

UNIT I : Environmental Pollution And Control - I

WATER TECHNOLOGY

Parameters to check pollution

used as :

1. Hardness
2. Alkalinity
3. DO (Dissolved O₂)
4. BOD (Biochemical O₂ demand)
5. COD (Chemical O₂ demand)

- (1) coolant
- (2) electricity

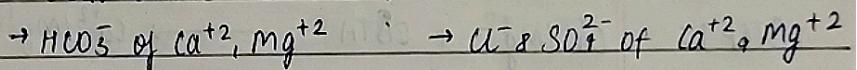
H₂O Pathogens
Ca, Cd, Pb,
AS, Hg

HARDNESS

def : soap consuming capacity of H₂O

TEMPORARY hardness

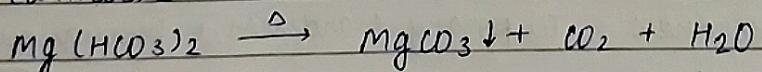
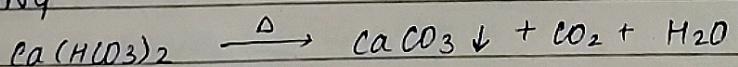
(carbonate hardness)



PERMANENT hardness

• Temporary hardness removal

1) BY BOILING



2) BY ADDING LIME Ca(OH)₂



• Permanent hardness removal

1) Zeolite method

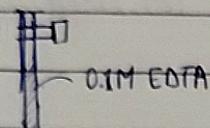
2) Ion-exchange method

3) Lime soda method

Determination of hardness of H₂O sample

1) EDTA Method

ETHYLENE DIAMINE
TETRA ACETIC ACID



END POINT: Wine Red → Blue

10 mL H₂O sample +

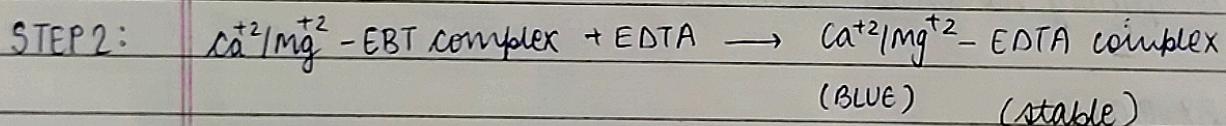
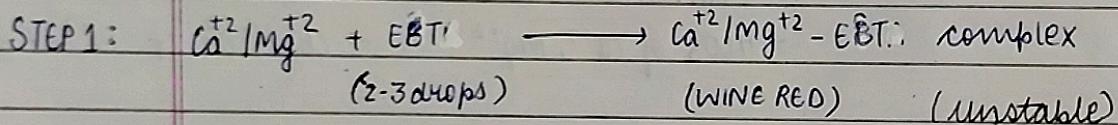
2-3 drops indicator (Eriochrome Black-T)

↳ BLUE color due to AZO group

-N=N-

BUFFER SOLUTION (8-9 pH)

NH₄Cl + NH₃ soln (5 mL)



TOTAL Hardness = Temporary Hardness + permanent hardness

unit: ppm = Mg / mL = mg / L
micro milli

27/08/24

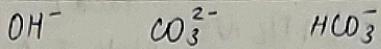
OSTEOPOROSIS: (due to deficiency of Ca⁺²/Mg⁺²)

→ bone disease that develops when bone mineral density and bone mass decreases, or when the quality or structure of bone changes.

calcinate crystals \rightarrow kidney stones (due to excess $\text{Ca}^{2+}/\text{Mg}^{2+}$ in H_2O)

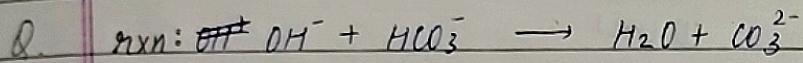
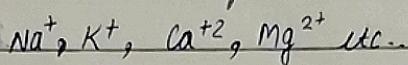
ALKALINITY

def: ability of H_2O to neutralise acids



hydroxide carbonate bicarbonate

combined form with

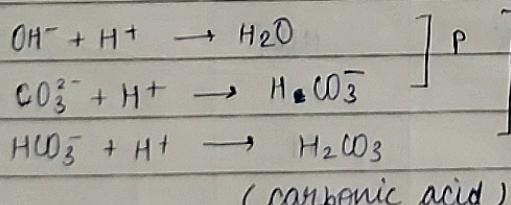
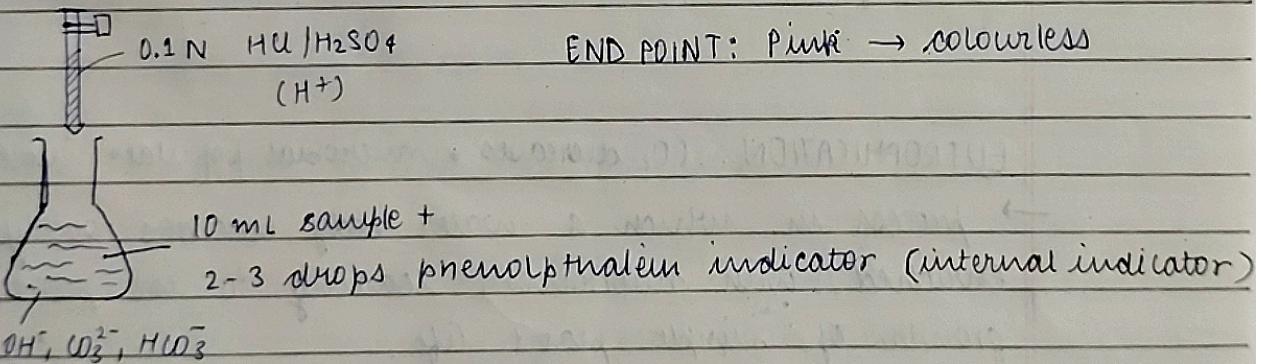


will OH^- and HCO_3^- exist together in H_2O ?

\rightarrow no, they will not exist together as they'll combine to form CO_3^{2-} .

