UNIT-II

WATER AND ITS TREATMENT

Introduction :-

→ Water is one of the most abundant and useful substance in nature but is also the most misused one.

→ Water is widely used in various fields such as in the generation of steam, electricity and in the production of paper, steel, textiles, chemicals.

→ It is essential for all living beings. Therefore, water plays an important role in various fields.

→ Depending on the association of impurities water classified as soft & hard.

→ Hard warter is not suitable for many applications Thus, water need to be treated to remove the hardness.

→ In this chapter, we shall focus our attention the types of hardness, estimation of hardness and water treatment methods.

Occurence :-

→ Water is found in all living things. The human body consists of about 60% of water. plants, fruits & vegetables contain 90 to 95% of water. The air contains 12 to 15% of volume of water vapour

→ It has been estimated that about 75% matter on the earth's surface consists of water

Sources of water :-

(2)

1. Surface water
   - (i) Flowing water - Rivers
   - (ii) Still water - lakes & ponds

2. Underground water
   - (i) Spring water
   - (ii) Shallow well water
   - (iii) Deep well water

3. Rain water

4. Sea water

Types of impurities present in water :-

1) Dissolved impurities :-

(i) Inorganic :- The carbonates, bicarbonates, chlorides and sulphates of calcium, magnesium potassium, iron and aluminium

(ii) Organic :- Amino acids, proteins, organic waste products

(iii) Gases :- O_2, CO_2, N_2, oxides of Nitrogen, NH_3, H_2S

2. Suspended impurities :-

(i) Inorganic :- clay, sand

(ii) Organic :- Vegetable and Animal matter

3. Microscopic impurities :-

Bacteria, Algae and fungi

(3)

SOFT WATER :-

The water which forms lather easily with soap is called soft water

Ex: Distilled water, Rain water

This water contains little or none of the dissolved salts.

Soap is the sodium or, potassium salts of higher fatty acids like stearic acid, palmitic acid, oleic acid

If soap is added to soft water, it is dissolved and lather is formed.

$$C_{17}H_{35}COONa + H_2O \rightarrow C_{17}H_{35}COOH + NaOH$$

(Sodium stearate) (formation of lather)

Hardwater :-

The water which does not form lather easily with soap but forms a white precipitate is called hard water

Ex: Seawater and well water

This water contains soluble salts namely bicarbonates chlorides and sulphates of calcium and magnesium.

If soap is added to hardwater, a white precipitate is formed. This is due to the formation of calcium or magnesium soap

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

(white ppt)

Hardness of water

The hardness of water is caused by the presence of dissolved salts such as bicarbonates, sulphates chlorides and nitrates of bivalent metal ions like calcium and magnesium

Degree of hardness :-

→ The degree of hardness means the strength of hardness causing substances present in water.

→ Hardness of water is expressed interms of calcium -carbonate equivalents.

→ If a sample of water contains two or more than two salts, their quantities are converted in equivalent to $CaCO_3$, then the sum will give the total hardness.

→ $CaCO_3$ is chosen as the standard for calculating hardness of water due to the ease in calculations as its molecular weight is exactly 100 and $CaCO_3$ is an insoluble salt all the dissolved salts of calcium are precipitated as $CaCO_3$.

$$\boxed{\text{Hardness of the H.C.S interms of } CaCO_3 = \frac{\text{Wt of H.C.S}}{\text{M.Wt of H.C.S}} \times \text{M.Wt of } CaCO_3}$$

CAUSES OF HARDNESS :-

Hardness of water is due to the presence of bicarbonates, sulphates and chlorides of calcium and magnesium. These soluble salts get mixed with natural water due to the some reasons

i) when natural water containing CO_2 flows over the rocks of lime stone ($CaCO_3$) and dolamite ($CaCO_3 \cdot MgCO_3$), they get converted into soluble bi carbonates. Thus, water gets hardness

$$CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$$

$$MgCO_3 + H_2O + CO_2 \longrightarrow Mg(HCO_3)_2$$

ii) When natural water flows over the rocks containing chlorides and sulphates of calcium and magnesium, these salts dissolved in water. Thus, water gets hardness.

Units of hardness :-

1. **Parts per million (PPM) :-** The number of parts by weight of $CaCO_3$ equivalents of hardness causing salt present in one million parts of water
2. **Milligrams per Litre (mg/lit) :-** The amount of the $CaCO_3$ equivalents hardness causing salt in milligrams present in one litre of water
3. **Degree clark (°cl) :-** In the English system hardness of water is expressed in terms of degree clark (°cl), that is number of parts of $CaCO_3$ equivalents of hardness causing salt in 70,000 parts of water.
4. **Degree French (°Fr) :-** It is a French unit which is expressed as number of parts of $CaCO_3$

equivalents of hardness causing substance in 10^9 parts of water.

