Water Treatment

Water treatment

(Hardness of water)

Hard water – soap consuming capacity of water

Cause of hardness - presence of dissolved salts of Ca/Mg/other heavy metals

Types of Hardness

Hardness

$MgCO_3$, $Ca(HCO_3)_2$

$Mg(HCO_3)_2$, $FeCO_3$

Cl^-

SO_4^{2-}

$CaCl_2$ $CaSO_4$

$MgCl_2$ $MgSO_4$

Temporary hardness

→ which can be remove by boiling

Permanent Hardness

→ which cannot be remove by boiling → L/s me

→ zeolite method

→ calgon

Water Treatment

Degree of Hardness

[Hardness in terms of $CaCO_3$ equivalent]

→ $CaCO_3$ is most insoluble ppt

→ Mass is exactly 100.

$$CaCO_3 \text{ equivalent} = \frac{\text{Amount of hardness producing salt} \times \text{Eq. wt of } CaCO_3}{\text{Eq. wt of hardness producing salt}}$$

→ 2 gm $CaCl_2$ $\quad 40+2(35.5)$ $\quad \frac{2 \times 100/2}{111/2}$

Calcium ki Valency

Water Treatment

Equivalent weight

$$\text{Eq. wt} = \frac{\text{Mass of Substance}}{n}$$

n - Acid - No. of H^+ ion

n - Base - No. of OH^- ion

n - Salt - Valency of cation

n - ion - charge

Water Treatment

Units of hardness

PPM

mg/L

Degree french (°Fr)

Degree clark (°cl)

1 PPM = 1 mg/L = 0.1°Fr = 0.07°cl

Calculate temporary and permanent hardness of water sample containing following impurities $Ca(HCO_3)_2$ = 40.5 ppm, $CaCl_2$ = 33.3ppm, $MgCO_3$ = 33.6ppm, $Mg(HCO_3)_2$ = 14.6ppm, CO_2= 22ppm, $NaHCO_3$ = 6.8ppm.

Solution-

Water Treatment

Salts	Amount (PPM)	$CaCO_3$ equivalent	Type of Hardness
$Ca(HCO_3)_2$	40.5	$= \frac{40.5 \times 100/2}{162/2} = 25$	Temp.
$CaCl_2$	33.3	$= \frac{33.3 \times 100/2}{111/2} = 30$	Perm.
$MgCO_3$	33.6	$= \frac{33.6 \times 100/2}{84/2} = 40$	Temp.
$Mg(HCO_3)_2$	14.6	$= \frac{14.6 \times 100/2}{146/2} = 10$	Temp.
CO_2	22	Does not contribute	to Hardne
$NaHCO_3$	6.8	Does not contribute	to Hardne

Temp. Hardness = 25 + 40 + 10 = 75 ppm

Perm. Hardness = 30 ppm.

Water Treatment

Water treatment

External Method

- Zeolite Method
- Lime-soda Method
- Ion-exchange Method
- Reverse osmosis method

Internal Method

- Calgon Method
- Phosphate conditioning Method

Permutit

Water Treatment

Zeolite Method

Formula - $Na_2O \cdot Al_2O_3 \cdot x\,SiO_2 \cdot y\,H_2O$

[$x = 2-6$, $y = 2-10$]

