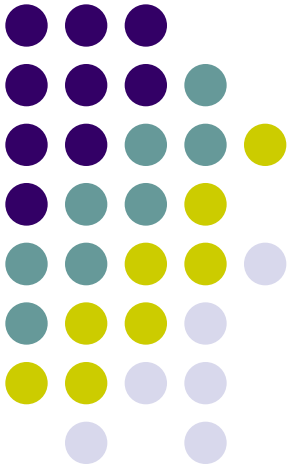
Chapter 8

Water treatment



Cooling tower

Sources of water

Sea water

Surface water*(rivers, streams, lakes)*

Rain water

ground water*(springs, shallow wells)*

Nature of impurities in water

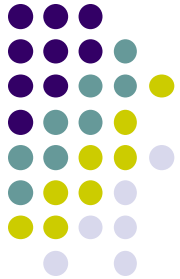
Suspended matter (insoluble).

Colloidal material (insoluble).

Soluble salts.

Dissolved gases (CO2 ,O2,…).

Removal of suspended and colloidal impurities



1. ***settling(sedimentation):***

water is allowed to settle in large tanks, so any suspended material will settle down.

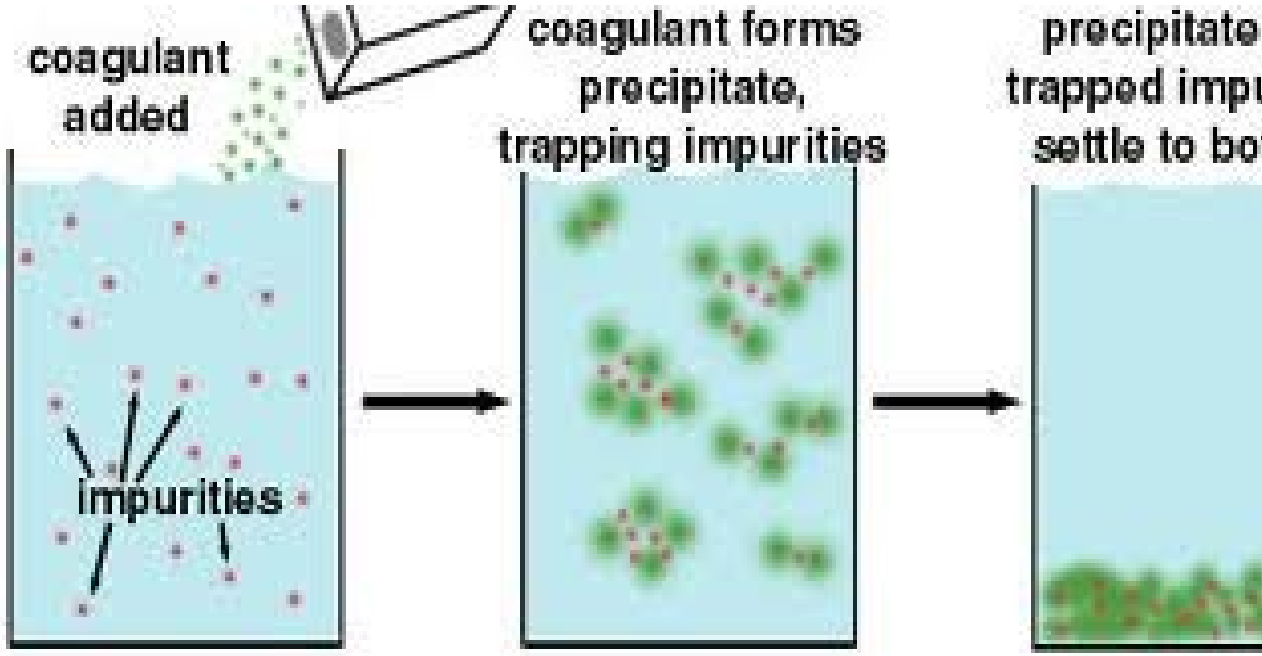
2. coagulation:

by addition of coagulant like salts of sulfate and aluminum(alum), and help to the settling of colloidal and oil drops.