→ The hardness of water can be converted into all the four units by making use of the interconversion formula.

$$1\ ppm = 1\ mg/lit = 0.07\ ^\circ Cl = 0.1\ ^\circ Fr$$

$$1\ ^\circ Cl = 1.43\ ^\circ Fr = 14.3\ ppm = 14.3\ mg/lit$$

$$1\ mg/lit = 1\ ppm = 0.07\ ^\circ Cl = 0.1\ ^\circ Fr$$

$$1\ ^\circ Fr = 10\ ppm = 10\ mg/lit = 0.7\ ^\circ Cl$$

Determination of Hardness of water :-

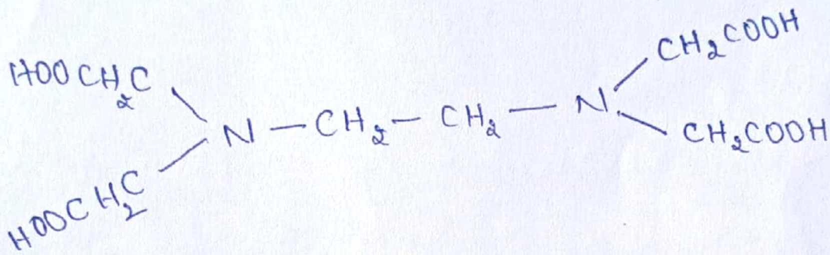
Sample of water is analysed qualitatively and the amount of salts present in the given quantity of water is determined. The degree of hardness of water is calculated. But the total degree of hardness of a sample of water can be estimated with out analysing it qualitatively. Three methods are generally employed for the estimation of hardness of water; which are

1. soap titration method.
2. O- Hehner's alkalimetric method
3. complexometric method (EDTA method)

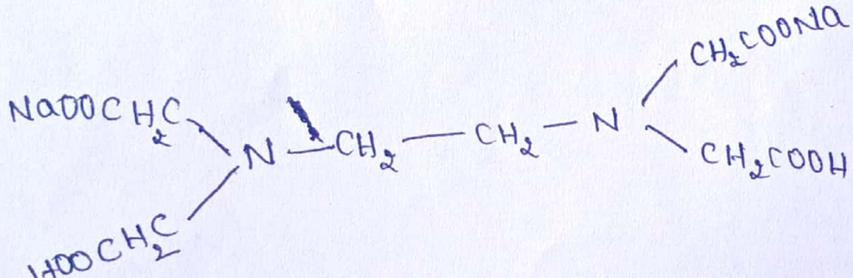
(4)

EDTA METHOD :- (complexometric method)

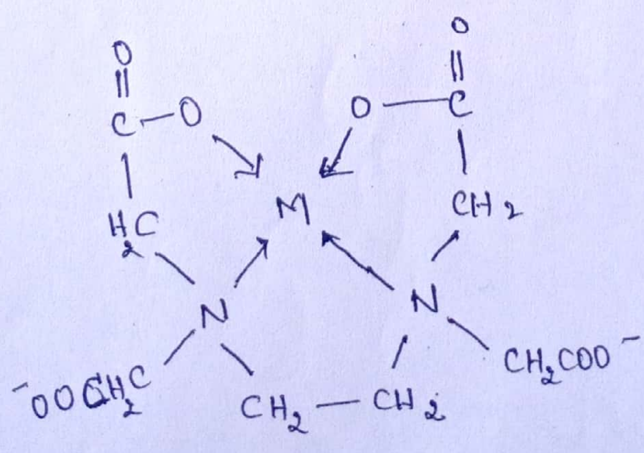
This is a complexometric method where Ethylene diamine tetra acetic acid (EDTA) is the reagent. EDTA forms complexes with different pH. calcium and magnesium ions form complexes with EDTA at pH 9-10. TO maintain the pH 9-10 NH_4Cl, NH_4OH buffer solution is used. An alcoholic solution of Eriochrome black-T is used as an indicator. The disodium salt of EDTA under the trade name Triplex- III is used for complexation.



EDTA



Di sodium salt of EDTA



(M - EDTA complex)

Stable, colourless

PRINCIPLE :-

When hardwater comes in contact with EDTA, at pH 9-10, the Ca^{+2} & Mg^{+2} forms stable, colourless complex with EDTA.