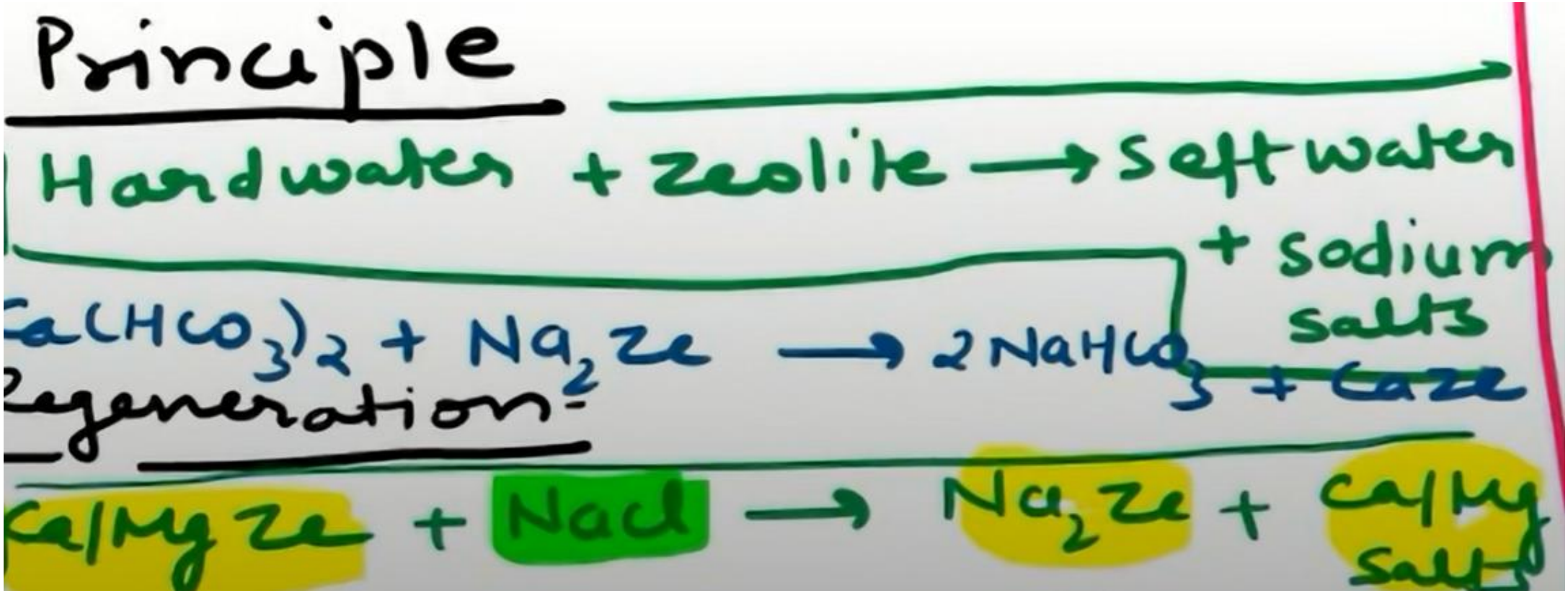
Chemical Name -

Sodium alumino ortho-silicate

Principle

Hard water + Zeolite → Soft water + Sodium salts

$Ca(HCO_3)_2 + Na_2Ze \rightarrow 2NaHCO_3 + CaZe$


Principle
Hard water + Zeolite → Soft water
+ Sodium salts
$Ca(HCO_3)_2 + Na_2Ze \rightarrow 2NaHCO_3 + CaZe$
Regeneration:
Ca/Mg Ze + NaCl → Na_2Ze + Ca/Mg salt

