Date: 27/08/24

UNIT-II

WATER CHEMISTRY

* HARDNESS OF WATER:

(i) It is the property and characteristics of water which Prevent the formation of lather & form with soap.
- If in a water magnisum calcium salts and heavy metals are present then the water is called Hard water.

(ii) Hardness is due to salts of calcium, magnisim and heavy metal.

(iii) When hard water is treated with soap it does not produce lather rather it produce white precipitate.

(iv) The precipitate is due to the formation of in soluble Soap of calcium & magnisum.

$$2C_{17}H_{35}COONa + CaCl_2 \longrightarrow (C_{17}H_{35}COO)_2 Ca\downarrow + 2NaCl$$
(Soap) (Soap of calcium)

$$2C_{17}H_{35}COOK + MgSO_4 \longrightarrow (C_{17}H_{35}COO)_2 Mg\downarrow + K_2SO_4$$
(Soap) (Soap of magnisum)

- water which doesnot produce lather or form with soap solution but form by white precepitate.

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* Soft Water:

→ Water which produce lather or form with soap Solution is called soft water.

Types of Hardness:-

It is of 2 types.

(i) Temporary Hardness
(ii) permanent Hardness

(i) TEMPORARY HARDNESS

→ The Hardness which can be removed by simple boiling is called temporary hardnes.

→ Temporary hardness is cause by carbonete and bi-carbonate of calcium and magnesium.

$$EX = \begin{Bmatrix} CaCO_3 & MgCO_3 \\ Ca(HCO_3)_2 & Mg(HCO_3)_2 \end{Bmatrix}$$

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

$$Ca(HCO_3)_2 \xrightarrow{\Delta} Ca(OH)_2 + 2CO_2$$

$$Mg(HCO_3)_2 \xrightarrow{\Delta} MgCO_3 \downarrow + H_2O + CO_2 \uparrow$$

$$Mg(HCO_3)_2 \xrightarrow{\Delta} Mg(OH)_2 \downarrow + H_2O + CO_2 \uparrow$$

→ when bi-carbonate decomposes. to insoluble carbonate and hydroxide (OH^-) the insoluble part are deposited at the bottom of the container.

(ii) Permanent Hardnes:-

→ The hardnes can't be removed by simple boiling is called permanent hardness.

→ It is also called non-carbonate hardness.

→ It is due to the sulphate&chloride of calcium and magensium and heavy metal.

$$EX = \begin{Bmatrix} CaCl_2 & MgCl_2 \\ CaSO_4 & MgSO_4 \\ FeSO_4 & FeCl_2 \end{Bmatrix}$$

+ Unit of hardness:-

① PPM (Parts Per million): PPM is the parts of $CaCO_3$ equivalent hardness for 10^6 part of water.

② Milligram/litre: one mg of $CaCO_3$ equivalent hardness Present Per litre of water.

(3) Clark degree (°c 2) : one part of $CaCO_3$ equivalent 70,000 parts of million.

(4) Degree Farenheit (°F) : one part of $CaCO_3$ equivalent hardness present in 10^5 parts of water.

(5) Milli equvalent / liter : One milli equivalent of $CaCO_3$ pres per litre of water.

$$1PPm = 1\ mg/L = 0.1°F = 0.07°Cl = 0.02\ mg/L$$

Q) Why hardness is expres in terms of $CaCO_3$ equivalent?

Ans) The concentration of hardness present in water expres in terms of equivalent amount of $CaCO_3$. The choice of $CaCO_3$ is due to:

(i) The molecular mass of $CaCO_3$ is 100. and equivalent mass is 50. Hence it is convinent for the calculat of hardness.

(ii) It is most insoluble salt that can be precepitate easily hence it can filtered out easity.

$CaCO_3$

molecular mass = $1 \times 40 + 1 \times 12 + 3 \times 6$

= 100

$$\text{Equivalent mass} = \frac{\text{molecular mass}}{\text{charge of metal ion}}$$

Equivalent mass of $CaCO_3$ = $\frac{100}{2}$

= 50

$$\text{Equivalent of } CaCO_3 = \frac{\text{Amount of substance causing hardness} \times \text{Equivalent mass of } CaCO_3}{\text{Equivalent mass of substance causing hardnes.}}$$

Q) $CaCl_2$ = 12 ppm convert it into $CaCO_3$ equivalent?

Ans:- Amount of substance causing hardness = 12 ppm.

Equivalent mass of $CaCO_3$ = 50

molecular mass of $CaCl_2$ = $1\times40+2\times35.5$
= 110.5
= 111

Equivalence mass of $CaCl_2$ = $\frac{111}{2}$ = 55.5

$\Rightarrow \frac{12\times50}{55.5}$ = 10.81

Q) $Mg(HCO_3)_2$ = 10 ppm, convert into, $CaCO_3$ equivalence.

Ans:- Equivalence mass of $Mg(HCO_3)_2$ = $\frac{146}{2}$ = 73.

Equivalence of $CaCO_3$ = $\frac{10\times50}{73}$ = 6.85.

Q) $FeSO_4\cdot7H_2O$ = 10 ppm, convert into, $CaCO_3$ equivalence.

Ans:- equivalence mass of $FeSO_4\cdot7H_2O$ = $\frac{278}{2}$ = 139

equivalence of $CaCO_3$ = $\frac{10\times50}{139}$ = 3.59

Q) $CaSO_4$ = 20 ppm, convert into, $CaCO_3$ equivalence.

Ans:- Equivalence mass of $CaSO_4$ = 68

Equivalence of $CaCO_3$ = $\frac{20\times50}{68}$ = 14.7

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* Determination of Hardness of water by EDTA method:-

- Preparation of chemicals:
- Standard hard water:

→ It can be prepared by desolving 1gm of $CaCO_3$ in 1 litre solution.

→ 1 ml of Standard water contain 1miligram of $CaCO_3$

• EDTA:

Desolve 4gm of EDTA and 0.1gm of $MgCl_2$ in 1l distilled water

• EBTA : Eriochrome black T :

Dissolve 0.5 gm of Eriochrome black T in 100ml of ethanol.

* BUFFER :

67.5 gm of Ammonium Chloride (NH_4Cl) and 570ml Ammonia and make of the Volume to 1 litre using distilled water.

* Theory :

$Ca^{2+}/mg^{2+} \xrightarrow{EBT} ca^{2+}/mg^{2+} - EBT \xrightarrow{EDTA} ca^{2+}/mg^{2+}$

(wine red) (Blue complex)

The hardness causing cation form complex with EBT The colour of the solution become wine red. On titration of standard hard water again EDTA wine red changes to blue. The blue colour indecates the formation of Calcium magnisum EDTA complex.

* Procedure :

Standardlization of EDTA :

Pipette out 50ml of Standard hard water and trasfer into conical flask, add 2 to 3ml of Ammonical buffer Solution. (PH = 10), add 2 to 3 drops of Eriochrome Black T indicator then the mixture solution Shake well and titrated against EDTA.