Ex: $Al_2(SO_4)_3.18H_2O$

Settlers

Coagulation Process



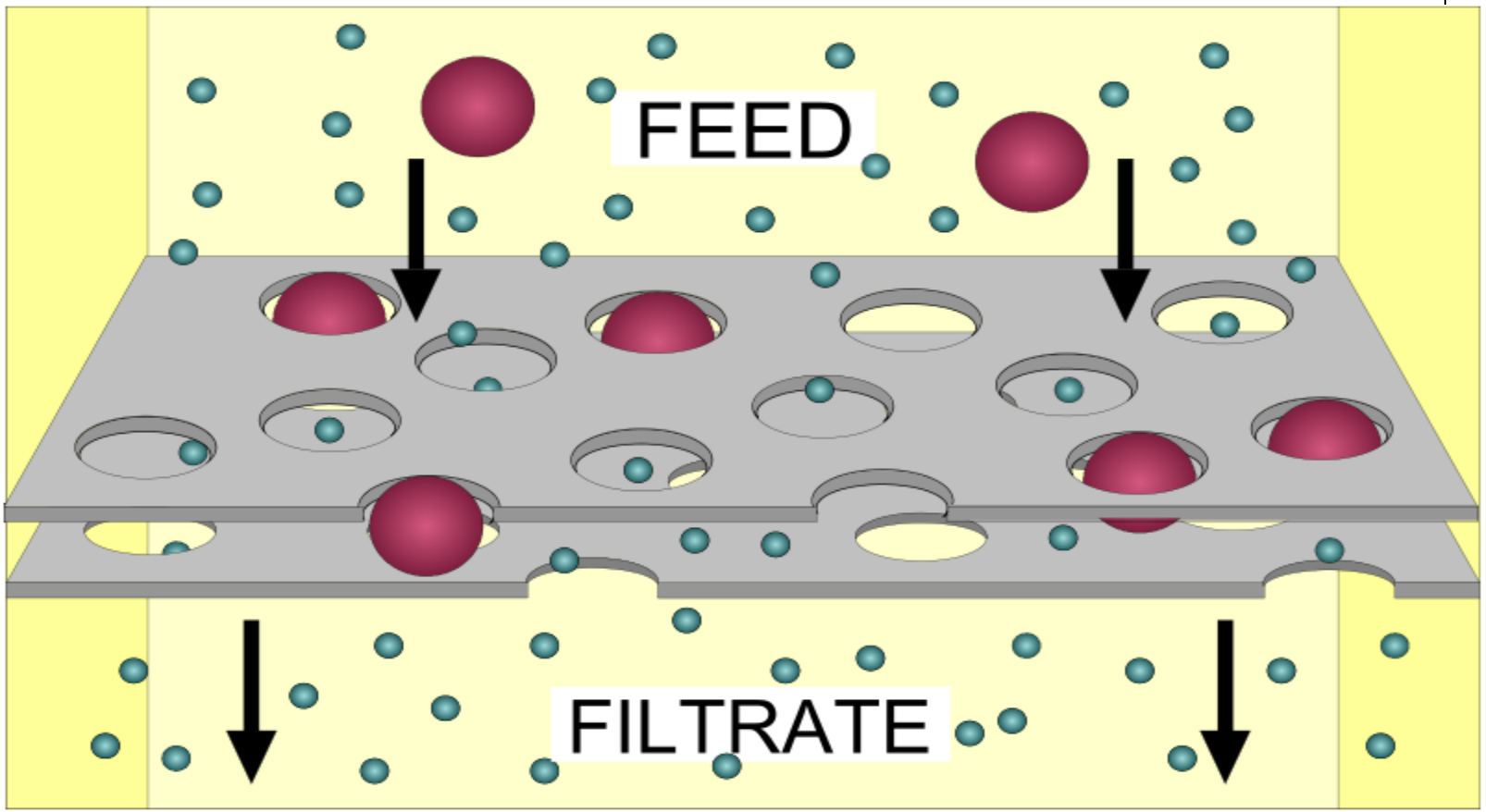
3. Settling (sedimentation):

To settle any coagulant particles with colloidal matter and oil drops.

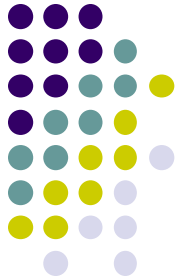
4. Filtration :

it’s carried out by passing water through rapid filter medium in order to removing any suspended and colloidal matter.

Filtration system



Removal of soluble impurities



Some industrial water should not contain any soluble impurities such as Ca, Mg, Fe salts(boiling feed water).

Removal of these soluble impurities called softening of hard water.

Water hardness

Ca and Mg salts dissolve in water .

1. Temporary water hardness

due to presence of Ca and Mg salts as bicarbonates salts.

$Ca(HCO_3)_2$ - $Mg(HCO_3)_2$

2. Permanent water hardness

due to presence of Ca and Mg salts as chlorides, sulfates or nitrates, ….

$CaSO_4$ - $MgSO_4$ - $CaCl_2$ - $MgCl_2$

Removal of water hardness

1. Temporary water hardness

removed by boiling.