To the hardwater sample the blue coloured indicator Eriochrome Black-T (EBT) is added along with the NH_4Cl, NH_4OH buffer solution. EBT forms an unstable, wine red complex with Ca^{+2} & Mg^{+2}.

$$\underset{\text{From hardwater}}{Ca^{+2}} + \underset{\text{Indicator}}{EBT} \xrightarrow{pH\ 9-10} \underset{\text{unstable wine red complex}}{[Ca-EBT]}$$

$$\underset{\text{from hardwater}}{Mg^{+2}} + \underset{\text{Indicator}}{EBT} \xrightarrow{pH\ 9-10} \underset{\text{unstable wine red complex}}{[Mg-EBT]}$$

The wine red coloured [Ca-EBT, Mg-EBT] complex is titrated with EDTA, where EDTA replaces EBT from [Ca-EBT, Mg-EBT] complex and forms stable colourless [Ca-EDTA] [Mg-EDTA] complex releasing the blue coloured indicator EBT into H_2O. Hence the colour change at the end point is wine red to blue colour.

$$[Ca-EBT] + EDTA \xrightarrow{pH\ 9-10} [Ca-EDTA] + EBT$$

$$[Mg-EBT] + EDTA \xrightarrow{pH\ 9-10} \underset{\text{stable colourless complex}}{[Mg-EDTA]} + \underset{\text{(Blue)}}{EBT}$$

→ EDTA method is carried out in the four steps

1. preparation of standard hard water
2. standardisation of EDTA ~~[illegible]~~ solution
3. Estimation of total hardness
4. Estimation of permanent hardness

Preparation of standard hard water :-

→ Dissolve 1 gr of pure, dry $CaCO_3$ in minimum quantity of dilute HCl and evaporate the solution to dryness on a water bath.

→ Dissolve the residue in distilled water to make 1 litre in a standard flask and shake well

$$\text{Molarity of standard hard water solution } (M_1) = \frac{\text{Wt of } CaCO_3}{\text{M.Wt of } CaCO_3} \times \frac{1000}{\text{volume of solution in ml}}$$

$$= \frac{1}{100} \times \frac{1000}{1000}$$

$$= 0.01M$$

2. Standardisation of EDTA solution :-

→ Pipette out 20 ml of standard hard water solution into a conical flask.

→ Add 2-3 ml of buffer solution and 1-2 drops of EBT indicator to the conical flask solution.

→ Titrate the wine red coloured complex with EDTA taken in a burette after rinsing it with EDTA solution till the wine red colour changes to clear blue.

→ Note the burette reading and let the volume be 'x' ml.

→ Repeat the titration to get concurrent values.

Calculations :-

Molarity of standard hard water solution (M_1) = 0.01M

Molarity of EDTA solution (M_2) :

$$\frac{M_1V_1}{n_1} = \frac{M_2V_2}{n_2}$$

n_1 & n_2 are no. of moles of Ca^{+2} and EDTA = 1 each

V_1 → Volume of standard hard water

n_1 → No. of moles of standard hard water

V_2 → Volume of EDTA

n_2 → No. of moles of EDTA

M_2 → Molarity of EDTA

$$M_2 = \frac{M_1V_1}{n_1} \times \frac{n_2}{V_2}$$

$$= \frac{0.01 \times 20}{1} \times \frac{1}{\text{titre value ('x' ml)}}$$

3) Estimation of total hardness :-

→ pipette out 20ml of the water sample collected from the tap into a 250 ml conical flask.

→ Add 2-3 ml of buffer solution and 1-2 drops of EBT indicator to the conical flask solution

→ Titrate the wine red coloured complex with EDTA taken in a burette after rinsing it with EDTA solution till the wine red colour changes to clear blue.

→ Note the burette reading and let the volume of EDTA be 'y' ml.

→ Repeat the titration to get concurrent values.

Calculations :-

Molarity of hard water sample (M_3):

$$\frac{M_2V_2}{n_2} = \frac{M_3V_3}{n_3}$$

M_2 → Molarity of EDTA (calculated in the previous step)

V_2 → volume of EDTA

n_2 → No. of moles of EDTA (1)

M_3 → Molarity of hard water sample

V_3 → volume of hard water sample

n_3 → No. of moles of hard water sample (1)

$$M_3 = \frac{M_2V_2}{n_2} \times \frac{n_3}{V_3}$$

$$= \frac{\text{calculated in previous step} \times \text{titre value}(y)}{1} \times \frac{1}{20}$$

Total hardness $= M_3 \times 100 \times 1000$ mg/lit or ppm

4. Estimation permanent hardness: –

→ pipette out 100ml of hard water sample in a beaker and boil till the volume reduces to 20ml.

→ cool the solution and filter the water into a conical flask.

→ Add 2-3 ml of buffer solution and 1-2 drops of EBT indicator to the conical flask solution.