Let Volume of EDTA consumed is V_1.

Determination of unknown Hard water :

Pipette out 50 ml of unknown water and transfer into conical flask, add 2 to 3ml of Ammonical buffer Solution (PH = 10), then add 2 to 3 drops of Eriochrome Black T indicator then the mixture solution Shake

well and titrated against EDTA.
Let volume of EDTA consumed is V_2.

Determination of permanent Hardness:

Take 250 ml of unknown hard water boiled and reduced the volume to 50ml then filter out and washed the precipitate with distilled water and collect the filtered solution and 2-3 flask add 2-3 ml of ammonical buffer solution and 2-3 drop of EBT indicator, then titrated against EDTA.
Let volume of EDTA consumed is V_3.

Calculation:-

1gm of $CaCO_3$ = 1L of Standard hard water
1mg of $CaCO_3$ = 1 ml of standard hard water.

Standardisation of EDTA:

V_1 ml of EDTA $\Rightarrow$ 50 ml of standard hard water.
1 ml of EDTA $\Rightarrow \frac{50}{V_1}$ ml of standard hard water.
$\Rightarrow \frac{50}{V_1} \times 1$ ml of standard hard water.
$\Rightarrow \frac{50}{V_1} \times 1$ mg of $CaCO_3$

Determination of Total Hardness:

50 ml of unknown Hard water = V_2 ml of EDTA
1 ml of unknown Hard water = $\frac{V_2}{50} \times 1$ ml of EDTA
$= \frac{V_2}{50} \times \frac{50}{V_1}$ mg of $CaCO_3$

1000 ml of unknown hard water = $\frac{V_2}{50} \times \frac{50}{V_1} \times 1000$ mg of $CaCO_3$

Determination of permanent Hardness:

50 ml of boiled water = V_3 ml of EDTA
50 ml of boiled water = $\frac{V_3}{50}$ ml of EDTA

$= \frac{V_3}{50} \times \frac{50}{V_1}$ mg of $CaCO_3$

1000 ml of boiled water $= \frac{V_3}{50} \times \frac{50}{V_1} \times 1000$ mg of $CaCO_3$

Date: 03/09/24.

Questions:

About 0.28 gm of $CaCO_3$ is dissolving in HCl and the solution was made up 1l, about 100ml of standard hard water containing 10ml of EDTA solution find out the permanent hardness of the solution.

Ans- 0.28 gm of $CaCO_3$ = 1 liter of standard hardwater.

0.28 mg of $CaCO_3$ = 1 ml of standard hardwater.

+ Standardization of EDTA:

30 ml of EDTA = 100 ml of standard hardwater.

1ml of EDTA $= \frac{100}{30} \times 1$ ml of standard hardwater.

$= \frac{100}{30} \times 0.28$ mg of $CaCO_3$

$= 0.933$

+ Determination of permanent Hard water:

10 ml of stream water = 10 ml of EDTA

1ml of stream water $= \frac{10}{10} \times 1$ ml of EDTA.

1000 ml of steam water $= \frac{10}{10} \times 1000 \times \frac{100}{30} \times 0.28$ mg of $CaCO_3$

$= 933.33$.

Question:

0.1gm of $CaCO_3$ added in a water to prepare 1l of Standard hard water. 50ml of these water consume 35ml of EDTA, 50 ml of unknown water sample consume 28 ml of EDTA, where as 50 ml of boiled water Consumed 21 ml of EDTA. Calculate Total hardness

Permanent hardness Temporary hardness.

Ans: 0.1 gm of $CaCO_3$ = 1l of Standard hardwater.

0.1 mg of $CaCO_3$ = 1 ml of Standard hardwater.

Standardization of EDTA :

35 ml of EDTA = 50 ml of Standard hardwater.

1 ml of EDTA = $\frac{50}{35}$ x 1 ml of Standard hardwater.

= $\frac{50}{35}$ x 0.1 mg of $CaCO_3$.

Determination of Total hardness :-

50 ml of unknown hard water = 28 ml of EDTA.

1 ml of unknown hard water = $\frac{28}{50}$ x 1 ml of EDTA

1000 of stream of water = $\frac{28}{50}$ x 1000 x $\frac{50}{35}$ x 0.1 mg of $CaCO_3$

= 80 mg of $CaCO_3$

Determination of permanent hardnes :-

50 ml of boilied water = 21 ml of EDTA

1 ml of boilied water = $\frac{21}{50}$ x 1 ml of EDTA

1000 of boilied water = $\frac{21}{50}$ x 1000 x $\frac{50}{35}$ x 0.1 mg of $CaCO_3$

= 60 mg of $CaCO_3$.

Determination of Temporary hardness :-

Temporary Hardness = Total hardness - Permanent

= 80 - 60

= 20 gm of $CaCO_3$.

Questions :-

250 mg of $CaCO_3$ was dissolved in HCl and solution was made up to 250 ml with distilled water, 50 ml of above solution required 20 ml of EDTA. 50 ml of unknown hardwater consumed 25 ml of EDTA. Calculate the total Hardness.

Ans:- 250 mg of $CaCO_3$ = 250 ml of distilled water

1 mg of $CaCO_3$ = 1 ml of distilled water.

Standardisation of EDTA:

20 ml of EDTA = 50 ml of standard hardwater.

1 ml of EDTA = $\frac{50}{20}$ ml of standard hardwater.

= $\frac{50}{20}$ x 1 ml of standard hard water

= $\frac{50}{20}$ x 1 mg of $CaCO_3$

Determination of Total Hardness:-

50 ml of unknown hard water = 25 ml of EDTA.

1 ml of unknown hard water = $\frac{25}{50}$ x 1 ml of EDTA

1000 ml of unknown hard water = $\frac{25}{50} \times \frac{50}{20}$ x 1000 m of $CaCO_3$

= 1250 mg of $CaCO_3$.

Questions:-

0.5gm of $CaCO_3$ was dissolved in HCl and the solutio was made up to 500 ml distilled water. 50 ml of above solution required 48 ml of EDTA and 50 ml of unknown hardwater required 25 ml of EDTA and after boiling and filtering 50 ml of hardwater required 10 ml of EDTA solution. Find out total hardne Permanent hardness and Temporary hardness:-

Ans:- 0.5 gm of $CaCO_3$ = 0.5 of standard hard water.

1 mg of $CaCO_3$ = 1 ml of standard hard water.

Standardization of EDTA:

48 ml of EDTA = 50 ml of Standard hard water.

1 ml of EDTA = $\frac{50}{48}$ ml of Standard hard water.

= 50/48 x 1 ml of Standard hardwater.

$= \frac{50}{48} \times 1$ mg of $CaCO_3$

Determination of Total hardness :-

50 ml of unknown Hardness = 15 ml of EDTA

1 ml of unknown Hardness $= \frac{15}{50} \times 1$ ml of EDTA

$= \frac{15}{50} \times 1$ mg of $CaCO_3$

1000 ml of unknown Hardness $= \frac{15}{50} \times \frac{50}{48} \times 1000 \times 1$

$= 312.5$ mg of $CaCO_3$.