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

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

2. Permanent water hardness

removed by chemical treatment .

boilers

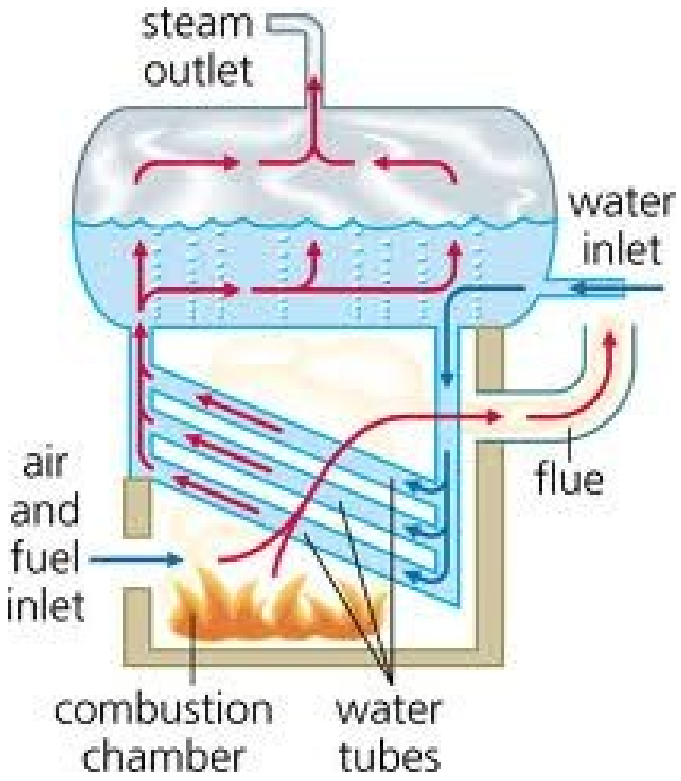
Low pressure boilers

maximum concentration of dissolved salts is 0.05ppm.

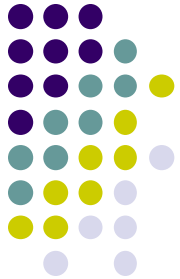
High pressure boilers

maximum concentration of dissolved salts is 0.005ppm.

Boiler


steam
outlet
water
inlet
air
and
fuel
inlet
flue
combustion
chamber
water
tubes

Defects of use untreated (hard)water in boilers



1. **formation of scale and sludge.**
2. **Corrosion.**

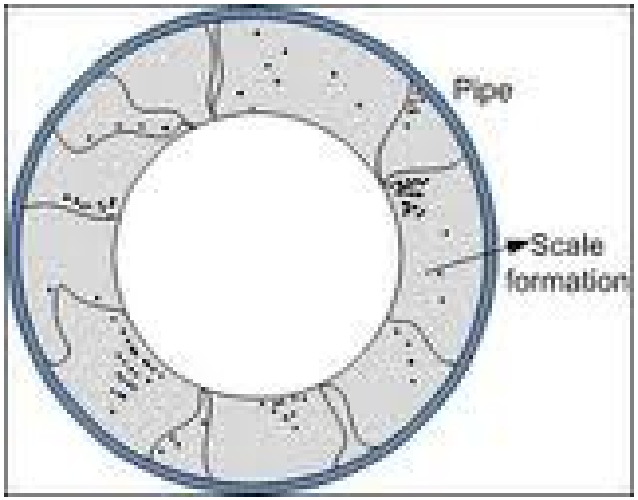
Scale:

it's insoluble salts in hot water which precipitated after boiling forming dry layer with strong adhesive on hot surfaces(heat sources).