→ Titrate with EDTA solution taken in the burette till a clear blue colour endpoint is obtained.

→ Note the burette reading.

→ Let the volume of EDTA be 'Z' ml

calculations: –

Molarity of hard water sample after boiling: (M_4)

$$\frac{M_2 V_2}{n_2} = \frac{M_4 V_4}{n_4}$$

M_2 → Molarity of EDTA

V_2 → volume of EDTA

n_2 → No. of moles of EDTA

M_4 → Molarity of hard water sample after boiling

n_4 → No. of moles of " " "

V_4 → volume of " " "

$$M_4 = \frac{M_2 V_2}{n_2} \times \frac{n_4}{V_4}$$

$$= \frac{\text{calculated in previous step} \times \text{titre value (Z)}}{1} \times \frac{1}{20}$$

Permanent hardness $= M_4 \times 100 \times 1000$ mg/lit or ppm

Temporary hardness = Total hardness − permanent hardness

$= (M_3 \times 100 \times 1000) - (M_4 \times 100 \times 1000)$ ppm

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POTABLE WATER :−

→ Water which is safe to drink and is free from contaminants is called as potable water.

→ Access to good quality drinking water is essential to human health.

Specifications:−

1. The water should be clear, colourless and odourless
2. The water must be free from pathogenic bacteria and dissolved gases like H_2S
3. The optimum hardness of water must be 125 ppm and pH must be 7.0 to 8.5
4. The turbidity in drinking water should not exceed 25 ppm.
5. The water must be free from heavy metals like Lead, Arsenic, Chromium and Manganese
6. The recommended maximum concentration of total dissolved solids in potable water must not exceed 500 ppm.

6 Treatment of water for Municipal supply :-

→ The water collected from natural sources (rivers, lakes, ponds etc) does not fulfil the required characteristics of water.

→ If this water is used directly for drinking purpose, it may cause damage to the health of human beings. Hence, water should be treated before using it for drinking purpose.

→ The treatment consists of two steps

1. Removal of suspended impurities
2. Removal of microorganisms

Removal of suspended impurities :-

Screening, plain sedimentation, coagulation, filtration methods are used in a sequence for the removal of suspended impurities.

a) **Screening** :- The process of removing floating matter from water is called screening.
In this process, water is passed through a screen. The floating matter is arrested by the screen and water is free from floating bodies.

b) **Plain sedimentation** :- The process of removing large suspended solids from water is called plain sedimentation.
In this process, water is stored in big tanks for several hours. Most of the solids settle down due to the force of gravity.

c) coagulation:- The process of removing fine particles (colloidal particles) is called coagulation.

In this process, coagulants such as alum, sodium aluminate are added to water. This helps in associate fine solids to bulky form which settle - down.

d) Filtration:- The process of removing suspended impurities and some micro organisms is called filtration. In this process, water passes through fine sized sand beds

2. Removal of Micro organisms:-

The process of killing microorganisms from water is called disinfection. This can be done by the

a) Boiling b) chlorination c) ozonization

d) Aeration e) Addition of potassium permanganate

a) Boiling:- Water becomes safe for use after boiling water for 10 to 15 min. Most of the harmful microorganisms are killed due to boiling

b) Chlorination:-

The process of utilising chlorine as a powerful disinfectant is called chlorination.

There are three types of chlorinating reagents

i) By passing chloramines:-

chloramine passes through water which generates hypochlorous acid, a powerful disinfectant, that kills bacteria.

$$ClNH_2 + H_2O \longrightarrow HOCl + NH_3$$

Chloramine — Hypo chlorous acid

$$HOCl \longrightarrow HCl + (O)$$

Nascent oxygen

$$Bacteria + [O] \longrightarrow$$ Oxidised bacteria or killed Bacteria

(ii) By ~~passing~~ bleaching powder :-

Bleaching powder contains 80% chlorine. when bleaching powder is used as disinfectant, this is method is also called hypo chlorination because the disinfectation is due to hypochlorous acid

$$CaOCl_2 + H_2O \longrightarrow Ca(OH)_2 + Cl_2$$

$$Cl_2 + H_2O \longrightarrow HOCl + HCl$$

$$HOCl \longrightarrow HCl + (O)$$

$(O) +$ Bacteria $\longrightarrow$ Killed Bacteria

(iii) By chlorine :- The process of applying calculated amount of chlorine to water inorder to kill the pathogenic bacteria is called chlorination. chlorine also reacts with water and generate hypochlorous acid, which kills bacteria. chlorine is a powerful disinfectant than chloramine and $CaOCl_2$

