Ch- Water and its treatment

Sources :-

(I) Surface
(II) Underground
(III) Rain
(IV) Sea

Hardness of water → Soap consuming capacity of water

$$2C_{17}H_{35}COONa + MgCl_2 \longrightarrow \underbrace{(C_{17}H_{35}COONa)_2 Mg \downarrow}_{(Scum)} + 2NaCl$$

* Temporary Hardness :- ~~Chlorides and Sulphates~~
Carbonates & bi-carbonates

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

* Permanent Hardness :-
Chlorides and sulphates

Hardness = Mass of hardness producing substance (mg/L) $\times \frac{\text{Chem. eqv. of } CaCO_3}{\text{chem. eqv. of hardness producing substance}}$

Q. The water sample 408 mg of $CaSO_4$ per litre. Calculate the hardness in terms of ~~CaCO3~~ $CaCO_3$ eqv.

Sol:

Q How many grams of $MgCO_3$ dissolve per litre gives 84 ppm of Hardness.

Soln

$$84 = m \times \frac{50}{84}$$

$$m = (84)$$

* Disadvantage of Hard water :-

1) Domestic :-

(a) Scum formation results in more soap consumption.

(b) Cooking needs more fuel

ii) Industrial :-

(a) Boiler corrosion

(b) Scale & Sludge

(c) Priming and foaming

(d) Caustic Embrittlement.

(b) Scale and Sludge :-

Ionic product > Solubility product ⇒ precipitate formation.

* Factors -

- $Ca(HCO_3)_2 \longrightarrow$
- Deposition of $CaSO_4$
- Hydrolysis of Mg-salt

$$MgCl_2 + 2H_2O \longrightarrow Mg(OH)_2 \downarrow + 2HCl$$

* Method to prevent scale and sludge :-

- External method
- Internal method — Add some ~~reaction~~ substance inside the boiler.
  Carbonates, phosphates, calgon conditioning.

(a) Boiler corrosion :- Decay or disintegration of boiler material either due to chemical reactions or electrochemical reactions with its environment.

- Factors :-

(I) $MgCl_2 + 2H_2O \longrightarrow Mg(OH)_2\downarrow + 2HCl$

$Fe + 2HCl \longrightarrow FeCl_2 + H_2$.

$FeCl_2 + 2H_2O \longrightarrow Fe(OH)_2 \downarrow + 2HCl$

$Fe(OH)_2 + O_2 \longrightarrow [Fe_2O_3 \cdot 2H_2O]$

(II) Presence of D.O.

$Fe + 2H_2O + O_2 \longrightarrow Fe(OH)_2 \downarrow \longrightarrow$ Rust

(III) Presence of CO_2 :-

$CO_2 + H_2O \longrightarrow H_2CO_3$

* Methods to prvent Dissolved oxygen :-

- Pre heating
- Mechanical
- $N_2H_4 + O_2 \longrightarrow N_2\uparrow + H_2O$
- $2Na_2S + O_2 \longrightarrow 2Na_2SO_4$

$Na_2SO_3 + O_2 \longrightarrow 2Na_2SO_4$

$CO_2 + 2NH_4OH \longrightarrow (NH_4)_2CO_3 + H_2O$

(d) Caustic Embrittlement :-

It is the phenomenon during which the boiler matter becomes brittle due to accumulation of caustic substances. This type of corrosion is caused by the use of highly alkaline in high pressure boiler.

$$Na_2CO_3 \longrightarrow NaOH + CO_2$$
$$\downarrow Fe$$
Sodium Ferrate

*Factors :-

(I) Tannin or Lignum.

(II) Sodium phosphate

(III) Na_2SO_4

$$\frac{[Na_2SO_4]}{[NaOH]} = \begin{cases} 1:1 \longrightarrow 10\,atm \\ 2:1 \longrightarrow 20\,atm \\ 3:1 \longrightarrow 20\,atm \end{cases}$$

* Methods to prevent caustic embrittlement :-

1) Lime soda process
2) Zeolite
3) Ion-exchange
4) COD & BOD

iv) COD & BOD :- (Chemical O

$$C_2H_6 + Cr_2O_7^{2-} + H^+ \xrightarrow[\text{Time } 3\to4 \text{ Hours}]{\Delta} 2Cr^{3+} + CO_2 + H_2O$$

$$COD = \frac{(A-B) \times M \times 8000}{ml\ of\ sample}\ mg/L$$

A = ml of FAS req^d for Blank
B = " " FAS " " Sample
M = Molarity of FAS

(FAS = Ferrous Aluminium Sulphate.)

* BOD

{ Specific temp.
aerobic condition
time of incubation

COD > BOD

COD = Total oxidizable ion
= Bio-degradable ion + Non-biodegradable ion
= BOD + x

∴ COD > BOD

$\frac{COD}{BOD} > 1$

* when $\frac{COD}{BOD} = 1$ → all ions are bio-degradable ions

i) $BOD_5 = \frac{(D \cdot O_i - D \cdot O_f)}{P}$ mg/L

P = dilution factor
$P = \frac{\text{volume taken}}{300}$

ii) $BOD_5 = \frac{(DO_i - DO_f) - (1-P)(B_i - B_f)}{P}$ mg/L

iii) $BOD_t = L_o(1 - e^{-Kt})$

iv) $K_T = K_{20}\theta^{(T-20)}$ $\theta = 1.054$

Q.1 If the Initial D.O. and D.O. after 5 days incubated at 20°C in 1% dilution sample is 5 and 4 mg/L respectively. Determine the BOD_5 of sample.

Q.2 If BOD_5 of a waste water sample measured at 20°C is 250 mg/L, rate constant K is 0.35 d^{-1}. Calculate its ultimate B.O.D. and BOD_3.

Q.3 If BOD_5 of a sample measured at 20°C is 250 mg/L determine the BOD_3 of the sample. Assuming BOD rxn rate constant K, 0.23/day.

1. $$BOD_5 = \frac{(5-4)}{0.01} = 100 \text{ mg/L}$$

2. $$BOD_5 = L_o\left(1 - e^{-0.35 \times 5}\right)$$

$$\Rightarrow 250 = L_o\left(1 - e^{-0.35 \times 5}\right)$$

$$\Rightarrow L_o = \text{\_\_\_\_\_}$$

$$BOD_3 = L_o\left(1 - e^{-0.35 \times 3}\right)$$

$$= \text{\_\_\_\_\_}$$

3.

i) Lime-Soda

$Ca(OH)_2$, Na_2CO_3

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

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

ii) Zeolite :- (20-25ppm hardness)

$Na_2Ze + Ca(HCO_3)_2 \longrightarrow CaZe + 2NaHCO_3$ → it should be removed

$Na_2Ze + MgSO_4 \longrightarrow MgZe + Na_2SO_4$

$NaHCO_3 \longrightarrow NaOH + CO_2$

$NaOH$ → Caustic Embrittlement

CO_2 → Boiler corrosion

iii) Ion-exchange :-

$$\chi RSO_3^-H^+ + M^{x+} \underset{NaNO_3}{\overset{KCl}{\overset{KNO_3}{\rightleftharpoons}}} \left[RSO_3^-\right]_\chi^{} H^{x+} + \chi H^+$$

Solid | Soln | Solid | Soln

Cation exchange resin

$$\chi\left[R\overset{+}{N}(CH_3)_3\right]OH^- + A^{x-} \longrightarrow \left[R\overset{+}{N}(CH_3)_3\right]_\chi A^{x-} + \chi OH^-$$

Anion exchange resin