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Filtration

- A clear and sparkling water is obtained by treatment of filtration.
- There are several different types of filters, mainly divided into two classes:

i) Slow sand filters

ii) Pressure filters

Slow sand filtration

It is a type of centralised or semi-centralized water purification system.

A well-designed and properly maintained **slow sand filter** (SSF) effectively removes turbidity and pathogenic organisms through various biological, physical and chemical **processes** in a single treatment step.

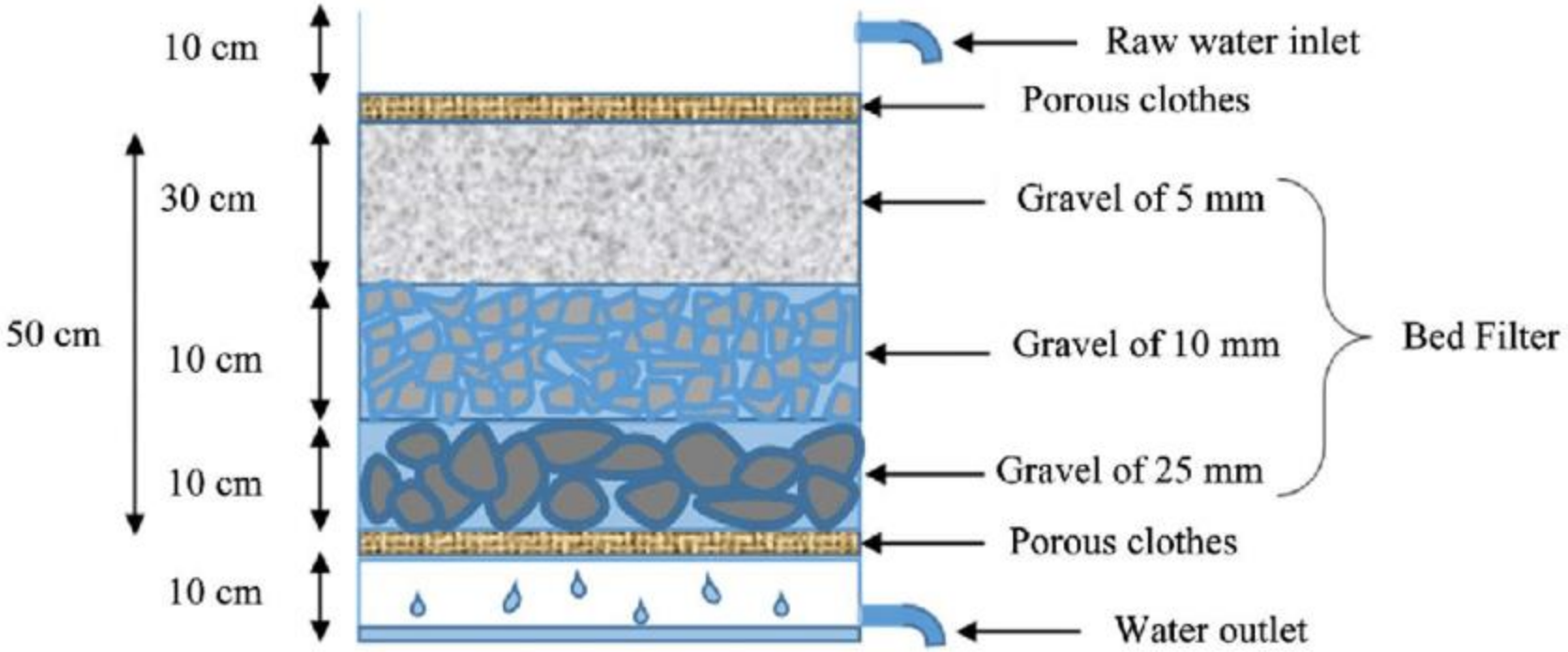
Slow sand filtration (contd…)

- In this process, water is passed through beds of fine sand, coarse sand, and other granular material.
- The porous material used is the filtering medium and the equipment used for filtration is known as filter, e.g. slow sand filter.
- It consists of a tank containing thick beds (3 feet thick) of fine sand (at the top), coarse sand (1 feet thick) fine gravel and coarse gravel (at the bottom) (8’’ thick bed).