$$Cl_2 + H_2O \longrightarrow HOCl + HCl$$

$$HOCl \longrightarrow HCl + (O)$$

$(O) +$ Bacteria $\longrightarrow$ Killed Bacteria

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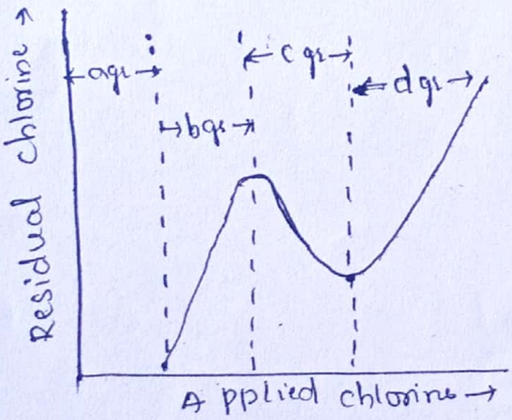
→ calculated amount of chlorine must be added to water because chlorine after reacts with bacteria and organic impurities or ammonia, remains in water as residual chlorine which gives bad taste, odour and toxic to human beings.

→ The amount of chlorine required to kill bacteria and to remove organic matter is called break point of chlorination.

→ The water sample is treated with chlorine and estimated for the residual chlorine in water and plotted a graph as shown below which gives the break point of chlorination



From graph it is clear that

* 'a' grms of chlorine added oxidises reducing impurities of water.
* 'b' grms of chlorine added forms chloramines & other chloro compounds
* 'c' grms of chlorine added causes distruction of bacteria
* 'd' grms of chlorine is residual chlorine

* 'c' gms is the break point for the addition of chlorine to water. This is called break point of chlorination.

* Advantages of break point chlorination :-

1. It removes bad taste, colour, oxidises completely organic compounds, ammonia and other reducing impurities.
2. It destroys completely all disease producing bacteria.

Dechlorination:-

over chlorination after break point produces unpleasant taste, odour, toxicity to water. The overchlorination is removed by passing the water through a bed of granular carbon and also by the addition of SO_2 and sodium thio sulphate.

c) Ozonisation :-

ozone when passed into water acts as disinfectant produces ozone is an unstable isotope of oxygen, produces nascent oxygen which is a powerful disinfectant.

$$O_3 \rightarrow O_2 + (O)$$

$$(O) + \text{Bacteria} \rightarrow \text{Killed Bacteria}$$

This treatment is costly and ozone is unstable and cannot be stored for a long time.

d) Aeration :- water is exposed to oxygen and uv rays of the sun. Due to this, microorganisms are killed.

e) Addition of $KMnO_4$:-

* $KMnO_4$ is a good oxidising agent.
* Well water is purified by the addition of $KMnO_4$.

Treatment of Boiler feed water :-

* Water used for industrial purposes especially for generation of steam should be sufficiently pure.
* The treatment of water includes the removal of hardness causing salts either by precipitation or by complex formation. Hence two types of treatments

1. Internal treatment :-

* The softening of water carried out inside the boiler is called conditioning of water or internal treatment of water
* In this process the hardness causing dissolved salts were prohibited.
* By complexing the hardness causing soluble salt by adding appropriate reagents
* By precipitating the scale forming impurities in the form of sludges which can be removed by blowdown operation
* By converting the scale forming salts into compounds which stay in dissolved form and do not cause any trouble to the boilers.

→ All internal treatment methods must be followed by blowdown operation so that accumulated sludges are removed

→ Important internal conditioning methods are

1. **colloidal conditioning** :- The scale formation in low pressure boilers is prevented by the addition of kerosene, tannin, agar agar etc which get coated over the scale forming precipitates preventing the coagulation of the particles. These form loose nonsticky deposits that can be removed by blowdown. This type of treatment is colloidal conditioning.

2. **phosphate conditioning** :-

* The scale formation due to permanent hardness causing calcium salts is avoided by complexation with sodium phosphate in high pressure boilers. The complex formed is soft, non adherent and easily removable.

$$3\,CaCl_2 + 2\,Na_3PO_4 \longrightarrow Ca_3(PO_4)_2 + 6\,NaCl$$

$$3\,MgCl_2 + 2\,Na_3PO_4 \longrightarrow Mg_3(PO_4)_2 + 6\,NaCl$$

* The $Ca_3(PO_4)_2$ + $Mg_3(PO_4)_2$ complexes were removed by blowdown operation.

* The three phosphates employed for conditions are NaH_2PO_4, Na_2HPO_4, Na_3PO_4.

3. carbonate conditioning :-

* The hard & strong adherant scales formed due to $CaSO_4$ are avoided by the addition of Sodium carbonate to boiler water and this is called carbonate conditioning.

$$Na_2CO_3 + CaSO_4 \longrightarrow CaCO_3\downarrow + Na_2SO_4$$

* The $CaSO_4$ is converted to $CaCO_3$ which is loose sludge and it can be removed by blowdown.