- Determination of alkalinity of H_2O sample

1)



(carbonic acid)

P: phenolphthalein

M: methyl orange

CALCULATIONS: $N_1 V_1 = N_2 V_2$
(acid) (H₂O sample)

STRENGTH = $N \times \text{eq wt of } \text{CaCO}_3$

$$= N \times 50 \text{ g/L}$$

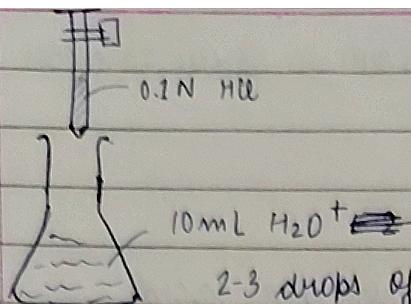
$$0.1 \times V_1 = N_2 \times 10$$

$$N_2 = \frac{0.1 \times V_1 \text{ (mL)}}{10 \text{ mL}}$$

$$= N \times 50 \times 1000 \text{ ppm}$$

(alkalinity)

2)



END POINT: Yellow → pink

CALCULATIONS: (acid)

$$N_1 V_1 = N_2 V_2 \text{ (H}_2\text{O)}$$

$$0.1 \times V_1 = N_2 \times 10$$

$$N_2 = \underline{0.1 \times V_1} \text{ (mL)}$$

$$10 \text{ (mL)}$$

$$= \underline{0.1 \times (V_1' + V_2')} \text{ (mL)}$$

$$10 \text{ (mL)}$$

$$\text{STRENGTH} = N_2 \times \text{eq wt (CaCO}_3$$

$$= N \times 50 \text{ g/L}$$

$$= N \times 50 \times 10^3 \text{ ppm}$$

(M alkalinity)

 V_1' = amt. of HCl in titration 1 V_2' = amt. of HCl in titration 2using Phenolphthalein - OH^- , CO_3^{2-} using Methyl indicator - OH^- , CO_3^{2-} , HCO_3^- → TOTAL ALKALINITYEUTROPHICATION: (O_2 decreases, microbial population increases)

→ process in which a water body becomes overly enriched with nutrients, leading to the plentiful growth of simple plant life.

28/08/24

| CASE | OH^- | CO_3^{2-} | HCO_3^- |
|---------------------|---------------|--------------------|------------------|
| $P=0$ | Nil | Nil | M |
| $P=0.5 \text{ M}$ | Nil | $2P$ | Nil |
| $P < 0.5 \text{ M}$ | Nil | $2P$ | $(M-2P)$ |
| $P > 0.5 \text{ M}$ | $(2P-M)$ | $2(M-P)$ | Nil |
| $P=M$ | $P=M$ | Nil | Nil |

case P = 1/2 M P = 50 ppm M = 100 ppm

RESULT: amt. of OH^- = nil

amt. of CO_3^{2-} = $2P = 2 \times 50 = 100 \text{ ppm}$

amt. of HCO_3^- = nil

case P < 1/2 M M = 200 ppm P = 50 ppm

RESULT: amt. of OH^- =

amt. of CO_3^{2-} =

amt. of HCO_3^- =

DISSOLVED OXYGEN (DO)

SOURCES: 1) atmospheric O_2 - 21%

2) photosynthesis by plants

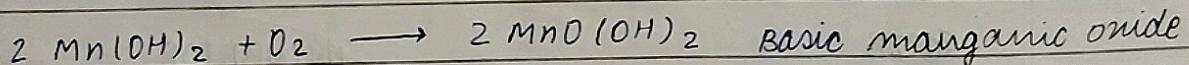
drinking water: 5-8 ppm

slightly contaminated: 0-1 ppm

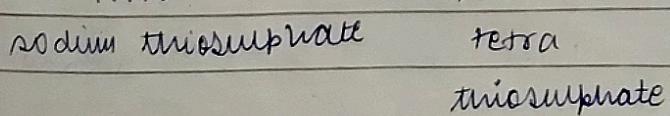
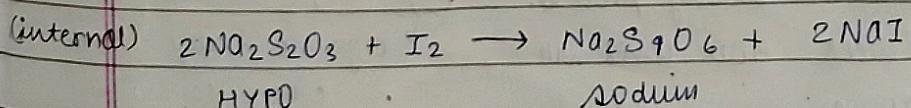
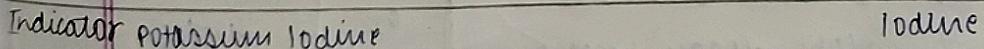
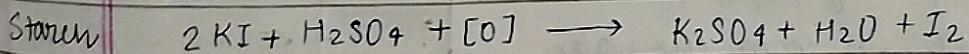
high purity: 98-15 ppm

determination of DO in H_2O sample

WINKLER'S METHOD on IODOMETRIC TITRATION



~~2KI~~



BIOM BIO CHEMICAL OXYGEN DEMAND

AEROBIC Organic matter + O₂ $\xrightarrow{\text{micro-organisms}}$ CO₂ + H₂O
 DECOMPOSITION (DECAY PLANTS, DEAD ANIMALS) (NON TOXIC PRODUCTS)

AN AEROBIC Organic matter $\xrightarrow{\text{micro-organisms}}$ CO₂ + NH₄
 DECOMPOSITION FLASH POINT (TOXIC)

FLASH POINT: (min BOD at which sample catches fire)

def: amt. of O₂ reqd. by microorganism to decompose organic matter into non-objectionable products.

Normal H₂O

B.O.D = NIL (340 ppm)

DO = 5-8 ppm

02/09/24

$$\text{BOD} = \left[\frac{\text{dissolved O}_2 \text{ (before incubation)} - \text{dissolved O}_2 \text{ (after incubation)}}{\text{dilut' factor}} \right]$$

BOD = 0 ppm: non polluted water

dilut' factor = 12

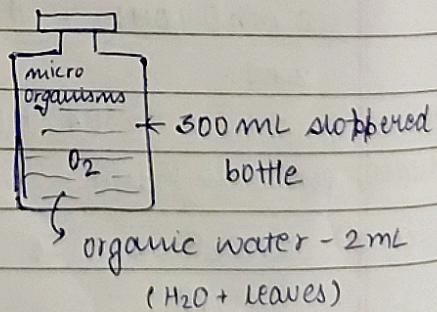
BOD = 100 ppm: polluted water

300

TEST TUBE

- micro-organisms take O₂ from the water and start decay process.
- after 1 week BOD level will come down

INCUBATOR



CHEMICAL OXYGEN DEMAND

BOD: amt of O_2 ,
microorganisms reqd
to breakdown org.
matter.

COD: amt. of O_2 reqd
to break down org.
matter via oxidation

COD > BOD, more
organic compd. can be
chemically oxidized
than biologically.