Slow sand filtration (contd…)

- When the water passes through the filtering medium, it flows through the various beds slowly due to gravity.
- The rate of filtration slowly decreases due to the clogging of impurities in the pores of the sand bed.
- When the rate of flow becomes very slow, filtration is stopped and the bed is cleaned by scrapping of a small layer of the sand bed (top layer) and replacing it with clean sand.
- Bacteria are also partly removed by this process.

Slow sand filtration (contd…)



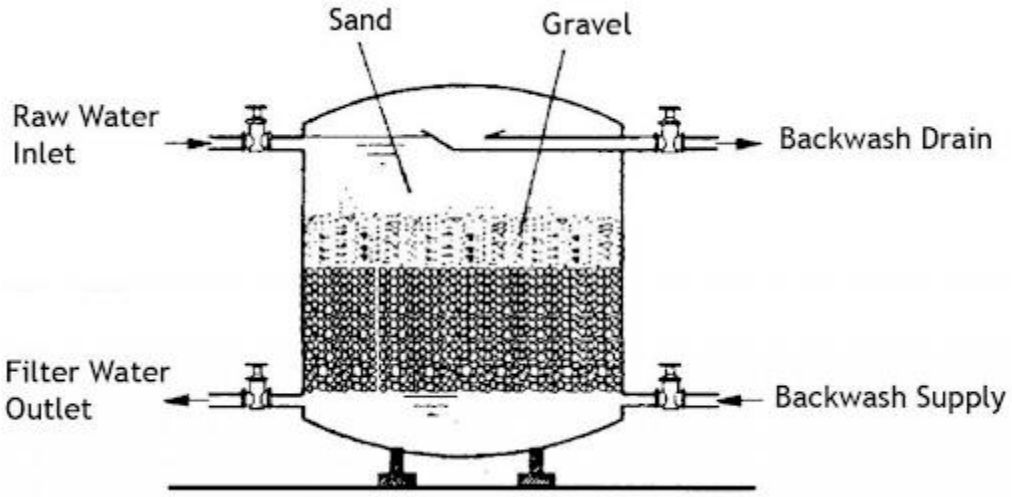
Pressure Filters

- **Pressure filters** are in many respects similar to conventional rapid **filters**.
- The main differences are that the media is contained in a **pressure** vessel (such as a steel tank) and that they are operated under **pressure** provided by means of a pump or high-**pressure** water source on the influent side rather than gravity.

Pressure Filters (contd...)

- These filters can be installed in water supply line, so that repumping of filtered water can be avoided.
- These filters are widely used for the industrial water cooling.

Pressure Filters (contd...)



Pressure Filters (contd...)

Construction:

- Closed steel cylinders.
- Diameter varies from 1.5 to 3.0 m.
- Length or height varies from 3.5 to 8.0m.
- Manholes are provided at the top for inspection.

Working:

- The water mixed with coagulant is directly admitted to the pressure filter.
- In working condition all valves are closed except those for raw water and filtered water.

Cleaning

- The compressed air may be used to agitate sand grains.
- Valves for wash water and wash water drain are opened during washing.

Rate of filtration: 6000-15000litres/hr/sq.m.

Efficiency: Less efficient than the rapid sand filters.

Disinfection

Disinfection

- The filtered water which is obtained by various filtration processes contains harmful diseases producing bacteria, these bacteria must be killed to make the water safe for drinking
- The chemical used for killing these bacteria are known as disinfectants and the process is known is known as disinfection

Disinfection (contd…)

- The presence of turbidity's, colour, minerals etc may not be dangerous but the presence of even single harmful organism will be definitely dangerous thereby making disinfection as the most important process. The disinfection not only removes the existing bacteria from the water at the plant but also ensures their immediate killing even afterwards in the distribution system. The contamination of water during its transit from the treatment plant to the place of its consumption is also thus, prevented by disinfectants.