* carbonate conditioning is used only for low pressure boilers.

* In high pressure boilers excess Na_2CO_3 is hydrolysed to NaOH, which causes caustic embrittlement.

$$Na_2CO_3 + H_2O \longrightarrow NaOH + CO_2 + H_2O$$

4. calgon conditioning :-

sodium hexametaphosphate $Na_2[Na_4(PO_3)_6]$ or $(NaPO_3)_6$ is called calgon. This forms soluble complex compounds with $CaSO_4$ which causes no boiler troubles.

$$Na_2[Na_4(PO_3)_6] \longrightarrow 2Na^+ + [Na_4P_6O_{18}]^{-2}$$

$$2CaSO_4 + [Na_4P_6O_{18}]^{2-} \longrightarrow \underset{\text{soluble complex ion}}{[Ca_2P_6O_{18}]^{2-}} + 2Na_2SO_4$$

The treatment of boiler water with calgon is called calgon conditioning.

External treatment / Softening of water :-

The treatment given to water for the removal of hardness causing salts before it is taken into the boiler is called external treatment or softening of water.

Ion exchange process or deionisation or demineralisation process :-

Ion exchang process includes the exchange of the cations and anions of the dissolved salts with H^+ and OH^- ions respectively.

For this two types of ion exchanges are used, which are insoluble, cross linked long chain organic polymers with microporous structure.

Cation exchangers are capable of exchanging their H^+ ions with cations of the dissolved salts, which comes in their contact. The cation exchangers, are represented by general formula RH, are mainly styrene - divinyl benzene copolymers containing the functional groups — COOH or $-SO_3H$. R is the general structure of resin and H is exchangeable with cation.

Anion exchangers are phenol formaldehyde or amine formaldehyde copolymer resin with exchange their OH^- ion with any anion present in the dissolved salts.

The anion exchangers are represented by the formula $R'OH$. R' is the representation of the general structure of the resin and OH is exchangeable with anion.

Thus all the cations and anions present in the dissolved salts are exchanged with cation exchange and anion exchanges.

Process :- Raw water is first passed through cation exchanger and the removal of cations. ~~takers place~~

The Ca^{+2} & Mg^{+2} are retained by the cation exchanger as CaR & MgR releasing H^+ into water. Thus the water coming out of the resin is highly acidic because the H^+ released by the exchange combine with anion of the dissolved salt to produce the corresponding acids

$$2RH + Ca(HCO_3)_2 \longrightarrow R_2Ca + 2H_2CO_3$$
$$2RH + Mg(HCO_3)_2 \longrightarrow R_2Mg + 2H_2CO_3$$
$$2RH + CaCl_2 \longrightarrow R_2Ca + 2HCl$$
$$2RH + MgCl_2 \longrightarrow R_2Mg + 2HCl$$
$$2RH + CaSO_4 \longrightarrow R_2Ca + H_2SO_4$$
$$2RH + MgSO_4 \longrightarrow R_2Mg + H_2SO_4$$
$$2RH + Ca(NO_3)_2 \longrightarrow R_2Ca + 2HNO_3$$
$$2RH + Mg(NO_3)_2 \longrightarrow R_2Mg + 2HNO_3$$

Then water is passed through anion exchanger where the anions of the acids present in water are removed by the exchanger releasing OH^- into water. The H^+ and OH^- released from exchangers get combined and produce H_2O.

$$R'OH + HCl \longrightarrow R'Cl + H_2O$$
$$2R'OH + H_2SO_4 \longrightarrow R_2SO_4 + 2H_2O$$
$$R'OH + H_2CO_3 \longrightarrow R'HCO_3 + H_2O$$
$$R'OH + HNO_3 \longrightarrow R'NO_3 + H_2O$$

Thus the water coming out from exchanger is free from all ions known as deionised or demineralised water.

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When water sample is completely deionised, it has the tendency to absorbs gases like CO_2, O_2 etc from atmosphere which cause boiler corrosion. Hence deionisatio must be followed by degasifications.

Regeneration :-

After the deionisation of certain amount of raw water the cation & anion exchangers will be exhausted.

Regeneration of cation exchanger is carried out by passing dil HCl or H_2SO_4 solution into the bed. The H+ ions of the acid are exchanged with the cations present in the cation exchanger regenerating it.

$$R_2Ca + 2HCl \longrightarrow 2RH + CaCl_2$$
(Washings)

$$R_2Mg + H_2SO_4 \longrightarrow 2RH + MgSO_4$$
(Washings)

The Washings containing $CaCl_2$ & $MgSO_4$ etc were passed to sink or drain.