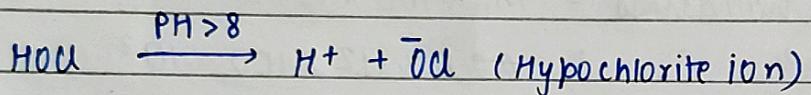
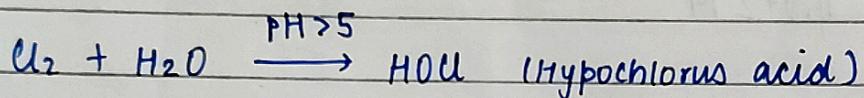
BREAK POINT CHLORINATION

• disinfection of H₂O sample

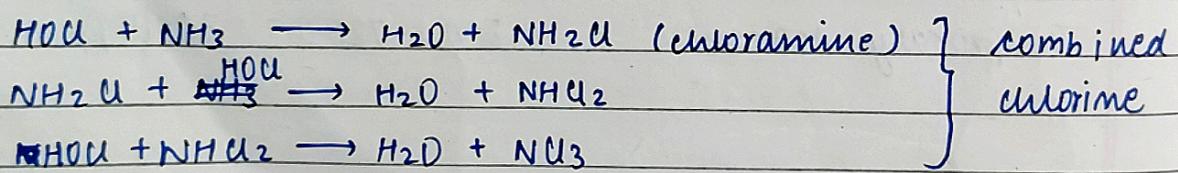
Removal of organic, inorganic impurities
and pathogens from waste H₂O.

↳ disease

causing organisms (Bacteria, fungi, virus etc.)



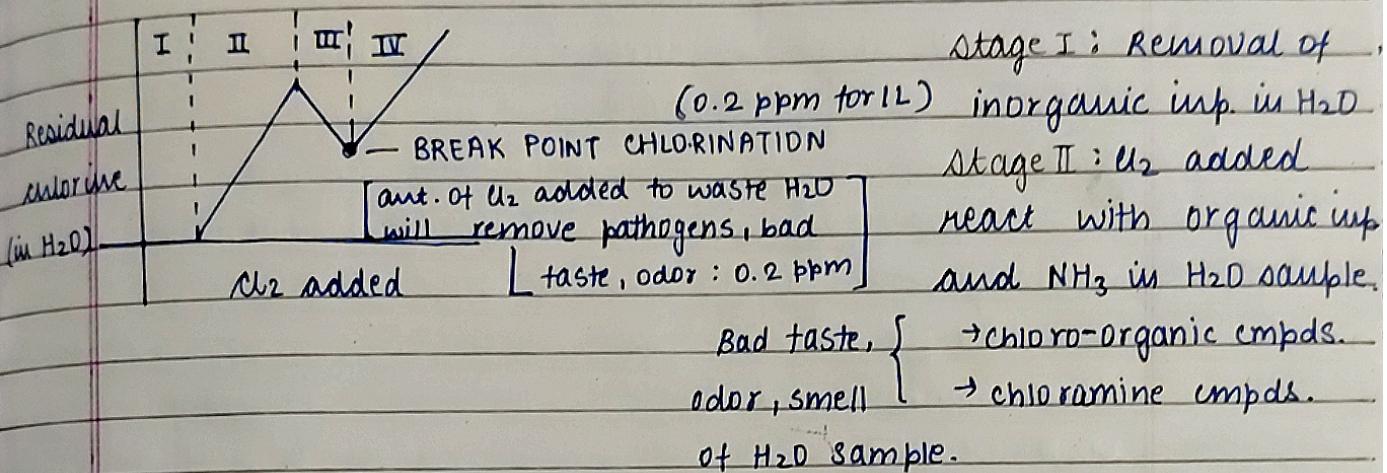
Cl₂, OCl⁻, HOCl → free chlorine



• Enzymatic hypothesis (Green and Strub)

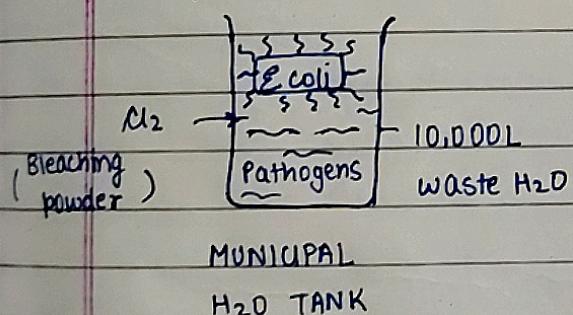
1. Inactivation of enzymes
2. Rupture of cell wall membrane (lipids + proteins)
3. DNA damage
4. Mitochondrial ~~is~~ damage

Cl_2 will dissolve
2



Stage III : destruction of chloro-organic & chloramine cmpds.

Stage IV : Cl_2 remains unutilised in H_2O (residual Cl_2)

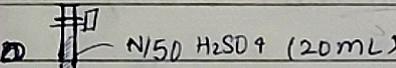


NUMERICAL ON ALKALINITY

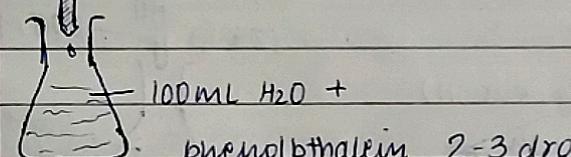
BOOK: Engineering chemistry

AUTHOR: Shashi Rawat

- Q1. A H_2O sample is alkaline to both phenolphthalein as well as methyl orange. 100 ml of ~~titre~~ H_2O sample on titration with $\text{N} \frac{1}{50} \text{ H}_2\text{SO}_4$ reqd. 20 ml of the acid to phenolphthalein end point. When a few drops of MCOH is added to the same solution and the titration further continued, the yellow colour of the soln just turns to red after addition of another 50 ml 20 ml of acid soln. Elucidate the type and extent of alkalinity present in H_2O .