Disinfection (contd…)

- There are different disinfection methods:
- Disinfection by Ozone
- Disinfection by Ultraviolet Rays
- Disinfection by Potassium Permagnate
- Disinfection by Chlorine or bleaching powder

Disinfection by Ozone

Treatment with Ozone

- Ozone gas is unstable allotropic form of oxygen, with each of its molecules containing three oxygen items.
- It can be produced by passing high tension electric current through the stream of air in a closed chamber
- Reaction
- $3O_2 \xrightarrow{\text{under high electric arc voltage}} 2O_3$
- Ozone breaks down into nascent oxygen as
- $O_3 \longrightarrow O_2 + O$
- The nascent oxygen so produced is powerful oxidizing agent and removes the organic matter and bacteria from water.

Disinfection by Ozone (contd…)

Advantages:

- Ozone being unstable nothing remains in water by the time it reaches in water to distribution system.
- Ozone removes the colour, taste and odour from water in addition to removing bacteria from it.
- The ozonized water becomes tasty and pleasant unlike the chlorinated water which becomes bitter to tongue.

Disadvantages

- It is much costlier than chlorination
- It needs electricity for its manufacture and hence can be used when electricity is available easily and cheaply
- No residuals can be maintained because it is highly unstable and hence it does not ensure safety against possible contamination.

Disinfection by Ultraviolet Rays

Treatment with ultraviolet rays

- Ultraviolet rays are invisible rays having wavelength 1000-4000 mμ
- And can be produced by passing electric current through mercury enclosed in quartz bulbs.
- The water to be treated with ultraviolet rays should, however, be less turbid and low in colour. Normally it should be colourless and turbidity should not exceed 15 mg/l
- The depth of water over the bulbs should not generally exceed 10cm or so because these rays can effectively penetrate through this much distance only.

Disinfection by Ultraviolet Rays (contd…)

Advantages

- Sterilization with UV rays does not impart any addition taste or odour to water , as no chemicals are added.
- The method possesses ample scope for treating small quantities of water in hospitals and dispensaries for surgical uses or for drinking purposes for the place where cost is minor factor.

Disadvantages

- Method is very costly, needs technical knowhow, and possesses possibilities of interruption due to failure of electricity.

Disinfection by Potassium Permanganate

Treatment with potassium permanganate

- This is used as popular disinfectant for disinfecting well water in villages which are generally contaminated with lesser amount of bacteria. Normal doses of this disinfectant varies between 1-2mg/l with a contact period of 4-6hrs.
- Advantages
- Besides killing bacteria it also helps in oxidizing the taste producing organic matter hence it is added in small doses to chlorinated water also.
- It has also been used as an algaecide and for removing colour and iron from water.

Disinfection by Potassium Permanganate (contd…)

Disadvantages

- Potassium permanganate though cheap , handy and useful yet can't guarantee 100% removal of bacteria.
- It can possibly remove organisms causing cholera , but is of little use against other disease organisms.
- Water treated with potassium permanganate with the passage of time , produces a dark brown precipitate , which is noticeable as a coating on porcelain vessels and is difficult to remove without scouring.

Disinfection by Chlorine

Chlorination

- When chlorine is added to water, it forms hypochlorous acid or hypochlorite ions, which have an immediate and disastrous effect on most forms of microscopic organisms.
- $Cl_2 + H_2O \xrightarrow{PH > 5} HOCL + HCL$
- The hypochlorous acid is unstable and may break into hydrogen ions and hypochlorite ions
- $HOCL \underset{PH<7}{\overset{PH>8}{\rightleftharpoons}} H^+ + OCL^-$

Disinfection by Chlorine (contd…)