Determination of permanent hardness :-

50 ml of Hard water = 10 ml of EDTA.

1 ml of Hard water $= \frac{10}{50} \times 1$ ml of EDTA

1000 ml of Hard water $= \frac{10}{50} \times \frac{50}{48} \times 1000 \times 1$ mg of $CaCO_3$

$= 208.33$ mg of $CaCO_3$.

Determination of Temporary hardness :-

Temporary hardnes = Total hardness − Permanent

$= 312.5 - 208.33$

$= 104.17$ mg of $CaCO_3$.

Date : 06/09/24

✱ Water Treatment :

+ PURIFICATION OF WATER :

(i) Screening :
(ii) sedimentation :
(iii) Casecading :
(iv) Floculation / couagulation :
(v) Filteration.
(vi) Disinfection /or/ Steanlization.

(vii) Softening of water:

(i) Screening :-

It is the process to remove floating materials like leaves wood particles, plastic caps, clothes etc from water.

→ The Row water is allow to pass through a screen having large number of holes which retain the floating material.

→ Screening angle 45° to 60°.

→ Screening depends upon water velocity.

→ Screening velocity should not exceed 0.75 m/s to 1

(ii) Sedimentation :-

In this process suspended particles are removed by gravitational force.

→ Suspended particles are basically soil particle, clay particel etc.

→ Settleing suspended particles depends upon :

(i) Velocity of water

(ii) Density of water.

(iii) Specific gravity of particle.

(iv) Shape and size of particel.

→ Sedimentation removes only 75% of the suspended particel.

→ Particle settle down more rapidly in water and high temprature then low temprature.

→ The suspended particle are in settledown in the ordina tank in 6-8 hour of period of time and depth of tank is 3-6 m.

(iii) Casecading :

In casecading process enhance the dissolved oxygen

Content that [illegible] for living body.

(iv) Floculation / Couagulation :-

Finely divided plate, silica etc does'nt settledown easily hence, cannot be removed by sedimentation. Such impurity are removed by couagulation.

→ Couagulation is a process of adding of couagulate Fesoy, Sodium Alumunate, magnisum carbonate etc.

→ Mostly used when turbidity of water is greater tha 45 PPM.

→ They provide Al^{3+} and Fe^{3+} which neutralized the negat charge of collodial clay particles.

→ After lossing their charge the tiny clay particles com closer to each other and combines to form a bigger particle is called Floc. This process is known as Floculation.

→ For better result of sedimentation the couagulation added in the solution form.

1) Alum $[K_2SO_4\ Al_2(SO_4)_3 \cdot 24H_2O]$

$$Al_2(SO_4)_3 + Ca(HCO_3)_2 \longrightarrow 2\,Al(OH)_3 \downarrow + 3(CaSO_4) + 6CO_2$$

Ppt.

→ When Alum is added to water it will give $Al_2(SO_4)_3$ Aluminium sulphate get hydrolized to form gelatinou percipitate of $Al(OH)_3$ entreped the finely divided collodial impurity and get settle down and can easily be removed.

Date: 10/09/24

Three types of sand :-

1) Fine Sand
2) Gravel sand
3) Core sand.

2) Sodium Aluminate

$NaAlO_2 + H_2O \longrightarrow Al(OH)_3 + NaOH$

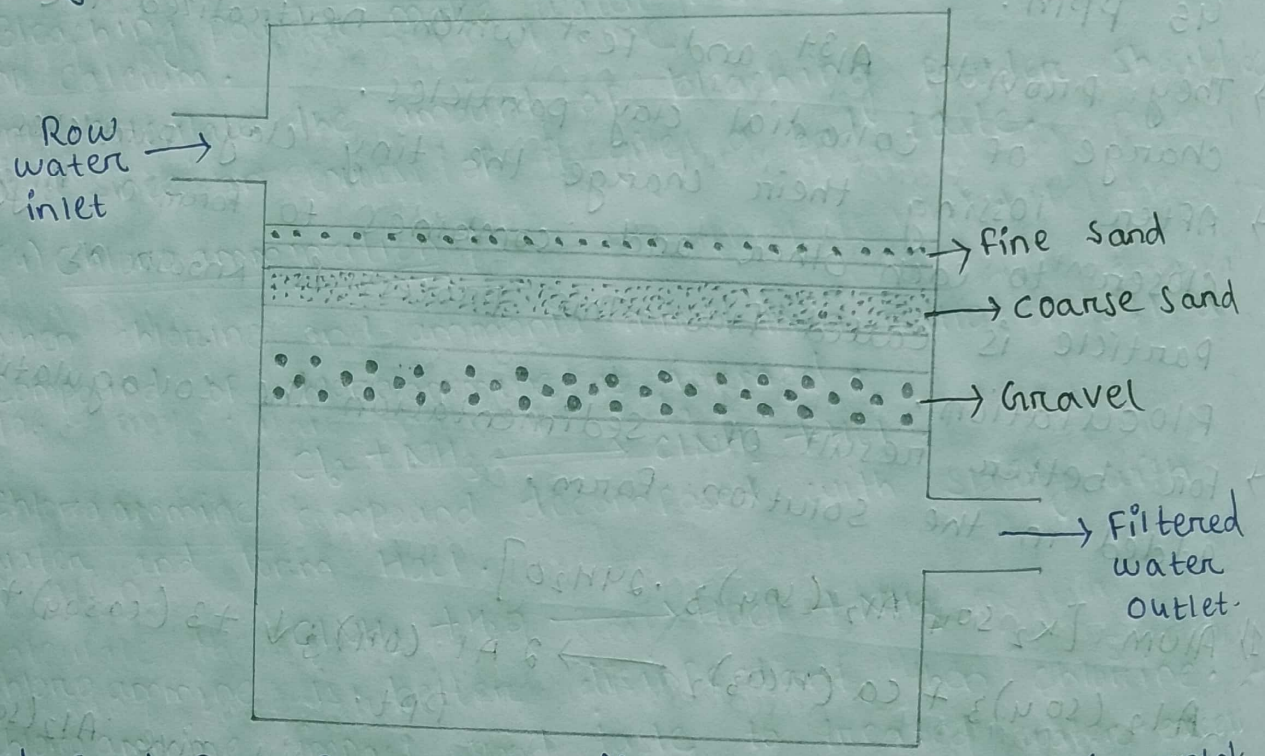
3) $Fesoy + mg(HCO_3)_2 \longrightarrow Fe(OH)_2 + mgso_4 + CO_2 + H_2O$

$Fe(OH)_2 \xrightarrow{ox_1^n} Fe(OH)_3$

(v) Filteration:

→ It is a process of removal of bacteria, colour, taste and suspended impurity by passing water through filter bed containing fine sand, coarse sand and Gravel.