Brine

Ion exchange Method

Principle

Cation exchange Resin

$2RH + Ca^{2+} \rightarrow R_2Ca + 2H^+$

Regeneration

$R_2Ca + 2HCl \rightarrow 2RH + CaCl$

Anion exchange Resi

$ROH + Cl^- \rightarrow RCl + OH^-$

Regeneration -

$RCl + NaOH \rightarrow ROH + Na$

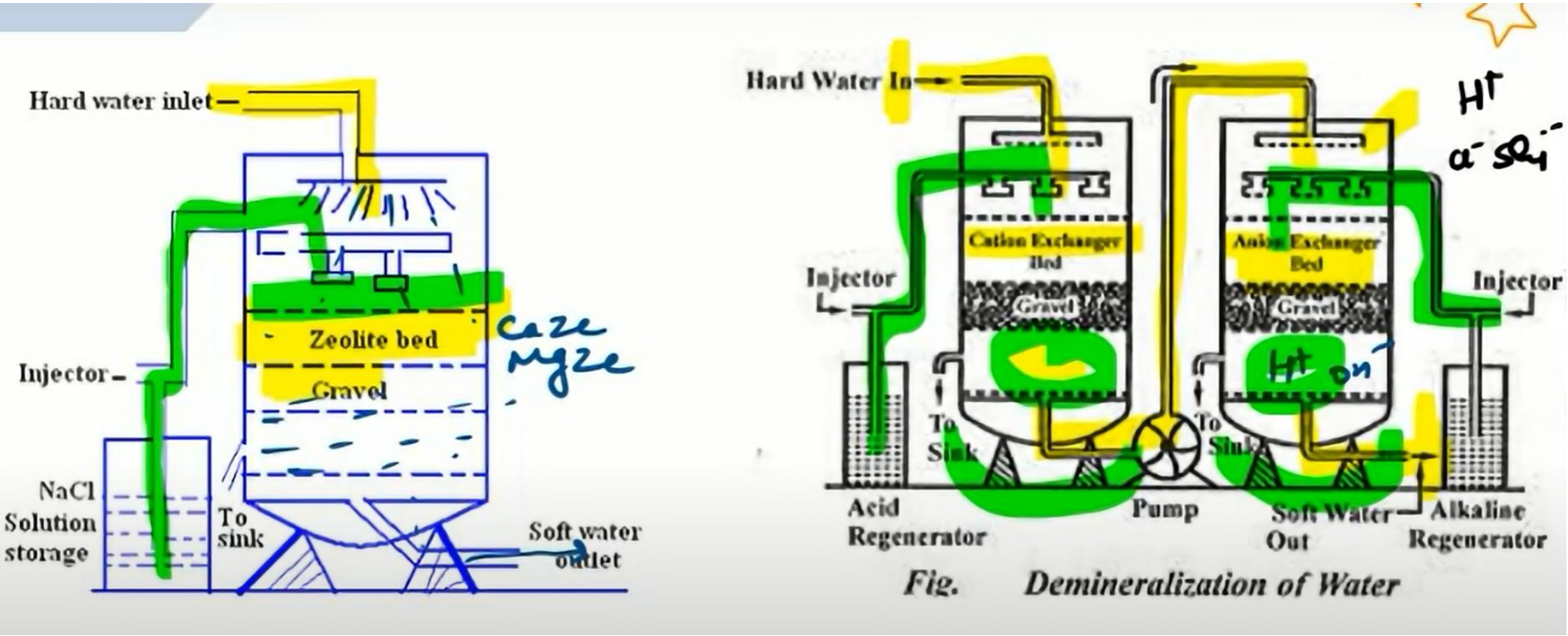
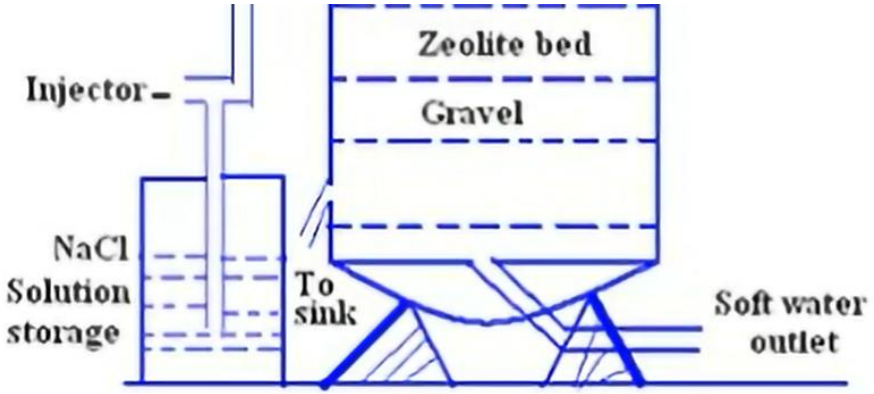


Fig. Demineralization of Water



Advantages

Disadvantages - Minerals (Ca/Mn^{++})

