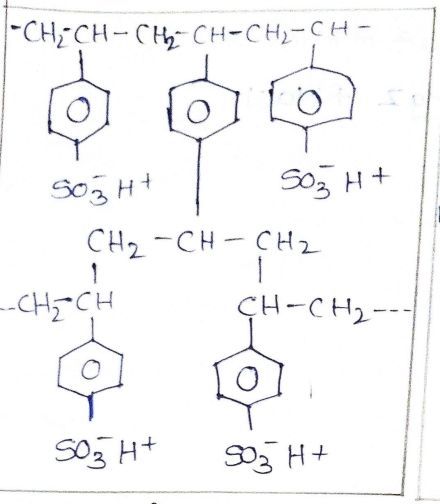


4. Demineralization Process or Ion Exchange Processes

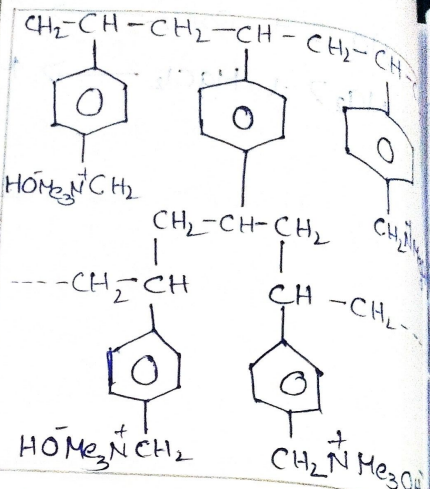
- Demineralization process is an ion exchange process in which porous, insoluble, cross linked long chain high molecular weight synthetic resins are used as ion exchanges.
- The functional groups attached to the polymers are responsible for ion exchange property. Resins containing acidic groups are capable of exchanging their H^+ ions with cations in water as those containing basic groups are capable of exchanging their OH^- ions with anions in water.
- The organic ion exchange resins are:

  Cation exchange resin.

  Anion exchange resin.



Structure of cation Exchange resin



Structure of Anion Exchange resin

(3) EUTROPHICATION:

1) The word eutrophication literally means "well nourished"

2) It is referred to as excessive fertilization of lakes, reservoirs, slow-flowing rivers, and certain marine coastal waters by nutrients, which result in the nuisance growth of aquatic plant materials such as algae and macrophytes. This in turn leads to deterioration of water quality and taste, odour problems, oxygen depletion, reduced transparency, declines of fisheries, possible fish kill, and toxic effects on animals and human beings.

consequences of Eutrophication:

Eutrophication of lakes, reservoirs, ponds, rivers, and coastal waters is related to the obstruction of recreation for bathers, health concern such as dermatitis, and ingestion of toxin-producing algae. In addition to these factors, Eutrophication also causes impairment of fisheries and consumption of contaminated shell fish, adverse effects on livestock, drinking of toxicologically contaminated water.

control of Eutrophication:

1) Eutrophication can be controlled effectively by drastic reduction in the total nutrient load in an overloaded water system.

2) An integrated approach based on water body nutrient mass balance, taking into consideration specific geographical, climatological, and ecological conditions, can be effective.