→ A typical sand filter is as follows:



→ Find Sand Free From Clay, lime, raw and organic metal.

→ It should be uniform size and nature.

→ It should not be loss more than 5% weight if its placed in HCl for 24 hours.

→ When the water passes through the filtering medium it flows through the various bed slowly.

→ The rate of filteration decreases slowly due to the cloging of impurity in the pore of the sand bed.

→ When the rate of filteration become very slow or the filteration is stopped and the thick top layer of fine sand is scrapped off and replaced with clean sand.

→ The bacteria are partially removed by this process.

(vi) Disinfection or Stearlization:

→ The process of destroying or killing harmful bacteria, microbes etc. From water and making it safe for use is called disinfectant or stearlization.

→ The chemical are used for this purpose are called disinfectants this process can be carried out by the following methods.

☆ (1) Chlorine:-

→ Chlorine is commonly used disinfection element.

→ The process of apply chlorine in a small quantity of water is called chlorination.

→ Chlorine is used for disinfection not be used more than 20 minute.

→ Chlorine either in gas or in concentrated solution form Produces hypochloros acid. which is a powerful Germicide

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

↳ Hypochloro acid (Germicide)

* Advantages:-

→ It is effective and economy.
→ It required little space for storage.
→ It can be used in both low and high temperature.
→ It introduce no salt impurity in water.
→ It is the most ideal disinfectants.

* Disadvantages:-

→ Excess of Chlorine produces unpleasent taste and odour (smel
→ Excess of chlorine produces irritation on mucus membrane

☆ (2) Boiling:-

→ When water boiled for 10-15 min all the harmful bacteria are killed and water become safe for us.

* Disadvantages:-

→ Boiling alter the taste of waters.
→ It is impossible to employed it in municipal water tank.
→ This method is costly and cannot be used in industrial cases.

(3) Bleaching powder :-

→ When bleaching powder is added to water it produce hypochlorosacid.

→ HOCl is a powerful Germicide.

$$Ca(OCl)Cl + H_2O \longrightarrow Ca(OH)_2 + Cl_2$$

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

$$HOCl + Bacteria \longrightarrow kill.$$

* Disadvantages :-

→ Bleaching powder make water harder due to the present of Calcium.

→ only calculate the amount of bleaching powder should be used since an excess of it gives a bad taste.

(4) Chloro ammination :-

→ When chlorine and ammonia mixed in a ratio of 2:1 a Compound of chloro ammine is formed.

$$Cl_2 + NH_3 \longrightarrow ClNH_2 + HCl.$$

→ Chloro ammine compound decomposed with slowly with water and form HOCl.

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

→ Chloro ammine is better disinfectant then chlorine.

→ Chloro ammine impact good taste to treated water excess of it does'nt produce any irritated odour.

(5) UV radiation :-

→ UV radiation is also called as an disinfectant.

→ most of the water purifier used in house hold purpose use this technique to kill microbes.

* Disadventages :-

→ It is costly process.

→ It cannot be used in turbidity water.

→ It cannot be used for large water supply.

Date : 11/09/24

Na_2CO_3 → Soda
$Ca(OH)_2$ → lime

(vii) Softening of water :

→ Removing of hardness from hardwater is called softwater and the process is called as water softening process.

(1) LIME SODA METHOD / CLARKS METHOD :

→ Lime react with dissolve salt of Ca^{2+}, Mg^{2+}, Fe^{2+}, CO_2, HCl, H_2SO_4, to form precepitate.

(a) Removal of Temporary calcium and magnisum hardness.

* TEMPORARY :

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

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

$MgCO_3 + Ca(OH)_2 \longrightarrow Mg(OH)_2 \downarrow + CaCO_3 \downarrow$

$CaCO_3 + Ca(OH)_2 \longrightarrow Ca(OH)_2 + CaCO_3$

→ Lime can't be removed.

* PERMANENT :

$CaCl_2 + Ca(OH)_2 \longrightarrow Ca(OH)_2 + CaCl_2$

$CaSO_4 + Ca(OH)_2 \longrightarrow Ca(OH)_2 + CaSO_4$

$MgCl_2 + Ca(OH)_2 \longrightarrow Mg(OH)_2 \downarrow + CaCl_2$

$MgSO_4 + Ca(OH)_2 \longrightarrow Mg(OH)_2 \downarrow + CaSO_4$

→ Lime remove all temporary hardness and permanent hardness of magnessium, Aluminium and iron.

→ It cannot be removed by $CaCO_3$, $CaCl_2$, $CaSO_4$.

→ Lime increases the calcium permanent hardness when react with acid.

$2HCl + Ca(OH)_2 \longrightarrow CaCl_2 \downarrow + 2H_2O$

$H_2SO_4 + Ca(OH)_2 \longrightarrow CaSO_4 \downarrow + 2H_2O$

→ Soda react with calcium salt causing permanent hardness to form $CaCO_3$ which can be easily removed by Filteration.

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

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

→ Lime also removed carbon dioxide and hydrogen sulphite.

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 \downarrow + H_2O$$

$$Ca(OH)_2 + H_2S \longrightarrow CaS + 2H_2O$$

★ Calculation of lime soda requirement:-

(i) Total lime required $= \frac{74}{100}$ [2 x Temporary of mg + Temporary of Ca + Permanent of mg + (salts of Fe + Al) + CO_2 + HCl + H_2S + HCO_3^- − $NaAlO_2$ all in terms of CaCO

74 = molecular mass of lime

(ii) Total Soda required $= \frac{106}{100}$ [Permanent of Ca + Permanent of mg + (salts of Fe + Al) + HCl + H_2SO_4 − HCO_3^- all in terms of $CaCO_3$ equivalent

106 = molecular mass of Soda

Date: 13/09/24

Question:

1) Calculate the quantity of lime and soda required for softening 50,000 litre of water. The following salts per liter.

constituent	Amount	Equivalent of $CaCO_3$
$Ca(HCO_3)_2$	= 9.2 mg → Temp	$\frac{100}{162} \times 9.2 = 5.67$
$mg(HCO_3)_2$	= 7.9 mg → Temp	$\frac{100}{146} \times 7.9 = 5.41$
$Ca(SO_4)_2$	= 15.3 mg → Per	$\frac{100}{136} \times 15.3 = 11.25$
$mg(SO_4)$	= 15.0 mg → Per	$\frac{100}{120} \times 15.0 = 12.5$
$mgCl_2$	= 3.0 mg → Per	$\frac{100}{95} \times 3.0 = 3.15$
NaCl	= 4.3 mg	

Total lime required $= \frac{74}{100}$ [2 x Temp. mg + Temp. Ca + Per m

$= \frac{74}{100}$ [2 x 5.41 + 5.67 + 12.5 + 3.15

$= 23.78$ mg/l

Mass of lime = Strength x Volume

$\Rightarrow 23.78 \times 50,000 \Rightarrow 1189000$ mg

$= 1189.00$ gm

$= 1.189$ kg.