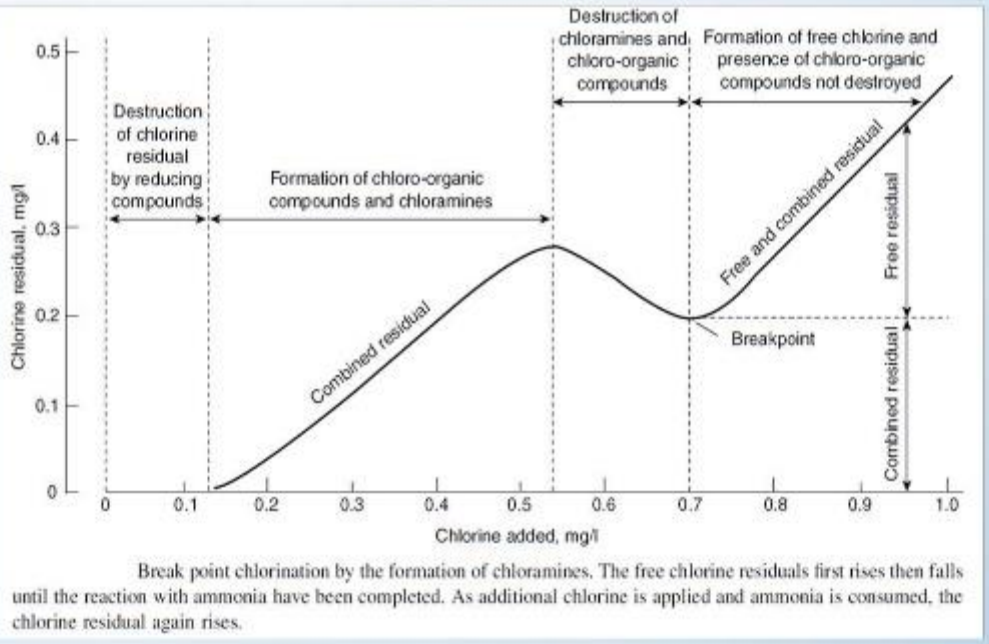
- Thus, at PH values greater than 10, only OCL ions are found; while in ph values of less than 7(more than5), HOCL will generally exist without dissociating into OCL ions; and in the PH range below 5, chlorine does not react and remains as elemental chlorine.
- Out of these forms of free available chlorine, the hypochlorous acid is the most destructive, being about 80 times more effective than hypochlorite ions. For this reason, the PH value of water during chlorination is generally maintained slightly less than 7, so as to keep the dissociation of HOCL to minimum, and thereby keeping more HOCL in solution compared to OCL ions.

Break Point Chlorination

❖ What is Chlorine Breakpoint?

- **Breakpoint chlorination** is the point where the demand for **chlorine** has been fully satisfied in terms of **chlorine** addition to water. When **chlorine** is added to water, a reaction is produced in the compounds present in the water. These compounds utilize the **chlorine**, resulting in zero **chlorine** residual.
- The initial point where free 'available' chlorine residual is present / detected.
- Breakpoint residual occurs after the chlorine dosage rate exceeds the demand created by reducing agents, ammonia, and organics.
- B.P. curve-shape is determined by contact time, temp, chlorine and ammonia concentration, pH, and water quality.

Break Point Chlorination (contd…)



Break point chlorination by the formation of chloramines. The free chlorine residuals first rises then falls until the reaction with ammonia have been completed. As additional chlorine is applied and ammonia is consumed, the chlorine residual again rises.

Break Point Chlorination (contd…)

❖ Addition of sufficient amount of oxidise:

- Organic matter
- Reducing substances
- Free ammonia in raw water
- Leaving behind mainly free chlorine

