

Chapter - 12

Water Technology

12.1 INTRODUCTION

Water is the most important compound for the existence of human beings, animals and plants. About 80% of the earth's surface is occupied by water. The main sources of water are

- (i) rain,
- (ii) rivers and lakes (surface water),
- (iii) wells and springs (underground water),
- (iv) sea water.

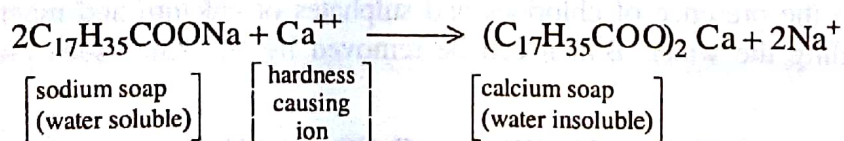
Among the above sources of water, rain water is the purest form of water but it is very difficult to collect whereas sea water is the most impure form. So, surface and underground water are normally used for domestic and industrial purposes. Such water must be free from undesirable impurities. **The process of removing all types of impurities from water and making it fit for domestic or industrial purposes is called water technology (or) water treatment.** Before treating the water, we should know the nature as well as the amount of impurities.

12.2 HARD WATER AND SOFT WATER

1. Hard water

Water, which does not produce lather with soap solution, but produces white precipitate (scum) is called hard water.

This is due to the presence of dissolved Ca and Mg salts.



2. Soft water

Water, which produces lather readily with soap solution is called soft water.

This is due to the absence of Ca and Mg salts.

12.3 HARDNESS OF WATER

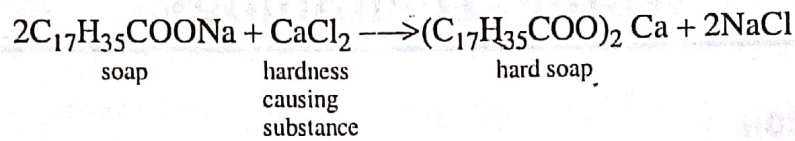
Hardness is the property or characteristics of water, which does not produce lather with soap.

How to detect hardness?

Hardness of water can be detected in two ways.

*oil and soap
get out of
oil and soap*

(i) When the water is treated with soap solution, if it prevents lathering and forms white scum, the water contains hardness.



(ii) Water containing hardness, gives wine red colour with Eriochrome Black-T indicator at pH 9-10.

12.3.1 Types of hardness

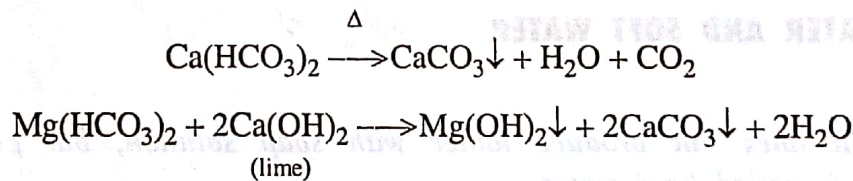
Depending upon the types of dissolved salts present in water, hardness of water can be classified into two types

1. Temporary hardness.
2. Permanent hardness.

1. Temporary hardness (or) Carbonate hardness (CH) (or) Alkaline hardness

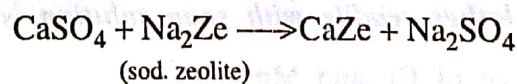
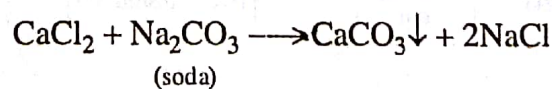
This is due to the presence of bicarbonates of calcium and magnesium. It can be removed by (i) boiling the water (ii) adding lime to the water.

The above two processes convert the bicarbonates into insoluble carbonates and hydroxides, which can be removed by filtering.



2. Permanent hardness (or) Non-carbonate hardness (NCH) (or) Non-alkaline hardness

This is due to the presence of chlorides and sulphates of calcium and magnesium. It cannot be removed by boiling the water. But, it can be removed by (i) Lime-soda process (ii) Zeolite process.



Total hardness

The sum of temporary hardness and permanent hardness.

12.3.2 Expression of hardness interms of equivalents of CaCO₃

The concentration of hardness producing salts are usually expressed interms of an equivalent amount of CaCO₃. CaCO₃ is chosen as a standard because,

(i) Its molecular weight (100) and equivalent weight (50) is a whole number, so the calculations in water analysis can be simplified.

(ii) It is the most insoluble salt, that can be precipitated in water treatment.