Soda required $= \frac{106}{100}$ [Perm mg + Perm ca]

$= \frac{106}{100}$ [11.25 + 15.0 + 3.0]

$= 28.54$ mg/l.

mass of soda = Strength x Volume.

$\Rightarrow 28.54 \times 50,000 \Rightarrow 1425700$ mg

$= 1425.00$ gm

$= 1.4257$ kg.

Questions:-

2) Hard water containing the following amount of different salts present per litre. Calculate the amount of lime and soda required to soften 10^6 litre of water.

Constituents:	Amount:	Equivalent of $CaCO_3$
$Ca(HCO_3)_2$	= 220 → Temp	$\frac{100}{162} \times 220 = 135.80$
$Mg(HCO_3)_2$	= 56 → Temp	$\frac{100}{146} \times 56 = 38.35$
$Ca(SO_4)_2$	= 98 → Per	$\frac{100}{136} \times 98 = 72.05$
$MgSO_4$	= 84 → Per	$\frac{100}{120} \times 84 = 70$
$MgCl_2$	= 130 → Per	$\frac{100}{95} \times 130 = 136.84$

Ans: Total lime required $= \frac{74}{100}$ [2 x Temp mg + Temp ca + Perm mg

$= \frac{74}{100}$ [2 x 38.35 + 135.80 + 70 + 136.84]

$= 316.3116$ mg/l

mass of lime = strength x volume

$\Rightarrow 310.3116 \times 10^6$ mg $\Rightarrow 310311600$

Total soda required $= \frac{106}{100}$ [Perm mg + Perm ca]

$= \frac{106}{100}$ [70 + 136.84 + 72.05]

$= 295.6234$ mg/l.

mass of soda = strength x volume

$= 295.6234 \times 10^6$ mg

$= 295623400$ mg.

3) Question:
Calculate the amount of lime and soda required for softening of 10,000 litre of water containing the following soluble salt.

Constituents:	Amount:	$CaCO_3$ equivalent:
$CaCO_3$	= 10 ppm → Temp	$\frac{100}{100} \times 10 = 10$
$CaSO_4$	= 13.6 ppm → perm	$\frac{100}{136} \times 13.6 = 10$
$Mg(HCO_3)_2$	= 14.6 ppm → Temp	$\frac{100}{146} \times 14.6 = 10$
$MgCl_2$	= 9.5 ppm → perm	$\frac{100}{95} \times 9.5 = 10$
HCl	= 3.5 ppm	$\frac{100}{36.5} \times 3.5 = 9.5$

Ans) Total lime required $= \frac{74}{100}$ [2 × Temp mg + Tem ca + Perm + HCl]

$= \frac{74}{100}$ [2 × 10 + 10 + 9.5 + 10]

$\Rightarrow 36.63 \times 10^4$ mg/l $\Rightarrow$ 366300 mg/l.

mass of lime = Strength × volume

$\Rightarrow 36.63 \times 10^4$ mg $\Rightarrow$ 366300 mg

Total soda required $= \frac{106}{100}$ [Perm mg + Perm ca + HCl]

$= \frac{106}{100}$ [10 + 10 + 9.5]

$= 31.27$ mg

mass of Soda = Strength × volume

$\Rightarrow 31.27 \times 10^4$ mg $\Rightarrow$ 312700 mg.

Temprary Hardness = $CaCO_3 + Mg(HCO_3)_2 \Rightarrow 10 + 10 \Rightarrow 20$

Permanent Hardness = $CaSO_4 + MgCl_2 \Rightarrow 10 + 10 \Rightarrow 20$

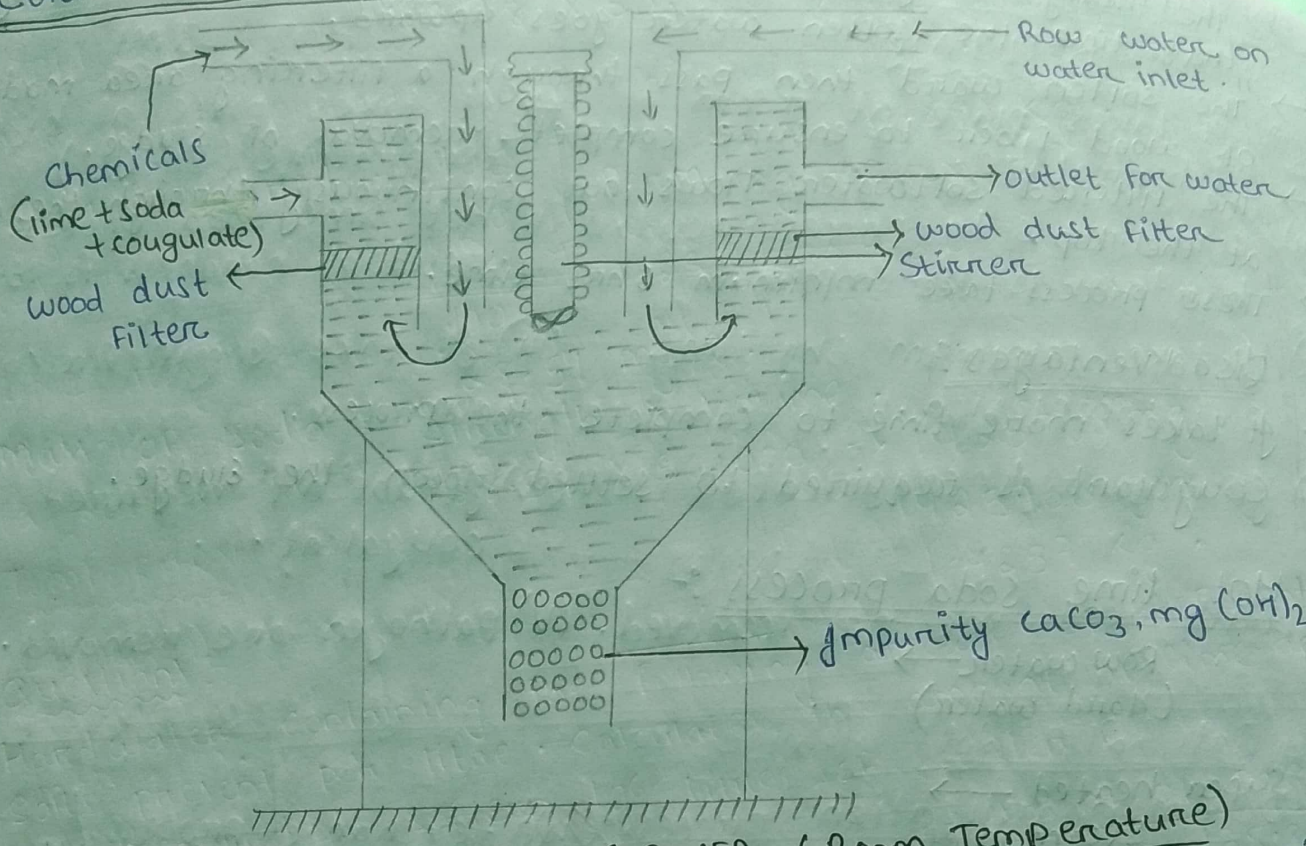
Date:- 14/09/24

LIME SODA PROCESS:-

In this method, the soluble salt of calcium and magnisum in water are chemically converted into insoluble compounds or Precipitate by adding calculated amount of lime and soda Precipitate of $CaCO_3$, $Mg(OH)_2$ are filtered off.