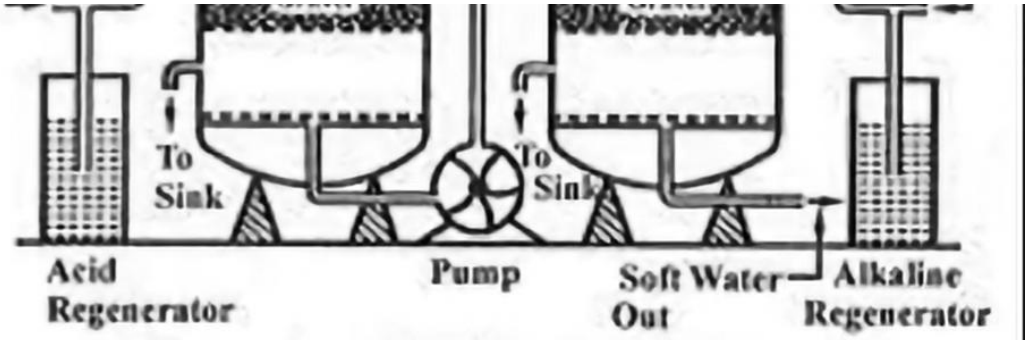


Fig. Demineralization of Water

Advantages

Disadvantages

Costly

Water Treatment

Numericals of Zeolite Method

Steps of Numericals -

Step-1
Amount of Nacl required

Step-2
Total hardness (as $CaCO_3$ equivalent)

Step-3
Hardness of water sample = $\frac{\text{Total Hardness}}{\text{Vol. of water}}$