SOLN:  $\text{N}/50 \text{ H}_2\text{SO}_4$ (20 mL)

END POINT: pink \rightarrow colourless

 100 mL H_2O + phenolphthalein 2-3 drops

$$\text{N}_1 V_1 = \text{N}_2 V_2$$

$$\frac{1}{50} \times 20 = \text{N} \times 100$$

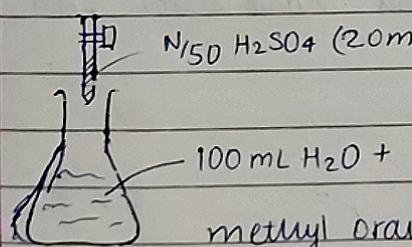
$$\text{Strength} = \text{N}_2 \times \text{eq. wt. of } \text{CaCO}_3$$

$$= \frac{1}{250} \times 50 \times 10^3 \text{ ppm}$$

$$\text{N}_2 = \text{N}/250$$

$$P = 200 \text{ ppm}$$

phenolphthalein alkalinity

 $\text{N}/50 \text{ H}_2\text{SO}_4$ (20 mL)
100 mL H_2O + methyl orange

END POINT: yellow \rightarrow red

$$\text{N}_1 V_1 = \text{N}_2 (V'_1 + V'_2)$$

$$\text{N}_2 \times 100 = \frac{1}{50} (20 + 20)$$

$$\text{Strength} = \frac{1}{10} \times \frac{1}{50} \times 50 \times 10^3$$

$$M = 400 \text{ ppm}$$

$$\text{N}_2 = \text{N}/25$$

$$P = 200 \text{ ppm}, M = 500 \text{ ppm}$$

$$\bullet P = 0.5M$$

$$HCO_3^- = \text{nil}$$

$$OH^- = \text{nil}, CO_3^{2-} = 2P = 400 \text{ ppm}, HCO_3^- = (M - 2P) = \frac{\text{nil}}{100 \text{ ppm}}$$

04/09/24

② NUMERICAL ON HARDNESS

Q. 15 gm of CaCO_3 was dissolved in HCl and the solution was made to 1L with distilled H_2O . 100 mL of the above solution required 25 mL of EDTA soln on titration. 100 mL of hard H_2O sample reqd. 18 mL of the same EDTA soln on titration. After boiling 100 mL of this water, cool & cooling, filtering and titration reqd. 12 mL of EDTA soln. calculate the permanent & temporary hardness of H_2O .

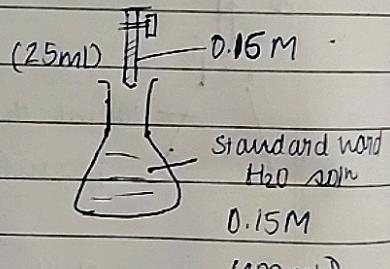
STEP 1:

molarity (conc. already known)

molarity of standard solution

Hard H_2O

$$M = \frac{w.t.}{M.M} = \frac{15}{100}$$



$$M = \frac{M}{V} = \frac{15/100}{(1)} = \frac{15}{100}$$

STEP 2:

Titration of EDTA with Standard hard water soln

$$M_1 V_1 = M_2 V_2$$

(hard H_2O) (EDTA soln)

$$\frac{15}{100} \times 100 = M_2 \times 25$$

$$0.6M = \frac{3}{5} = M_2 \text{ molarity of EDTA}$$

STEP 3

Titration of EDTA with sample hard H₂O

$$M_1' V_1' = M_2' V_2'$$

(sample
hard H₂O) (EDTA)

$$\textcircled{1} \quad M_1' \times 100 = 0.6 \times 18$$

$$M_1' = \cancel{0.6} \text{ M} \quad 0.108 \text{ M}$$

→ MM_{CaCO₃}

$$\text{hardness total} = M_{TH} \times 100 \times 1000 \rightarrow \text{convert to ppm}$$

$$= \frac{0.6 \times 18 \times 10^5}{100}$$

$$\text{total hardness} = 10.800 \text{ ppm}$$

of H₂O sample

1) mo. of moles = wt / MM

2) M = mo. of moles / V_L

3) M₁' V₁ = M₂ V₂

4) Total hardness = M × 100 × 10³

5) Tot hardness =

$$\begin{matrix} \text{Temporary} & + \text{Permanent} \\ \text{H}_2\text{O} & \text{H}_2\text{O} \end{matrix}$$

$$M_1' \times 100 = 0.6 \times 12$$

(EDTA)

$$M_1' = 0.072 \text{ M}$$

$$\text{permanent hardness} = M_1' \times 100 \times 1000$$

$$= \cancel{0.6} \times 12 \times 100 \times 10^3$$

$$= 7200 \text{ ppm}$$

$$\text{Temporary hardness} = 10.800 - 7200 = 3600 \text{ ppm}$$

Q A sample of hard H₂O contains 150 ppm of temporary hardness and 330 ppm of permanent hardness.
Express above hardness in °French °Clark

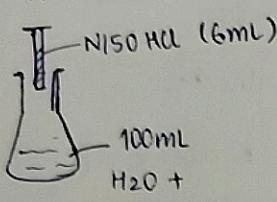
$$1 \text{ ppm} = 0.1^\circ \text{Fr} = 0.07^\circ \text{Cl}$$

$$TH = 150 \text{ ppm} = 15^\circ \text{Fr} = 10.5^\circ \text{Cl}$$

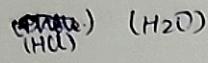
$$PH = 300 \text{ ppm} = 30^\circ \text{Fr} = 21.0^\circ \text{Cl}$$

Q1. A sample of water was alkaline to both phenolphthalein & Methyl orange 100mL of water. Sample reqd. 6mL of N/50 HCl for Phen. end point and 10mL of ~~N/50~~ HCl for methyl orange end point. Determine types & extent of alkalinity present.

TITRATION 1:



$$N_1 V_1 = N_2 V_2$$



$$\frac{N}{50} \times 6 = N_2 \times 100$$

$$N_2 = 1.2 \times 10^{-3} N$$

$$N_2 = 0.0012 N$$

END POINT :

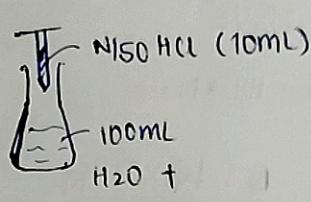
pink \rightarrow colourless

$$\begin{aligned} P &= N_2 \times \text{eq. wt. of } CaCO_3 \\ &= 1.2 \times 10^{-3} \times 50 \text{ (g/L)} \\ &= 60 \times 10^{-3} \times 10^3 \text{ (mg/L)} \\ &= 60 \text{ ppm} \end{aligned}$$

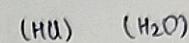
$$\underline{P \geq M/2 : OH^- = 2P = M}, CO_3^{2-} = 2(M-P)$$

$$= 20 \text{ ppm} \quad = 80 \text{ ppm}$$

TITRATION 2:



$$N_1 V_1 = N_2 V_2$$



$$\frac{N}{50} (10+6) = N_2 \times 100$$

$$N_2 = 3.2 \times 10^{-3}$$

$$N_2 = 0.0032$$

$$N_2 = 0.2 \times 10^{-3}$$

END POINT:

orange \rightarrow red

$$\begin{aligned} M &= N_2 \times \text{eq. wt. of } CaCO_3 \\ &= 2 \times 10^{-3} \times 50 \text{ (g/L)} \\ &= 160 \times 10^{-3} \times 10^3 \text{ (mg/L)} \\ &= 160 \text{ ppm, 100 ppm} \end{aligned}$$

Q2. A water sample is alkaline to both phenolphthalein as well as methyl orange. 100mL of water sample on titr. with N/50 H₂SO₄ reqd. 20mL of acid to phenolphthalein end point. When a few drops of me orange are added to same soln & titr. further takes place, color changes from yellow to red after another 20mL of acid.