Lime Soda process are of 2 Types:
(i) Cold lime Soda process.
(ii) Hot lime Soda process.

(i) Cold lime Soda process:



COLD LIME SODA SOFTNER (Room Temperature)

→ In this method calculated amount of lime and soda are mixed with hardwater at room temperature.

→ At room temperature the precipate form are very fine so they do not sittle down easily and cannot be filtered off. Thus, small amount of coagulant (Alum, Sodium Alumunate, $FeSO_4$) are added which hydrolizes to flucculant Gelntanious precipated of $Al(OH)_3$ and entraps the fine precipated.

$$Al(SO_4)_3 + 3Ca(HCO_3)_2 \longrightarrow Al(OH)_3 \downarrow + 3CaSO_4 + 6CO_2 \uparrow$$

→ Using sodium Alumunate remove Silica and oils present in water.

$$NaAlO_2 + H_2O \longrightarrow NaOH + Al(OH)_3$$

→ The cold lime soda process provide water containing recidual one hardness 50-60 ppm.

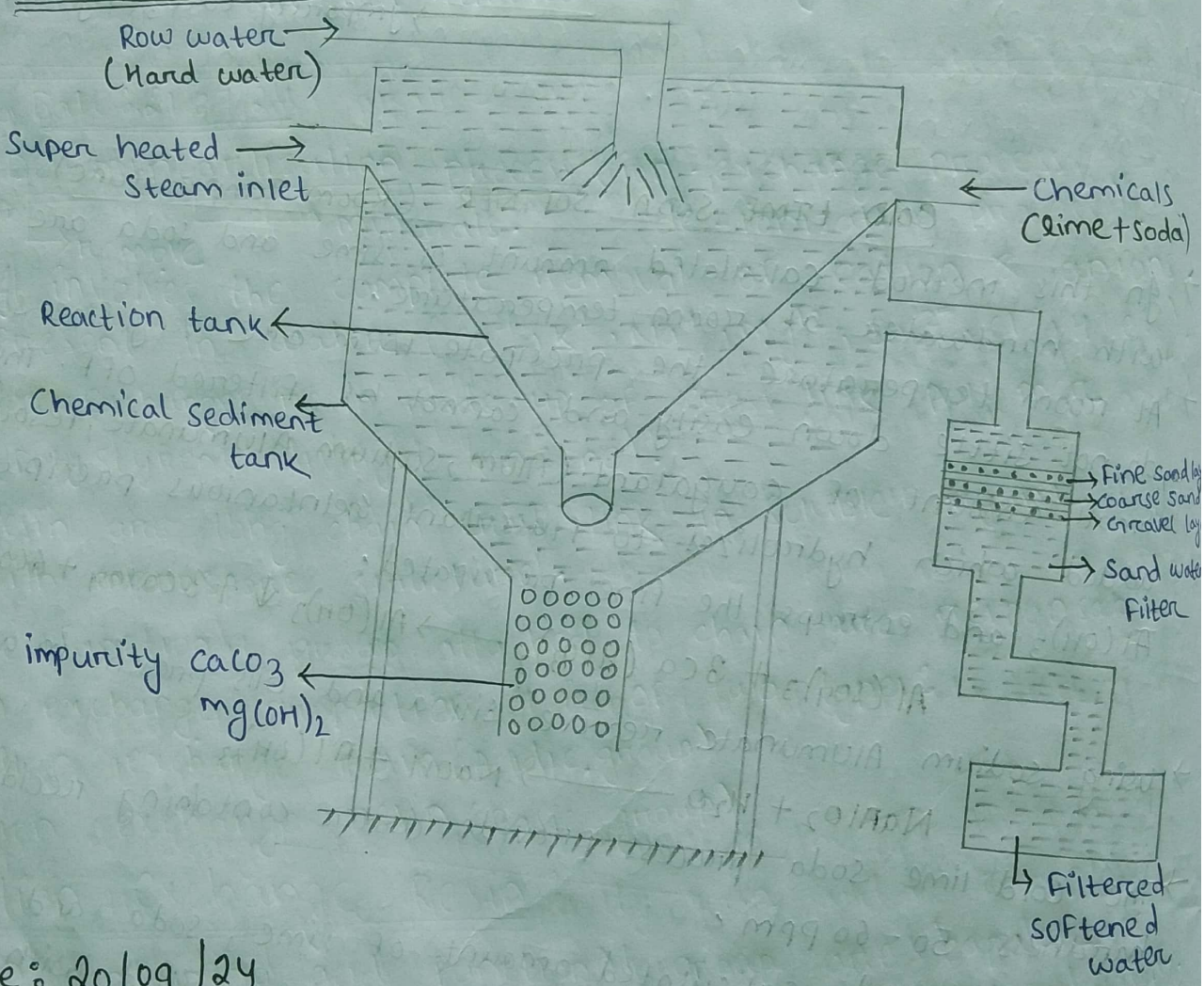
→ Hardwater and calculated amount of lime, soda and coagulant are feed from top into the inner chamber fitted with a Stirrer as the raw water or hardwater and chemical flow down then there is a vigorous stirring a continuous mixing there by softening of water takes place.

→ As the soften water comes into the outer chamber it arises upward.

→ The heavy sludge settled down in the water chamber by that time the soften water goes upward.
→ The soften ward then pass through a filtering area made of wood fiber to ensure complete removal of sludge.
→ The filtered softwater flows out continuously through the outlet at the top.
→ These process take minimum 6 hrs time.

* **Disadvantages:-**
→ It takes more time to complete the process.
→ Coagulant is required to settled down the sludge.

(ii) **Hot lime soda process:-**



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Hot lime soda process involved in treating water with softening chemicals at a temprature 80-150°c.
It is carried out in a steel tank having inner chambers and outer chamber.
The inner chamber contain 3 inlet through which hardwater calculated amount of lime and soda and steam is passed

through it.

→ The hardness providing ions reacts with lime and soda at high temprature and forum sludge, it get settled at the bottom of sediment tank or outer chamber. Since it is carried out at high temprature hence, cougulents are not required to settledown the sludge.

→ The water moves into the upward direction of outer chamber and passes through the sand filter.

→ The sand filter consists of fine sand layer, coarse sand layer and Gravel layer which absorb the residual percipated and soft water is collected through the outlet.