$$H = \frac{50 \times m \times V_2 \times 10^3}{58.5 \times V_1}$$

V_1 = Total vol. of water softened

V_2 = Vol. of Nacl

Water Treatment

Lime - soda Method

Principle

soluble Impurities $\xrightarrow[\text{soda}]{\text{lime}}$ Insoluble Impurities

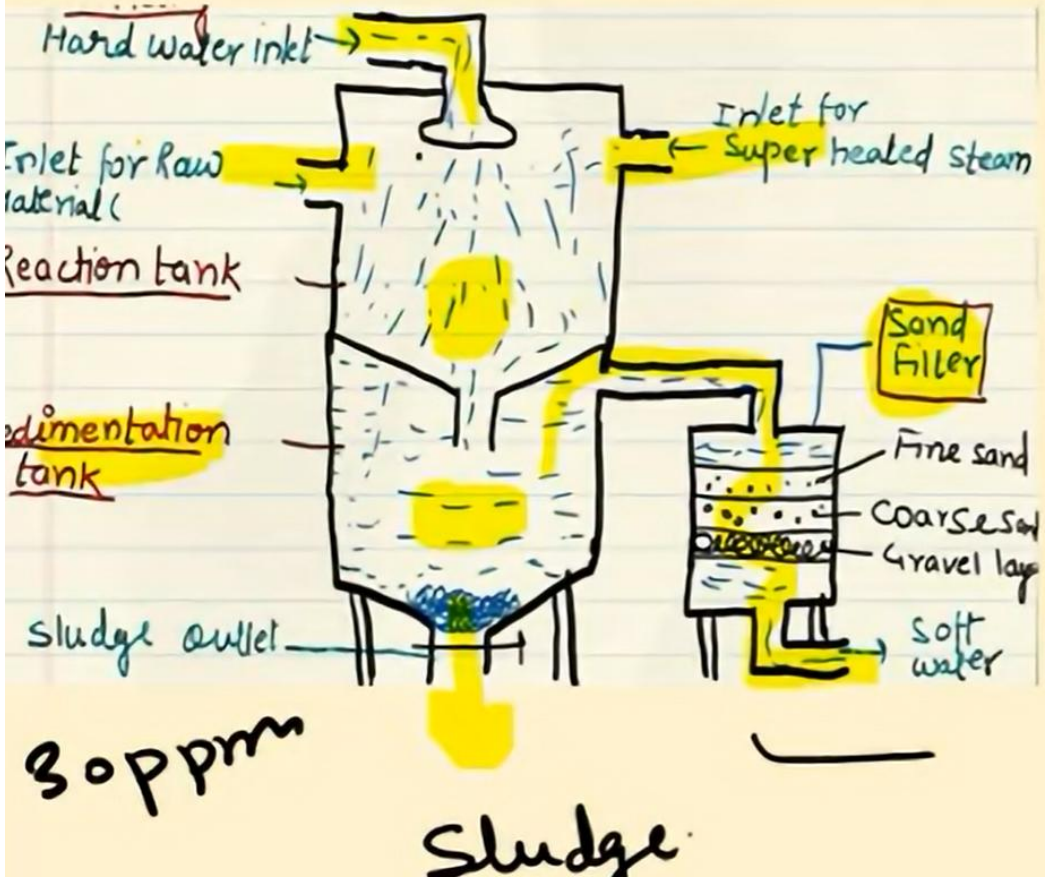
- lime - $Ca(OH)_2$
- soda - Na_2CO_3

Ca-salts - $CaCO_3 \downarrow$

Mg salts - $Mg(OH)_2 \downarrow$

Difference Between Hot and Cold Lime Soda Method

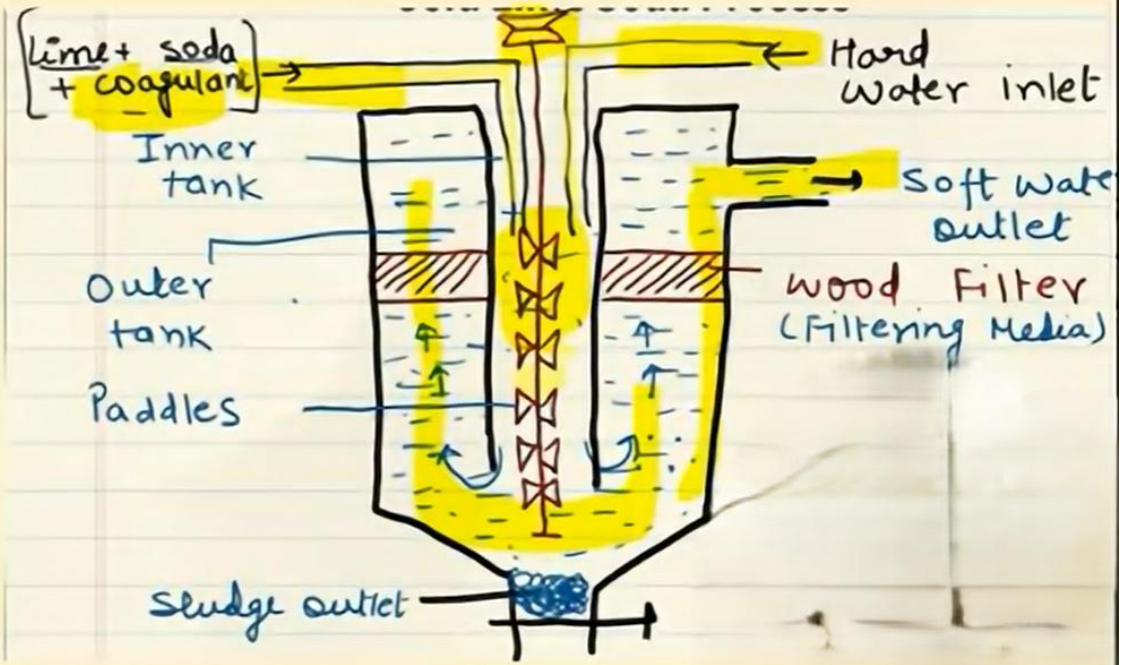
Hot Lime Soda Process



30 ppm

Sludge

Cold Lime Soda Process



50 ppm

Water Treatment

calculation of lime & soda requirement

L + L/2 − L

% purity (given, or else 100)