Similarly the exhausted anion exchanger is treated with dil NaOH solution. The regeneration can be represted as

$$R'_2SO_4 + NaOH \longrightarrow 2R'OH + Na_2SO_4$$
(Washings)

$$R'Cl + NaOH \longrightarrow R'OH + NaCl$$
(Washings)

$$R'HCO_3 + NaOH \longrightarrow R'OH + NaHCO_3$$
(Washings)

$$R'NO_3 + NaOH \longrightarrow R'OH + NaNO_3$$
(Washings)

The washings are discarded into sink.
The regenerated ion exchanger are used for softening.
Thus deionisation & regeneration are the alternate processes.

Advantages :-

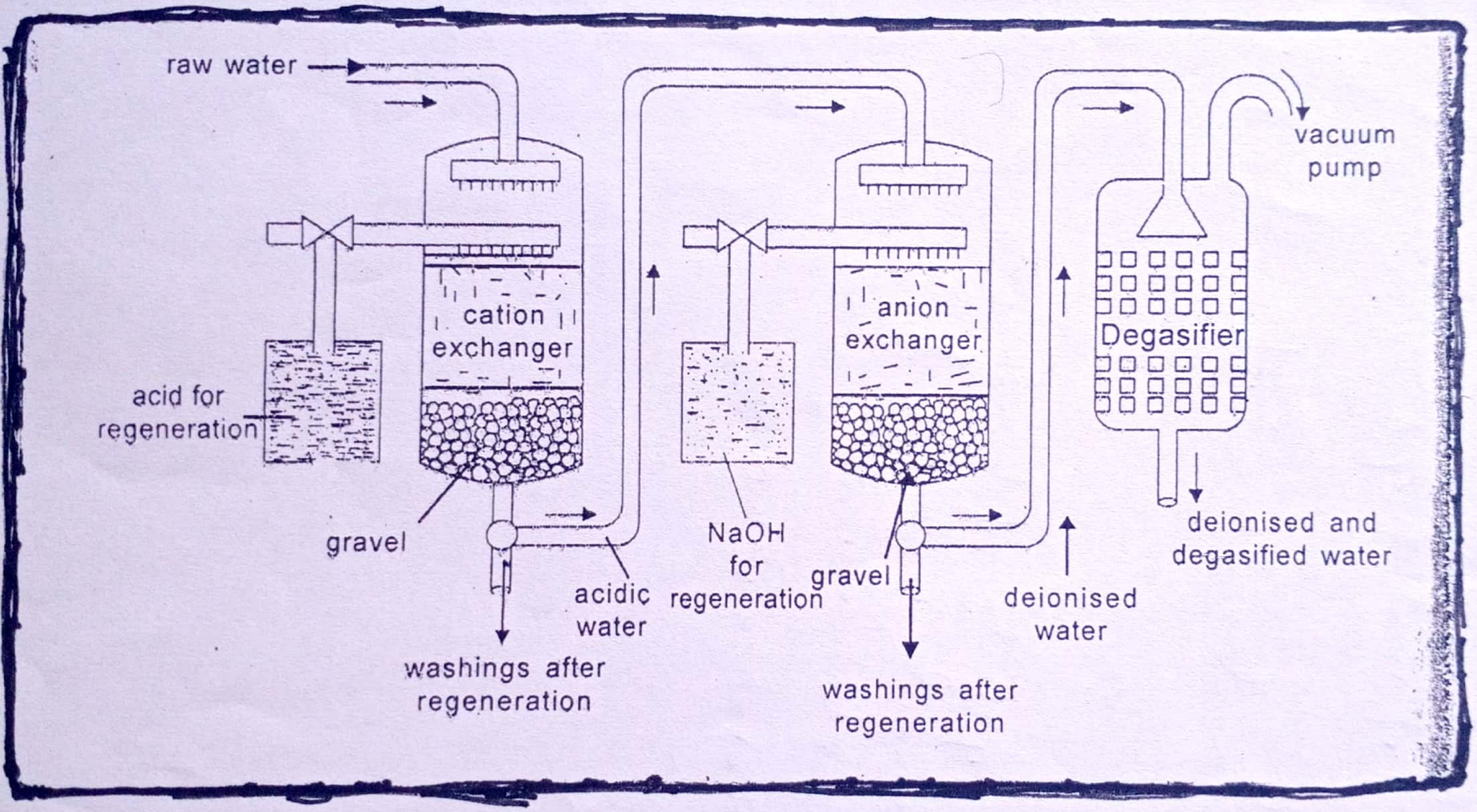
1. Highly acidic or alkaline water samples can be purified by this process
2. The hardness of water possessed by the deionised water is 2ppm
3. The deionised water is most suitable for high pressure boilers.