→ The hardness of treated water obtain about 15 - 30ppm.

I.M Question:
Why hot lime soda process is better then cold lime soda process?

Ans:- (i) Hot lime soda process can be completed with in 30min. cold lime soda process completed with in the 6hr.

(ii) Cougalents are not required for hot lime soda process. cougalents are required for cold lime soda.

(iii) The hardness of treated water is less as compared to cold lime soda process.
The hardness of treated water is high as compared to hot lime soda process.

✱ Advantages of lime soda process:-

→ It is economical. (cost)
→ In this process lesser amount of cougalent shall be needed.
→ Increase the PH value of treated water there by corrosion in reduced.
→ Minerals present in water are reduced, iron and manganese are also removed from the water for a certain extend.
→ Due to alcaline nature amount of pathogenic bacteria in water is considerably reduced.

✱ Disadvantages of lime soda process:-

→ Disposal of large amount of sludge (in soluble precipated) posses a problem.
→ This can removed hardness only up to 15ppm which is not good.

Q) Difference between cold lime & Hot lime soda process.

COLD LIME	HOT LIME
(i) It takes place at room temprature.	(i) It takes place at high temprature (80°-150°)
(ii) Cold lime soda process residual hardness is 15-60 ppm.	(ii) Hot lime soda process residual hardness is 15-30
(iii) It take minimum 6hr time for completion.	(iii) It take 30min for completion.
(iv) It required cougalent.	(iv) It doesn't required cougalent.
(v) Pathogens are not removed.	(v) Pathogen are removed.

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★ De-minearlization process: (ion-exchange process / de-ionization process).
- remove → minerals.

→ It involves the complete removal of cation & anions present in water (Ca^{2+}, K^+, Na^+, Mg^{+2}, SO_4^{2-}, Cl^-, H^+ etc)

→ Ion exchange resin made up of cross link polymer (polystyrene divinyel benzene).

→ Resin are long chain cross link in-soluble organic polymer with microspore structure.

→ The functional group attached to chain are responsable for ion exchange properties. It is of two types:

(i) Cation exchange resin (Acidic group)
(ii) Anion exchange resin (Basic group)

(i) Cation exchange Resin:-

→ Resin containing acid functional group are capable of exchange their H^+ ion with other cation of hardwater.
→ Cation exchange resin is represented by (R-H) ($COOH$, SO_3H).

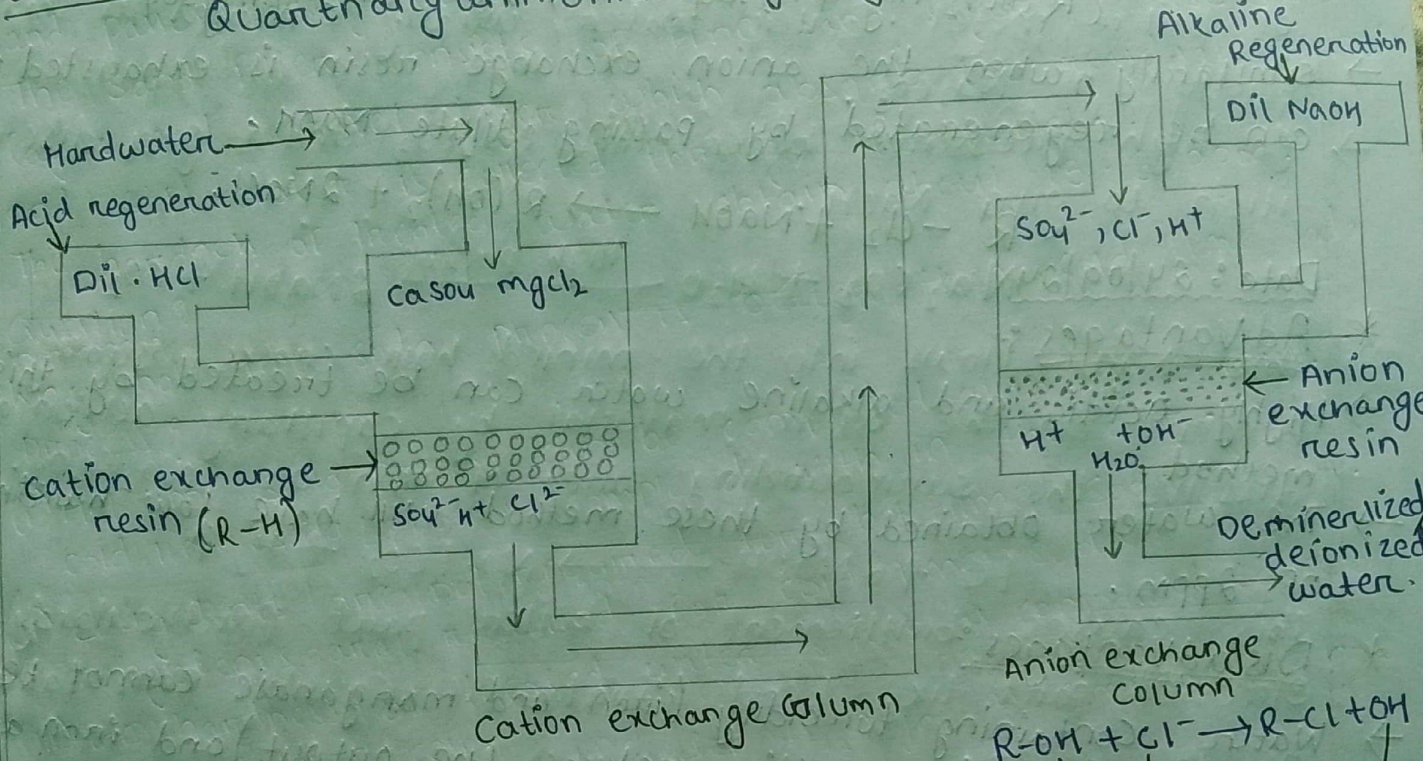
Example:- sulphalated polished styrine.

*(ii) Anion exchange Resin:-

→ Resin containing alcaline functional group ($-OH, -NH_2$) are capable of exchange their anion with other anion of hardwater.

→ Anion exchange resin is represented by (R-OH)

Example: Urea - Formaldehydrine resin.
Quartnary ammonium hydrogen salt.



$2R-H^+ + Ca^{2+}Cl \longrightarrow R_2Ca^+ + H^+$
Cation exchange

$R-OH + Cl^- \longrightarrow R-Cl + OH$
anion exchange.

$H^+ + OH^- \longrightarrow H_2O$ (D-I water)

* Process:-

→ The hardwater is pass through cation exchange resin in which all the cation such as $Na^+, K^+, mg^{2+}, Cl^{2+}$ get absorbed

$$2R-COOH + CaCl_2 \longrightarrow (RCOO)_2Ca + 2H^+ + 2Cl^-$$

$$2R-COOH + Ca^{2+} \longrightarrow (k-COO)_2Ca + 2H^+$$

→ The cation free water is then pass trough anion exchange column which absorb all the anions such as Cl^-, SO_4^{2-}, HCO_3^- present in water.

$$R'(OH)_2 + 2Cl^- \longrightarrow R'-Cl_2 + 2OH^-$$

→ The water coming out from anion exchanger is completely free from anion & cation.