TITRATION 1: $N_1 M = N_2 V_2$

$$\frac{N}{50} \times 20 = N_2 \times 100$$

$$N_2 = 4 \times 10^{-3}$$

$$P = N_2 \times 50 \times 10^3 \text{ (mg/L)}$$

$$= 200 \text{ ppm}$$

TITRATION 2: $N_1 V_1 = N_2 V_2$

$$\frac{N}{50} (20+20) = N_2 \times 100$$

$$N_2 = 8 \times 10^{-3}$$

$$M = N_2 \times 50 \times 10^3 \times 10^3 \text{ (mg/L)}$$

$$= 400 \text{ ppm}$$

$$P = M, P = \frac{M}{2}$$

$$OH^- = \underline{\text{null}}$$

$$CO_3^{2-} = 2P = 400 \text{ ppm, } HCO_3^- = \underline{\text{null}}$$

Q3. 100mL of water sample on titration with N1 50 H₂SO₄ gave a titre value of 5.8 mL to phenolphthalein end point and another 100mL sample on titration with same acid gave a titre value of 11.6 mL to methyl orange end point. calculate the alkalinity of water sample in terms of CaCO₃ and comment on type of alkalinity present.

$$\text{TITRATION 1 : } N_1 V_1 = N_2 V_2$$

$$\frac{N_1}{50} \times 5.8 = 100 \times N_2$$

$$N_2 = \underline{\underline{1.16 \times 10^{-3} \text{ N}}}$$

$$P = N_2 \times \text{eq. wt CaCO}_3 \times 10^3 \text{ (mg/L)}$$

$$= 1.16 \times 50 \times 10^3 \times 10^{-3}$$

$$= \underline{\underline{58 \text{ ppm}}}$$

$$\text{TITRATION 2 : } N_1 V_1 = N_2 V_2$$

$$\frac{N_1}{50} \times 11.6 = 100 \times N_2$$

$$N_2 = \underline{\underline{1.16 \times 10^{-3} \text{ N}}}$$

$$M = N_2 \times \text{eq. wt CaCO}_3 \times 10^3 \text{ (mg/L)}$$

$$= 1.16 \times 10^{-3} \times 50 \times 10^3$$

$$M = \underline{\underline{58 \text{ ppm}}}$$

$$P \neq M/2 :$$



$$OH^- = \underline{\underline{nil}} \quad CO_3^{2-} = 2P = \underline{\underline{58 \text{ ppm}}} \quad HW_3^- = \underline{\underline{nil}}$$

Q1. 15 g CaCO_3 was dissolved in HCl and the solution was made to 1L with distilled water. 100mL of above soln reqd 25mL EDTA soln on titration. 100mL of the same water sample reqd. 18mL of same EDTA soln on titration. After boiling 100mL of water, cooling, filtering and then titration reqd. 12mL of EDTA soln. Calculate the temporary & permanent hardness.

$$\text{STEP 1: } \text{CaCO}_3 \text{ weight} = 15 \text{ g}$$

$$\text{moles} = \frac{15}{100} = \underline{\underline{0.15}}$$

$$\text{MW} = 100 \text{ g}$$

$$\text{Volume of water} = 1 \text{ L}$$

$$\text{Molarity of standard H}_2\text{O soln} = \frac{M}{V_L}$$

$$= \frac{0.15}{1} = \underline{\underline{0.15 \text{ M}}}$$

$$\text{STEP 3: } M_1 V_1 = M_2 V_2$$

$$(\text{EDTA}) \quad (\text{H}_2\text{O})$$

$$0.6 \times 18 = M_2 \times 100$$

$$M_2 = 108 \times 10^{-3} \text{ M}$$

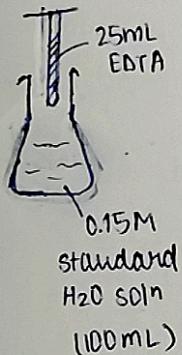
$$M_2 = \underline{\underline{0.108 \text{ M}}}$$

$$\text{TOTAL HARDNESS} = M_{TH} \times MM_{\text{CaCO}_3} \text{ (mg/L)}$$

$$= 0.108 \times 100 \times 10^3 \text{ (mg/L)}$$

$$= \underline{\underline{10800 \text{ ppm}}}$$

STEP 2: TITRATN OF EDTA WITH STAND. SOLN



$$M_1 V_1 = M_2 V_2$$

$$(\text{EDTA}) \quad (\text{H}_2\text{O})$$

$$M_1 \times 25 = 100 \times 0.15$$

$$M_1 = 3/5$$

$$M_1 = \underline{\underline{0.6 \text{ M}}}$$

$$\text{STEP 4: } M_1 V_1 = M_2 V_2$$

$$(\text{EDTA}) \quad (\text{H}_2\text{O})$$

$$0.6 \times 12 = M_2 \times 100$$

$$M_2 = \underline{\underline{0.072 \text{ M}}}$$

By boiling we remove temporary hardness

$$\text{Permanent hardness} = M_{TH} \times MM_{\text{CaCO}_3} \text{ (mg/L)}$$

$$= 72 \times 10^3 \times 100 \times 10^3 \text{ (mg/L)}$$

$$= \underline{\underline{7200 \text{ ppm}}}$$

$$(g/L)$$

$$\text{Temporary hardness} = 10800 - 7200$$

$$= \underline{\underline{3600 \text{ ppm}}}$$

Q2. 20mL of standard hard water (containing 15 g of CaCO_3 per litre) reqd. 25 mL EDTA soln for titration. 100mL of H_2O sample reqd. 18mL of EDTA soln, while same water after boiling reqd. 12mL EDTA soln. calculate temporary hardness.