Disadvantages :-

1. The ion exchanging resins are expensive, hence the cost of purification is high
2. Raw water should contain turbidity below 10 ppm. Otherwise pores in the resin will be blocked and output of the process is reduced.

Diagram :-

[P.T.O]



DEIONISATION OF WATER

DESALINATION OF BRACKISH WATER :-

Water containing high concentrations of dissolved solids with a peculiar salty or brackish taste is called brackish water.

Sea water is an example of brakish water containing about 3.5% of dissolved salts. This water cannot be used for domestic and industrial applications unless the dissolved salts are removed by desalination.

Reverse osmosis :-

when two solutions of unequal concentration are
Separated by a semipermeable membrane which does
not permit the passage of dissolved solute particles,
flow of solvent takes place from the dilute solution
to concentrated solution this is called Osmosis.
If a hydrostatic pressure in excess of osmotic pressure
is applied on the concentrated side the solvent, the solvent
is forced to move from higher concentration to lower
concentration side across. Thus the solvent flow is
reversed hence this method is called reverse osmosis.
Thus in reverse osmosis pure water is separated from
the contaminated water. This membrane filtration is
also called super fitration or hyper filtration.

Method of purification :- The reverse osmosis cell consists of a chamber fitted with a semipermeable membrane, above which seawater / impure water Is taken and a pressure of 15 to 40 kg/cm^2 is applied on the seawater / impure water. The pure water is forced through the semipermeable membrane which is made of very thin films of cellulose acetate. However superior membrane made of polymethacrylate and polyamide polymers have come to use.

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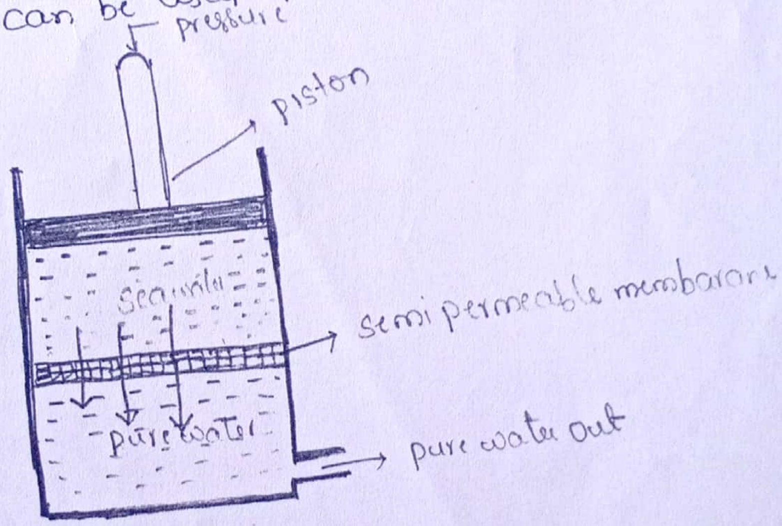
Advantages :-

1. Both ionic & nonionic, colloidal and high M.wt Organic matter is removed from the water sample.
2. cost of purification of water is less and Maintance cost is less.
3. This water can be used from high pressure boilers.



Reverse Osmosis cell

Types of hardness

The hardness of water is of two types

1. Temporary hardness or carbonate hardness
2. permanent hardness or non carbonate hardness

1. Temporary hardness :- Temporary hardness is caused by two dissolved bicarbonate salts $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$. The hardness is called temporary because it can be removed easily by means of boiling

$$Ca(HCO_3)_2 \xrightarrow{\text{heating}} CaCO_3\downarrow + H_2O + CO_2\uparrow$$

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

2. permanent hardness :- permanent hardness of water is due to the dissolved chlorides, sulphates and Nitrates of calcium and Magnesium. These Salts are $CaCl_2$, $CaSO_4$, $Ca(NO_3)_2$, $MgCl_2$, $MgSO_4$, $Mg(NO_3)_2$.

This hardness cannot be removed easily by boiling. Hence it is called permanent hardness. only chemical treatment can remove this hardness.

Total hardness of water = Temporary hardness + permanent hardness

Temporary hardness = Total hardness − permanent hardness

permanent hardness = Total hardness − Temporary hardness

UNIT-II

LAQ's

1. EDTA Method & problems.
2. Types of hardness of water & problem.
3. ion enchange process.
4. Steps involved in treatment of water.

SAQ's

1. Cause of hardess & units of hardness.
2. Internal treatement methods.
3. Specification of potable water.
4. Desalination - Reverse Osmosis.