→ H^+ & OH^- ion release from cation exchanger and anion exchanger respectively combain to produce water molecule.

This water is known as de-mineralized water or de-ion-zed water.

* **Regeneration:-**

→ When a cation exchange resin gets exhasted it can be regenerated by passing dilute HCl and H_2SO_4.

$$(R\,COO)_2\,Ca + 2HCl \longrightarrow 2R-COOH + CaCl_2$$

$$(R\,COO)_2\,mg + H_2SO_4 \longrightarrow 2R-COOH + mgSO_4$$

→ similarlly, when the anion exchange resin is exhausted it can be regenerated by passing dilute NaOH.

$$R'-Cl_2 + NaOH \longrightarrow R'(OH)_2 + 2NaCl.$$

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* **Advantages:-**

→ Highly acidic and alkaline water can be treated by this method.

→ The water obtained by these method will have low hardness of 2ppm.

* **Disadvantages:-**

→ Water containing turbidity (iron and manganase cannot be treated because turbidity reduces the output) and iron and manganase form stable compound with resin.

→ The equipment is costly and expensive chemical are required.

* **Boiler feed water:-**

→ The water feed into the boiler for the production of steam is called Boiler feed water.

→ Water is larged used the boiler for the production of steam the presence of impurity is in water sample renders it had (and corrsive in some cases) and any water sample cannot because as boiler feed as it may causes the problem of corresion in brittlement of the boiler, Verssel etc. Water with some specification used in boiler for steam production is called boiler feed water.

• Condition :-

→ It should free from suspended solid and dissolved corrosive gases such as carbon dioxide, Sox, Nox, Helogens, Hydrogen hylide.

→ Hardness should be less then 0.1 ppm.

→ Alkality should be in the range of 0.1 to 1ppm or less then 0.5ppm alkality is preforable.

→ It should be free form dissolved salts and oily and shopy matter that reduce the surface tension of water.

→ Boiler feed water should be free from hardness producing substances.

* Disadvantages :-

→ Formation of scales and sludges.

→ Boiler corrosion.

→ Caustic imbrittlement.

* Scales :-

Hard and adhering substance deposited on the inner wall of the boiler surface due to the presence of soluble salts like $mg(HCO_3)_2$, $mg(OH)_2$, $CaSO_4$, $ca(OH_3)_2$ etc. is known as scale producing salt.

* Disadvantages :-

→ It decrease the efficency of the boiler.

→ It cannot be removed easily.

→ Danger of explosion.

* Preventation & removal :-

→ By dissolving acids like HCl & H_2SO_4.

→ The scale can be removed by external and internal treatment.

* Sludge :-

The soft and slimy precipitated formed at the cooler part of the boiler due to the presence of soluble salt like $mgCl_2$, $mgSO_4$, $CaCl_2$, $mgCO_3$ etc...

* Disadvantages :-

→ Sludge are poor conductor of heat.

→ Excess of sludge formation decreases efficiency of boil

* Preventation & removal :-

→ By using soften water and performing frequent blow down operation.

* Caustic imbrittlement :-

→ Caustic imbrittlement means inter crystaline cracking of boiler metel. Boiler water usualy contains as small portion of Na_2CO_3.

→ In high pressure boiler this Na_2CO_3 under goes discomposition to give NaOH.

$$Na_2CO_3 + H_2O \xrightarrow{\text{High pressure}} 2NaOH + CO_2$$

→ This NaOH flows into the minied hair cracks, usually present on the boiler material by capillary action and dissolve the surrounding area of iron as Na_2FeO_2.

$$Fe + 2NaOH \longrightarrow Na_2FeO_2 + H_2\uparrow$$

This causes brittlement of boiler part particularly stressed part like bends, joints etc. causing even failure of the boiler.

* Preventation :

→ Using sodium phosphate as the softening agent insted of Na_2CO_3 (Soda).

→ By adding tannin, Ligning to the boiler water which block the crack.

* Boiler corrosion :-

Boiler is decay of boiler material by chemical or electro chemical attack of its enviroment. Boiler corrosion is due to presence of dissolved oxygen, dissolved carbon, dissolved carbon dioxide, dissolves sats like $mgCl_2$.

* Internal treatment of water :-

The removal of hardness producing ion form by the addition of chemical in boiler fluid of water is known as internal treatment of water or sequestination methods.

(i) Colloidal conditioning.
(ii) carbonate conditioning.
(iii) phosphate conditioning.
(iv) calgon conditioning.

(i) Colloidal conditioning :-

In this process the formation of scale is avoided. Adding organic substances like kerosene, tannin, Agar - Agar. They get coated over the scale forming precipitated and converts into soft and slimy (sludge) which can easily removed by blow down operation.

* Disadvantages :-

→ It leads towards preaming and foamy in the boiler.

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(ii) Carbonate conditioning :-

→ Low pressure boiler, scale formation can be avoided by adding sodium carbonate to the boiler water.

→ Scale forming salt like $CaSO_4$ converted into $CaCO_3$ which can be removed by blow down operation.

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

(iii) Phosphate conditioning :-

→ In high pressure boiler scale formation can be avoided by adding sodium phosphate.

→ The phosphate react with calcium^{2+}, Mg^{2+} salt to give soft sludge of calcium and magnesium phosphate.

$$3CaSO_4 + 2Na_3PO_4 \longrightarrow Ca_3(PO_4)_2 + 3Na_2SO_4$$
$$3CaCl_2 + 2Na_2PO_4 \longrightarrow Ca_3(PO_4)_2 + 6NaCl$$

→ The main chemical used are

Chemical	Nature	used against.
(i) Sodium dihydrogen phosphate (NaH_2PO_4)	Acidic	used against alkaline water.
(ii) Disodium hydrogen phosphate (Na_2HPO_4)	weakly alkaline	weakly acidic water.
(iii) Trisodium phosphate (Na_3PO_4)	Too alkaline	used against too acidic water.

Calgon conditioning:

Sodium nexa meca phosphate $Na_2[Na_4(PO_3)_6]$ Substance interact with calcium ion formaing a high Soluble complex and prevent scale and sludge Formati

$$Na_2[Na_4(PO_3)_6] \rightleftharpoons 2Na^+ + [Na_4(PO_3)_6]$$

$$[Na_4(PO_3)_6]^{2-} + 2CaSO_4 \longrightarrow Na[Ca_2P_6O_{18}] + 2Na_2SO_4$$

It is soluble complex ion ($Na_2[Ca_2P_6O_{18}]$), there is no problem of sludge disposal.

— X — X — X — X —

UNIT-2

completed