STEP 1: Molarity of standard hard water

$$\text{water} = \frac{15}{100}$$

$$= \underline{\underline{0.15 \text{ M}}}$$

$$\text{STEP 2: } M_1 V_1 = M_2 V_2$$

$$0.15 \times 20 = M_2 \times 25$$

$$M_2 = 3/5$$

$$M_2 = \underline{\underline{0.12 \text{ M}}}$$

$$\text{STEP 3: } M_1 V_1 = M_2 V_2$$

$$0.12 \times 18 = 100 \times M_1$$

$$0.216 = M_1$$

Tot. Hardness

$$0.216 \times 100 \times 10^3 = \underline{\underline{2160 \text{ ppm}}}$$

$$\text{STEP 1: } M_1V_1 = M_2V_2 \\ (\text{H}_2\text{O}) \quad (\text{EDTA})$$

$$0.12 \cancel{\text{M}} \times 12 = M_2 \times 100$$

$$\frac{12}{100} \text{ EDTA M} \\ M_2 = 0.1144 \text{ M}$$

EDTA

$$\text{permanent hardness} = 0.0144 \times 100 \times 10^3 \\ = 1440 \text{ ppm}$$

$$\text{Temporary hardness} = 2160 - 1440 \\ = 720 \text{ ppm}$$

Q3. 0.5 g of CaCO_3 was dissolved in dil HCl and the soln was diluted to 1 L. 50 mL of this solution reqd. 48 mL of EDTA soln, while 50 mL of sample water reqd. 15 mL of EDTA soln. On other hand, 50 mL boiled sample water when titrated against EDTA consumed 10 mL of soln. calculate hardness.

$$\text{STEP 1: Molarity of Standard} \\ \text{H}_2\text{O soln} = \frac{0.5 / 100}{1\text{L}} \\ = 0.005 \text{ M}$$

$$\text{STEP 2: } M_1V_1 = M_2V_2 \\ (\text{H}_2\text{O}) \quad (\text{EDTA})$$

$$50 \times 50 \times 10^{-3} = 48 \times M_2$$

$$\frac{25}{48} \times 10^{-2} = M_2$$

$$0.0052 = M_2$$

$$\text{STEP 3: } M_1V_1 = M_2V_2 \\ (\text{EDTA}) \quad (\text{H}_2\text{O})$$

$$\frac{15}{48} \times 10^{-2} \times 15 = M_2 \times 50 \times 10^{-3}$$

$$M_2 = \frac{15}{96} \times 10^{-2}$$

$$M_2 = 0.00156 \text{ M}$$

STEP 4: after boiling

$$M_1V_1 = M_2V_2 \\ (\text{EDTA}) \quad (\text{H}_2\text{O})$$

$$0.0052 \times 10 = M_2 \times 50$$

$$0.00104 \text{ M} = M_2$$

$$\text{Temporary} \\ \text{hardness} = 156 - 104 \\ = 52 \text{ ppm}$$

Total hardness

$$= M_2 \times MM_{\text{CaCO}_3} (g/L)$$

$$= 156 \times 10^{-5} \times 100 \times 10^3 (\text{mg/L})$$

$$= 156 \text{ ppm}$$

$$\text{Permanent hardness} = M_2 \times 100 \times 10^3 \text{ ppm} \\ = 104 \times 10^{-5} \times 10^5 \text{ ppm} \\ = 104 \text{ ppm}$$

Q4. 50 mL of a sample of hard water was titrated against 0.01 EDTA, it reqd. 15 mL of EDTA for titration. 50 mL of the same hard water after boiling and filtering reqd. 5 mL of EDTA for titratn. calculate the hardness of water.

$$\text{STEP 3: } M_1V_1 = M_2V_2 \\ (\text{EDTA}) \quad (\text{H}_2\text{O})$$

$$50 \times 15 \times 0.01 = 50 \times M_2$$

$$M_2 = 0.003 \text{ M}$$

STEP 4: after boiling

$$M_1V_1 = M_2V_2 \\ (\text{EDTA}) \quad (\text{H}_2\text{O})$$

$$0.01 \times 5 = 50 \times M_2$$

$$M_2 = 0.001 \text{ M}$$

Temporary hardness

$$= 300 - 100$$

$$= 200 \text{ ppm}$$

$$\text{Tot. hardness} = M_2 \times MM_{\text{CaCO}_3} (g/L) \\ = 3 \times 10^{-3} \times 100 \times 10^3 (\text{mg/L}) \\ = 300 \text{ ppm}$$

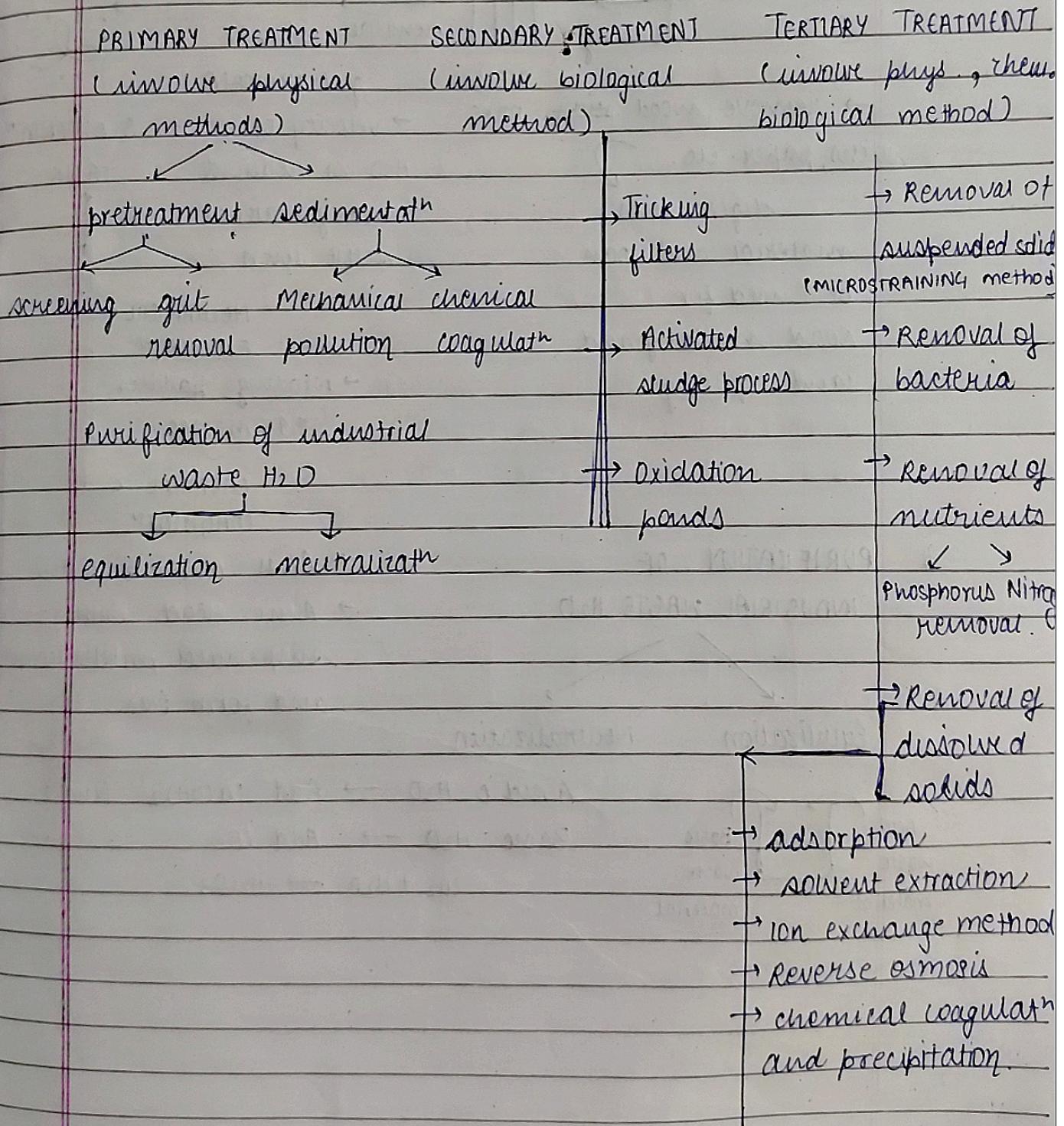
$$\text{Permanent hardness} = M \times MM_{\text{CaCO}_3} (g/L)$$