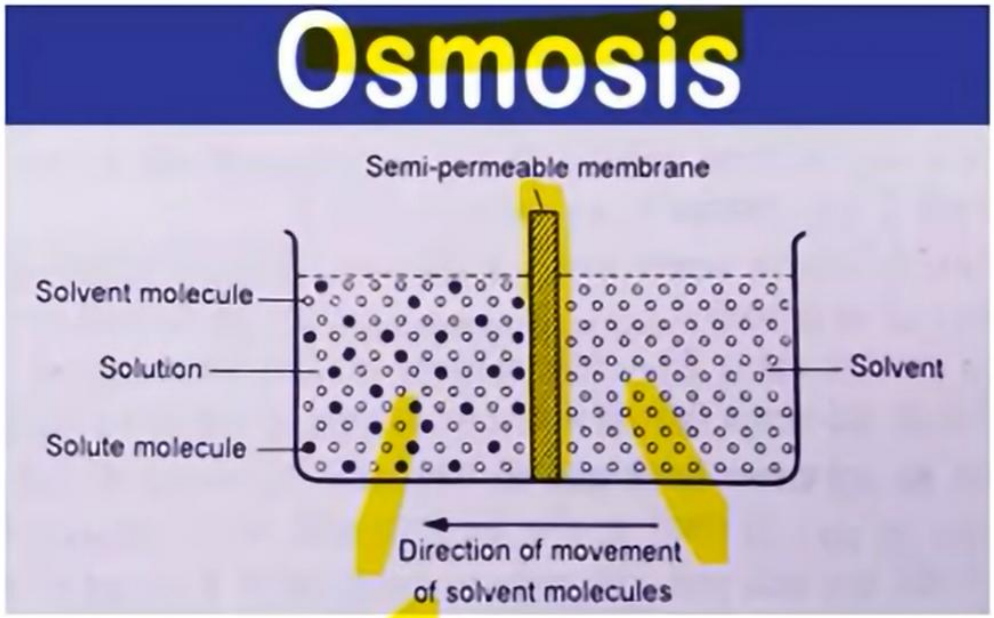
$$\text{Lime required} = \frac{74}{100}\left[\begin{matrix}\text{CaCO}_3 \text{ equivalent}\\ \text{of lime required}\\ \text{salts}\end{matrix}\right] \times \frac{\text{Vol. of water}}{10^6} \times \frac{100}{\%\ \text{purity}}$$ kg.

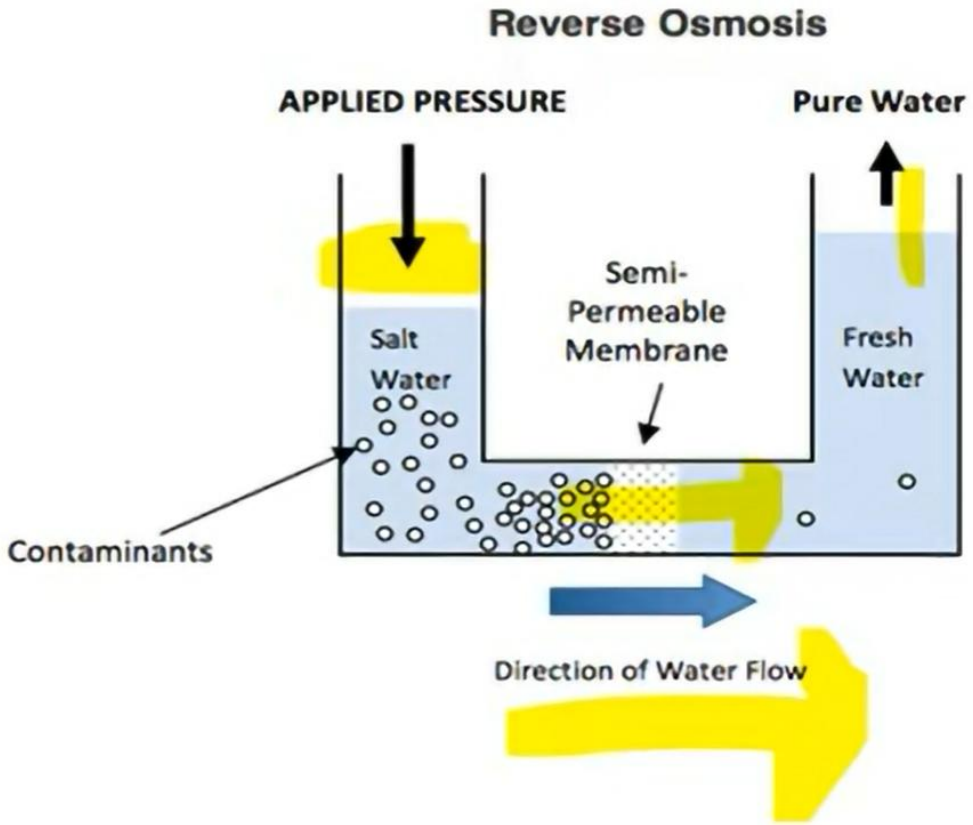
L, L/2, L

$$\text{Soda required} = \frac{106}{100}\left[\begin{matrix}\text{CaCO}_3 \text{ equivalent of}\\ \text{soda required}\\ \text{salts}\end{matrix}\right] \times \frac{\text{Vol. of water}}{10^6} \times \frac{100}{\%\ \text{purity}}$$ kg.