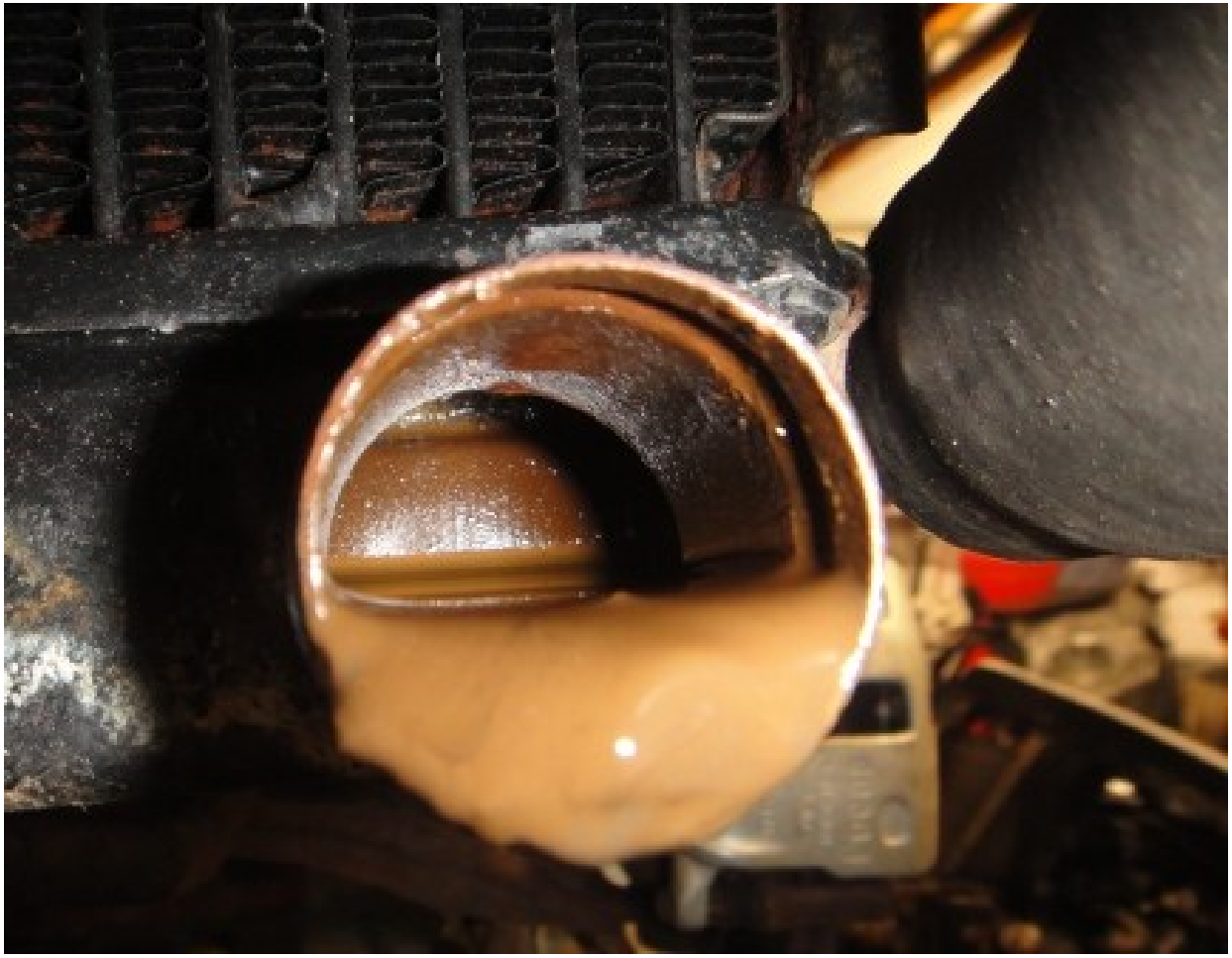
sludge:

it's refers to the quantity of insoluble salts in hot water which precipitated after boiling forming wetted layer.

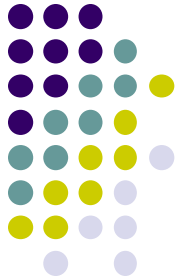
Scale formation in tubes



Sludge in pipes



Disadvantages of scale formation in boiler



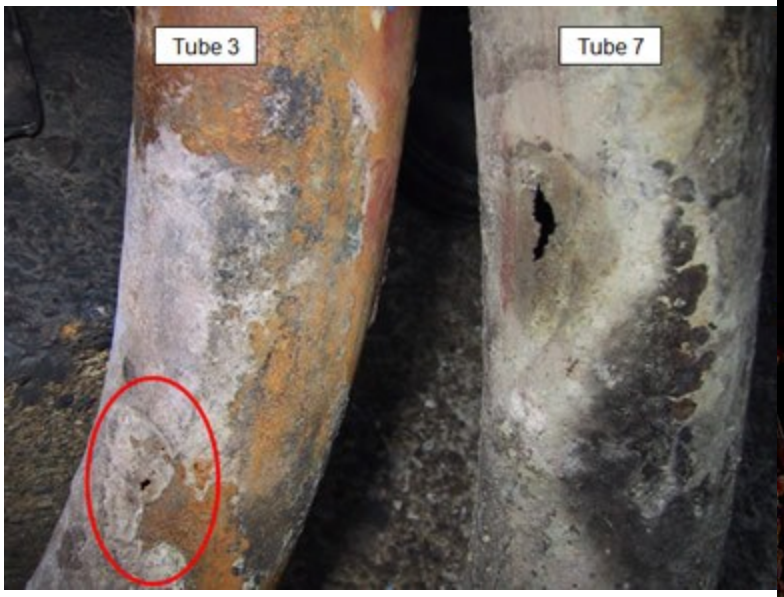
1. ***Decrease the heat transfer*** due to formation of scale which has low thermal conductivity.
2. ***Burning out or over heating.***
3. ***Decrease the efficiency of boiler***
4. ***Chemical corrosion***