$$= 1 \times 10^{-3} \times 100 \times 10^3 (\text{mg/L})$$

$$= 100 \text{ ppm}$$

WASTE H₂O TREATMENT

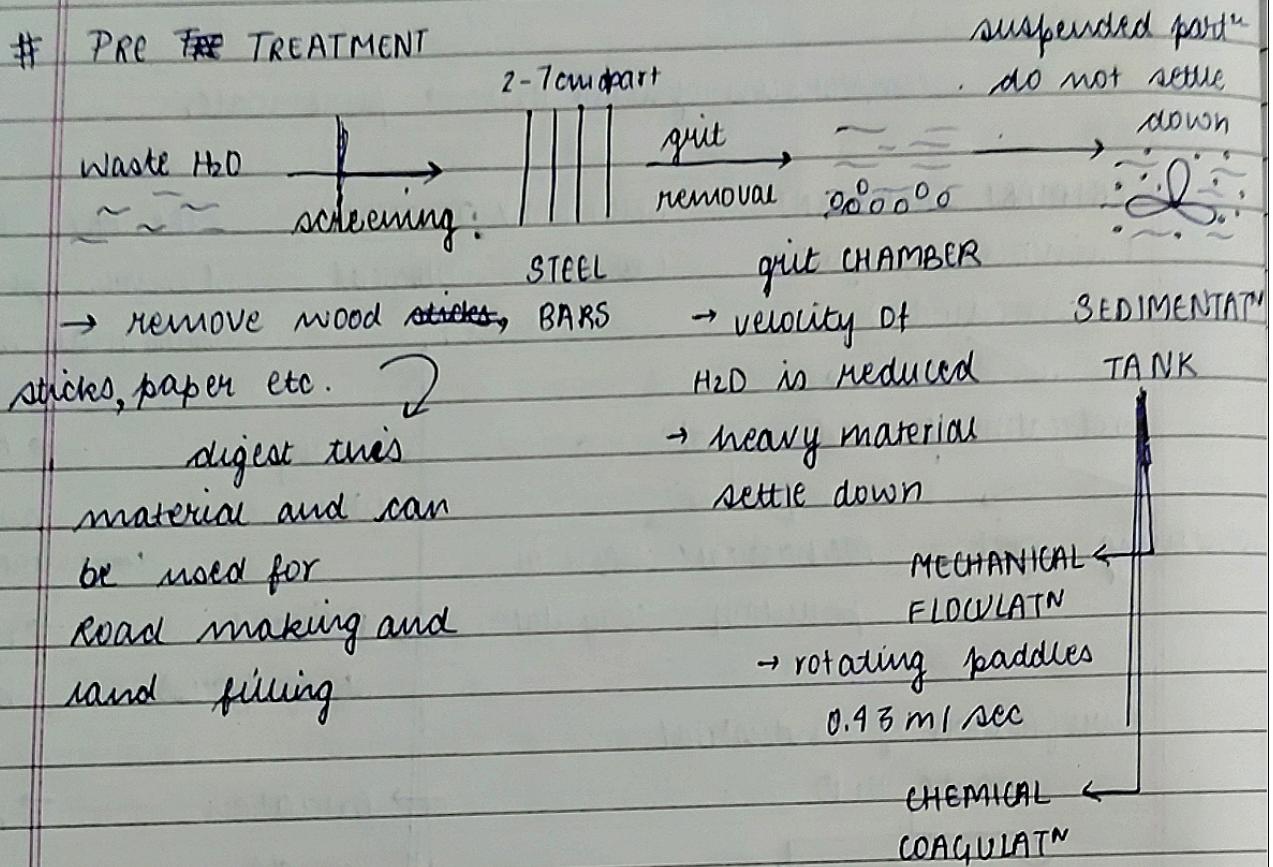
conversion of waste H₂O → pure water



• PRIMARY TREATMENT

Removal of suspended solids & floating matter.

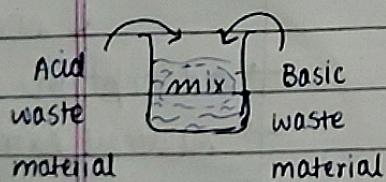
PRE TREATMENT



PURIFICATION OF

INDUSTRIAL WASTE H₂O

Equilization Neutralization



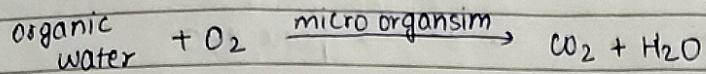
Acidic H₂O → Add Ca(OH)₂ (lime)