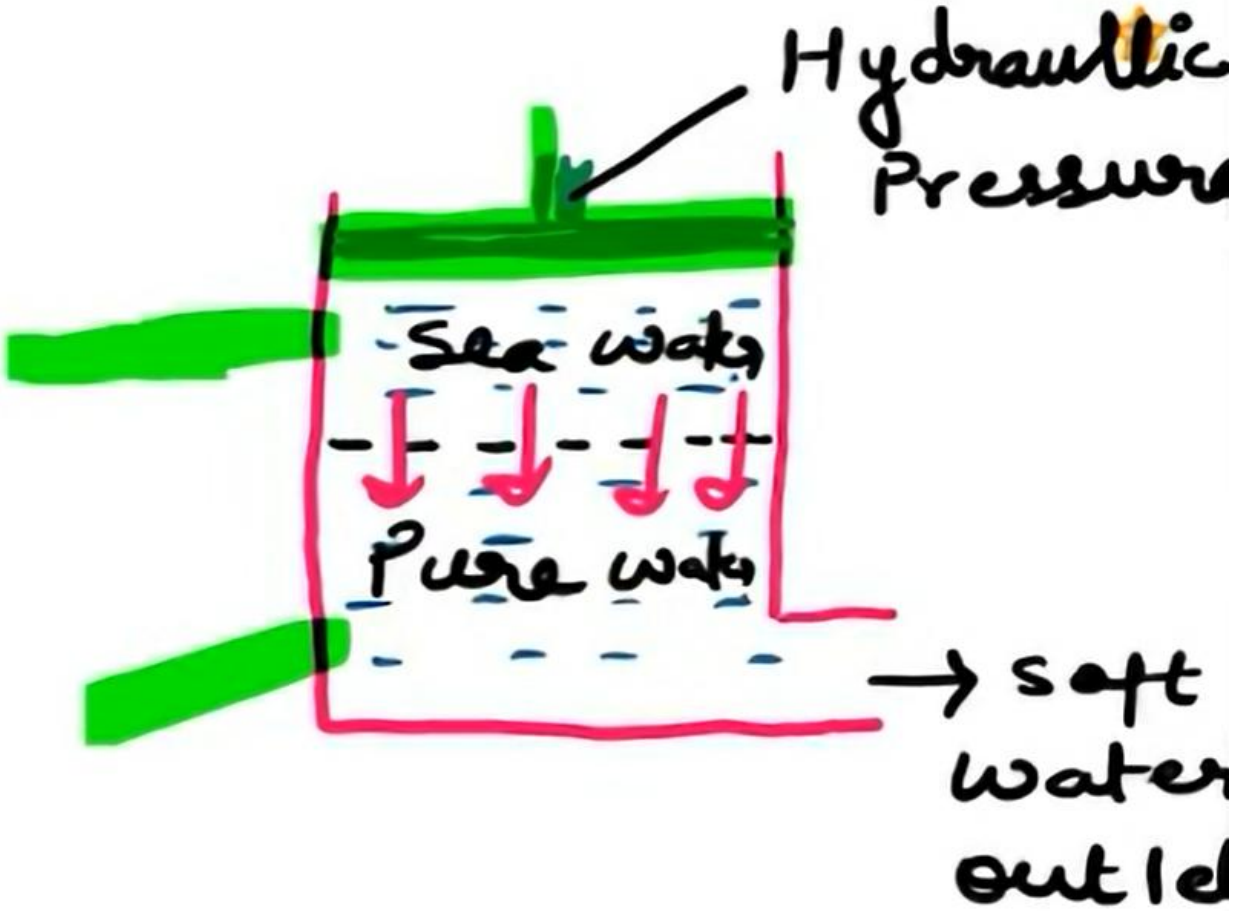
Water Treatment

Reverse Osmosis Method





Desalination of Brakish water



Water Treatment

Calgon Method

$Na_2[Na_4(PO_3)_6]$ OR $Na_6P_6O_{18}$

sodium hexa meta phosphate

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

$$[Na_4(PO_3)_6]^{2-} + 2Ca^{++} \longrightarrow [Ca_2(PO_3)_6]^{2-} + 4Na^{+}$$