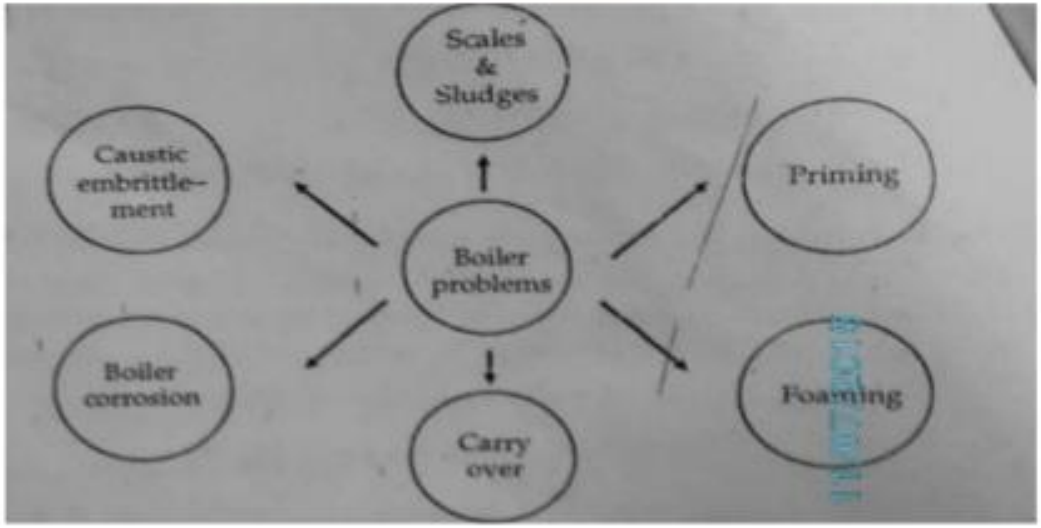
Break Point Chlorination (contd…)

❖ Advantages:

- It oxidises completely organic compounds, ammonia and other reducing compounds.
- It removes colour in water, due to organic matter.
- It destroys completely all the disease-producing bacteria.
- It removes both odour and taste from water.
- It prevents the growth of any weeds in water.

Boiler Troubles

BOILER PROBLEMS



Boiler Troubles (contd…)

Boiler feed water

- For steam generations, boilers are used
- if hard water is fed to the boiler, various problems are faced by boiler :

  - Scale and Sludge formation
  - Priming and Foaming
  - Boiler corrosion
  - Caustic embrittlement

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Sludge and Scale

Sludge and Scale Formation In Boilers

- In a boiler, water is continuously evaporated to form steam .This increases the concentration of dissolved salts Finally a stage is reached when the ionic product of these salts exceeds their solubility product and hence they are thrown out as precipitates. If the precipitates formed are soft loose and slimy, these are known as sludges ; while if the precipitate is hard and adhering on the inner walls, it is called as scale.

Sludge and Scale (contd…)

Sludge & Scale

- Continous evaporation of water takes place & conc. of dissolved salts gets increased & at saturation point forms ppts. on the inner walls of the boiler.
- Sludges : If loose & slimy ppts formed.
- Scales : If sticky, hard & adhernt coat formed.
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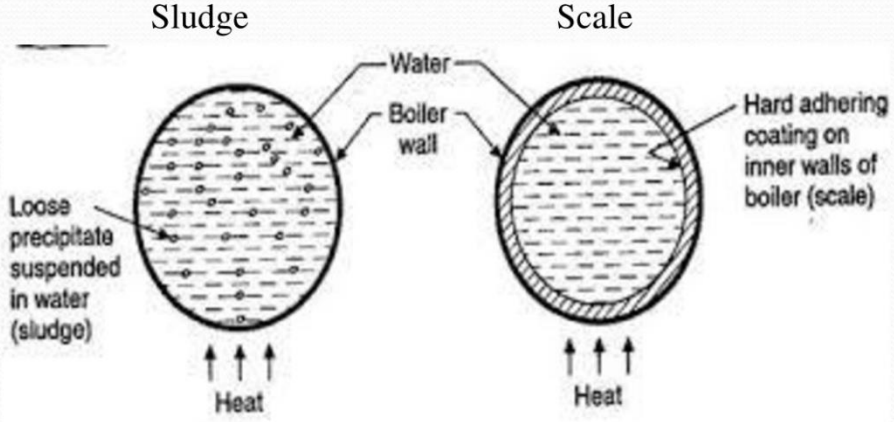

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Sludge and Scale (contd…)

Difference between Sludge & Scale

Sludge	Scale
Soft, loose & slimy precipitates.	hard deposits.
Non-adherent deposits & can be easily removed.	Stick very firmly to the inner surface of boiler and are very difficult to remove.
Formed by substances like $CaCl_2$, $MgCl_2$, $MgSO_4$ & $MgCO_3$.	Formed by substances like $CaSO_4$, $Mg(OH)_2$, $CaCO_3$ & $CaSio_3$.
Formed generally at colder portions of the boiler.	Formed generally at heated portions of the boiler.
Decrease the efficiency of boiler but are less dangerous.	Decrease the efficiency of boiler & chances of explosions are also there.