Basic H₂O → Add CO₂

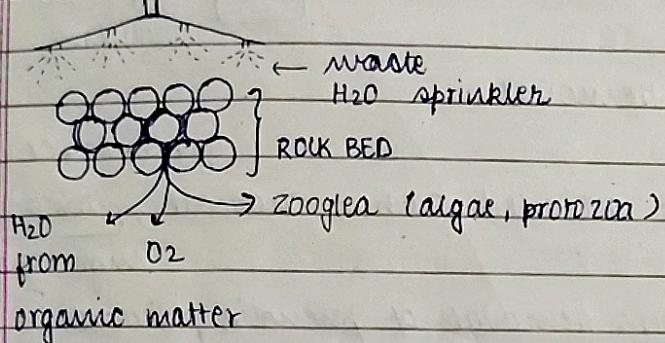


• SECONDARY TREATMENT

Removal of organic matter from waste H₂O

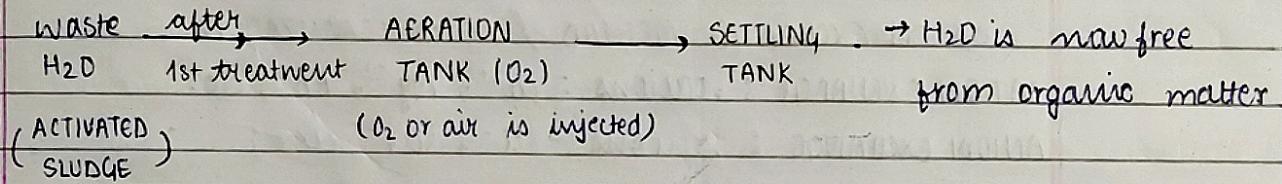


1. TRICKLING FILTER



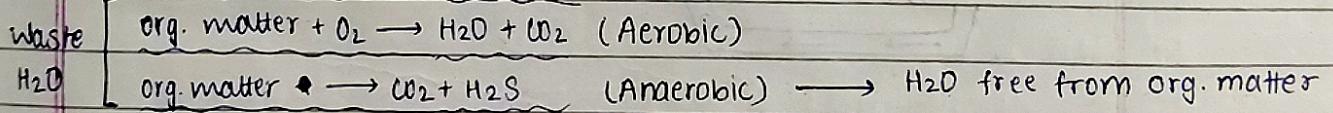
→ to avoid Rock bed from tumbling or crushing / crumbling, use of plastic material forms this biological tower.

2. ACTIVATED SLUDGE PROCESS.



3. OXIDATION PONDS

FACULTATIVE PONDS



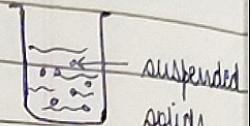
• TERTIARY TREATMENT

Physical, chemical and biological methods

waste $H_2O \rightarrow 1^\circ \rightarrow 2^\circ \rightarrow 3^\circ \rightarrow$ pure H_2O

1. Removal of suspended solids (MICROSTRAINING)

use of finely woven stainless steel fabric → to filter suspended solids

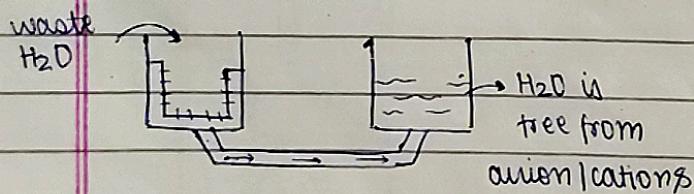


2. Removal of dissolved solids

a) ADSORPTION : adsorption done by ACTIVATED CHARCOAL, Hg, Pb, As, Cd, etc. ~~name nanomaterials~~, high surface area

b) SOLVENT ~~EXTRACTION~~ EXTRACTION : used to recover phenolic material
 → the waste water is intimately brought in contact with a solvent having high affinity for the solute.
 → 2,4 DNP, chlorophenol, Bisphenol etc.

c) ION EXCHANGE :

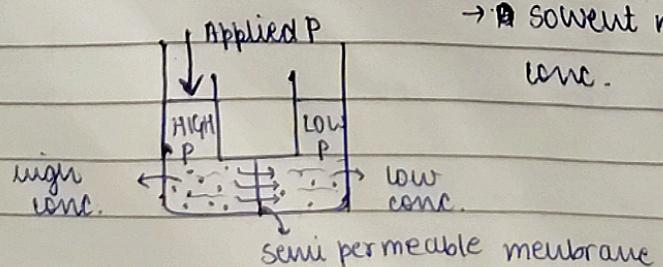


CATION EXCHANGE : $Ca^{2+}, Mg^{2+}, Pb^{2+}$, etc

ANION EXCHANGE : Cl^- , SO_4^{2-} , etc.

→ used to remove HARNESS & Fe & Mg salts from drinking H_2O .

d) REVERSE OSMOSIS :



→ Solute moves from high conc. to low conc.

c) CHEMICAL PRECIPITATING / COAGULATION:

$M^{+2} + \text{Alum} \rightarrow \text{Metal ppt} \downarrow$

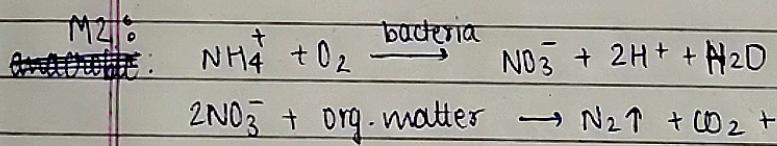
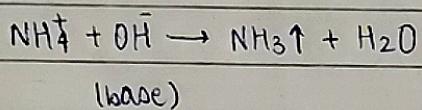
Heavy $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$
toxic metal.

→ ppt agents like lime, alum, ~~etc~~, FeSO_4 , FeCl_3
remove heavy metals ions by
precipitating them as hydroxides (OH^-)

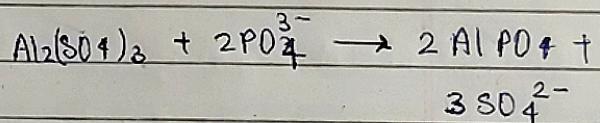
3. Removal of nutrients (P & N)

NITROGEN REMOVAL

Ammonia
stripping
method



PHOSPHORUS REMOVAL

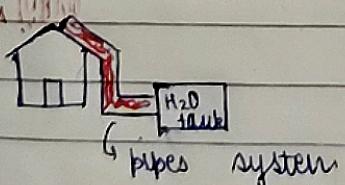


4. Removal of bacteria

- by retaining the effluents in maturation ponds or lagoons
- using bleaching power CaOCl_2

ROOF TOP RAIN H_2O HARVESTING | in Kerala, Karnataka, Rajasthani

Rain



RAIN WATER HARVESTING

BAMBOO DRIP IRRIGATION METHOD

Rain

Bamboo pipe line

← 10-50 drops/min

Agricultural lands for irrigation