$$2NaCl + MgSO_4 \longrightarrow Na_2SO_4 + MgCl_2$$

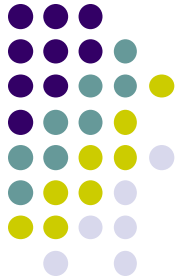
$$H_2O + MgCl_2 \longrightarrow Mg(OH)_2 + 2HCl$$

Tubes overheating

Chemical Corrosion



Removal of soluble salts



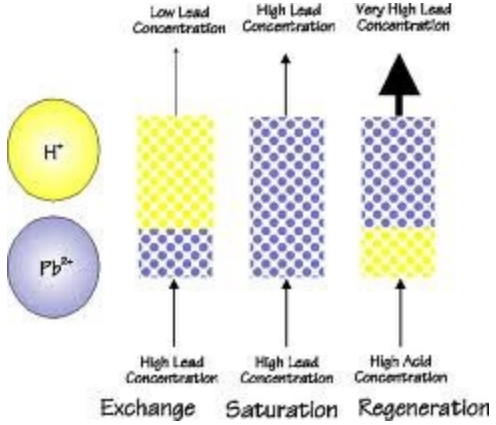
1. Lime soda process
2. Ion exchange method
3. Zeolite softener
4. Reverse osmosis
5. Electrolytic technique

Ion exchange method

Resin : it's elastic material react only with salts dissolved in water and insoluble in water.

Cation exchange resin

Ions Exchange Resin



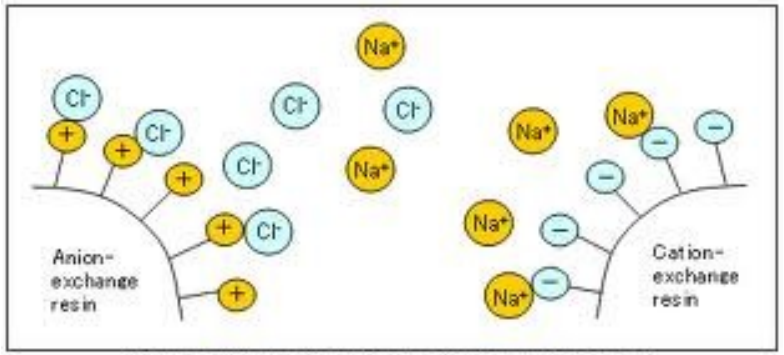
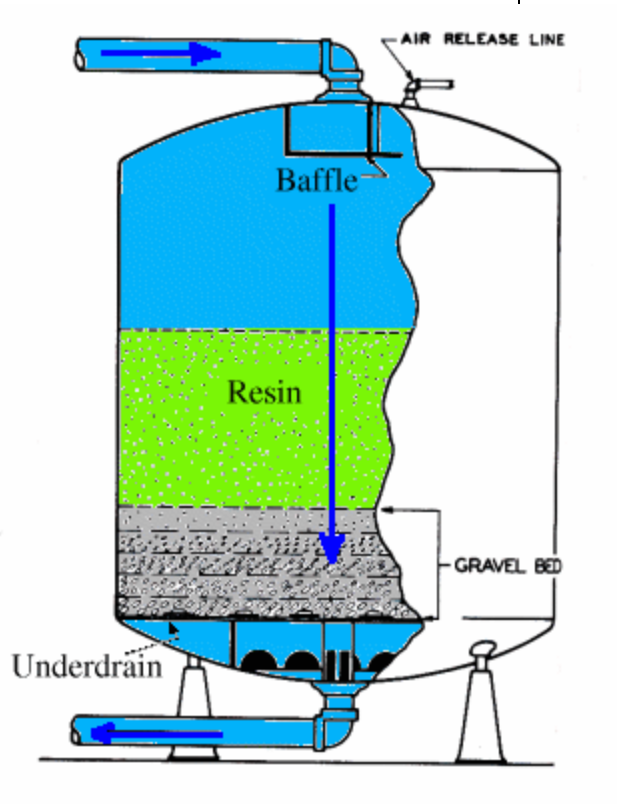


Figure 1. Pattern diagram illustrating ion exchange mode


AIR RELEASE LINE
Baffle
Resin
GRAVEL BED
Underdrain

Deaerator

Hydrazine safety labor