Sludge and Scale (contd…)

Disadvantages of sludge formation

- Sludge's are poor conductor of heat, so they tend to waste a portion of heat generated.
- Sludge's get entrapped in the scale and both get deposited as scales.
- Excessive sludge formation, disturbs the working of the boiler. It settle in the regions of poor water circulation such as pipe connection etc.

Prevention of sludge formation:

- By using well softened water
- By frequently 'blow-down operation', i.e., drawing off a portion of the concentrated water.

Sludge and Scale (contd…)

- **Disadvantages of Scale Formation:**
- Wastage of fuel
- Bagging
- Danger of Explosion

- **Prevention of Scale Formation:**
- Scale can be removed with the help of Scrapper
- Scale can be removed by giving Thermal Shocks
- Scale can be removed adding 5 to 10 % HCl.

Internal Treatment Methods

- Suitable chemicals are added to the boiler water either to precipitate or to convert the scale into compounds is called internal treatment of the boiler feed water.
- Internal treatment can be done with following types:

Internal Treatment Methods (contd…)

- **Calgon conditioning:** Involves in adding calgon to boiler water. It prevents the scale and sludge formation by forming soluble complex compound with $CaSO_4$.
- Calgon = Sodium hexa meta phosphate = $Na_2\,[Na_4\,(PO_3)_6]$
- $_2Na_2\,[Na_4\,(PO_3)_6] \rightarrow 2Na^+ + [Na_4\,P_6O_{18}]^-$
- $2CaSO_4 + [Na_4\,P_6O_{18}]^{-2} \rightarrow [Ca_2\,P_6O_{18}]^{-2} + 2Na_2SO_4$

Internal Treatment Methods (contd…)

- **Phosphate conditioning:** The addition of sodium phosphate in hard water reacts with the hardness causing agents and gives calcium and magnesium phosphates which are soft and non-adhere and can be removed easily by blow-down operation.
- $3CaSO_4 + 2Na_3PO_4 \rightarrow Ca_3(PO_4)_2 + 3Na_2SO_4$

Internal Treatment Methods (contd…)

- Generally three types of Phosphates are employed.
- i. Tri sodium Phosphate ($Na_3 PO_4$): is too alkaline used for treat to too acidic water.
- ii. Di sodium Phosphate (Na_2HPO_4): is weakly alkaline used for treat to weakly acidic water.
- iii .Sodium dihydrogen Phosphate (NaH_2PO_4): is too acidic used for treat to too alkaline water.

Internal Treatment Methods (contd…)

Colloidal Conditioning:

The addition of organic substances such as Kerosene, tannin, Gel. These substances gets coated over the scale forming precipitates and gives a loose and non-sticky precipitates which can be removed by using blow-down operation.

Internal Treatment Methods (contd…)

- **Carbonate Conditioning:** Scale formation can be avoided in boilers by adding sodium carbonate to boiler water. The scale foaming salt like calcium is converted into calcium carbonate which can be removed easily.
- $CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 + Na_2SO_4$

Internal Treatment Methods (contd…)

- **Treatment with Sodium Aluminate:** When sodium aluminate is treated with boiler water, it gets hydrolysed to give sodium hydroxide and a gelatinous precipitate of aluminium hydroxide
- $NaAlO_2 + 2NaOH \rightarrow NaOH + Al(OH)_3$

Internal Treatment Methods (contd…)

- The formed NaOH reacts with magnesium salts
- $MgCl_2 + 2NaOH \rightarrow Mg(OH)_2 + 2NaCl$
- The flocculent precipitates of $Mg(OH)_2$ and $Al(OH)_3$ entrap finely suspended and colloidal impurities like sand and oil drops which are difficult to remove ordinarily.
- The flocculent precipitates then settle to the bottom and can be removed easily.

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