If the concentration of hardness producing salt is x mgs/lit, then

$$\text{Amount equivalent to CaCO}_3 = \frac{x \times 100}{\text{Molecular weight of hardness producing salt}}$$

(or)

$$\text{i.e., Amount equivalent to CaCO}_3 = \frac{\text{Amount of hardness producing salt} \times \text{Molecular weight of CaCO}_3}{\text{Molecular weight of hardness producing salt}}$$

(or)

$$\text{Amount equivalent to CaCO}_3 = \frac{\text{Amount of hardness producing salt} \times \text{Equivalent weight of CaCO}_3}{\text{Equivalent weight of hardness producing salt}}$$

Example

If the concentration (or) weight of CaSO_4 is 43 mgs/lit, then weight equivalent to

$$\text{CaCO}_3 = \frac{43 \times 100}{136} \text{ mgs/lit}$$

12.3.3 Units of Hardness

1. Parts per million (ppm)

It is defined as the number of parts of CaCO_3 equivalent hardness per 10^6 parts of water.

2. Milligrams per litre (mg/lit)

It is defined as the number of milligrams of CaCO_3 equivalent hardness per 1 litre of water.

3. Clarke's degree ($^\circ\text{Cl}$)

It is defined as the number of parts of CaCO_3 equivalent hardness per 70,000 parts of water.

4. French degree ($^\circ\text{Fr}$)

It is defined as the number of parts of CaCO_3 equivalent hardness per 10^5 parts of water.

Relationship between various units

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

12.4 CHARACTERISTICS OF WATER

As per the suggestion given by World Health Organisation (WHO) and by Indian Council of Medical Research (ICMR), the followings are the important characteristics of potable water.

1. It should be clear, colourless and odourless.
2. It should be cool and pleasant to taste.
3. It should be free from harmful bacteria and suspended impurities.
4. It should be free from dissolved gases like CO_2 , H_2S , NH_3 etc., and poisonous minerals like lead, arsenic, manganese, etc.,
5. Hardness should be less than 500 ppm.
6. Chloride content should be less than 250 ppm.
7. Fluoride content should be less than 1.5 ppm.
8. Total Dissolved Solids (TDS) content should be less than 500 ppm.
9. pH of the potable water should be 6.5 - 8.5.

12.5 BOILER FEED WATER

The water fed into the boiler for the production of steam is called boiler feed water. Boiler feed water should be free from turbidity, oil, dissolved gases, alkali and hardness causing substances. If hard water obtained from natural sources is fed directly into the boilers, the following troubles may arise.

Boiler troubles (or) disadvantages of using hardwater in boilers

1. Scale and sludge formation.
2. Priming and foaming (carry over).
3. Caustic embrittlement.
4. Boiler corrosion.

12.5.1 Scale and Sludge Formation in boilers

When water is continuously converted into steam in boilers, the concentration of dissolved salts in water increases progressively. When the concentration of the salts reaches their saturation point, they are thrown out in the form of precipitates on the inner walls of the boilers. The least soluble one gets precipitated first.

1. Sludge

If the precipitate is loose and slimy it is called sludge. Sludges are formed by substances like MgCl_2 , MgCO_3 , MgSO_4 and CaCl_2 . They have greater solubilities in hot water than cold water.

MgCl_2 , Mg

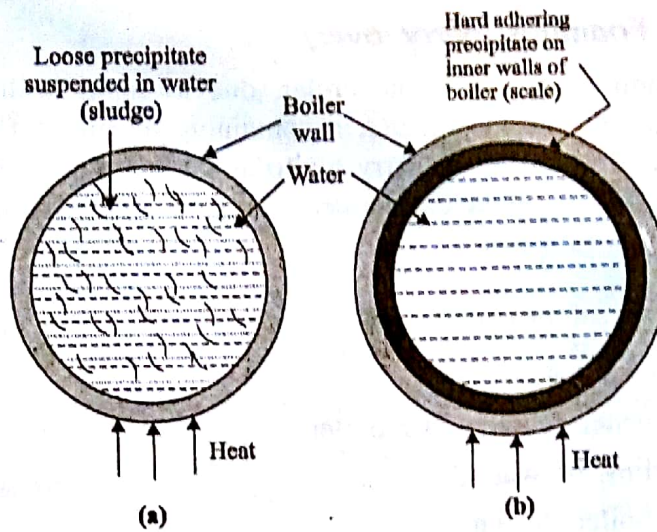


Fig 12.1 (a) Sludge in boiler (b) Scale in boiler

2. Scale

On the other hand, if the precipitate forms hard and adherent coating on the inner walls of the boiler, it is called scale. Scales are formed by substances like $\text{Ca}(\text{HCO}_3)_2$, CaSO_4 and $\text{Mg}(\text{OH})_2$.

Table 12.1 Comparison of Scales and Sludges

S.No.	Sludge	Scale
1.	Sludge is a loose, slimy and non-adherent precipitate.	Scale is a hard, adherent coating.
2.	The main sludge forming substances are MgCO_3 , MgCl_2 , MgSO_4 and CaCl_2 etc.,	The main scale forming substances are $\text{Ca}(\text{HCO}_3)_2$, CaSO_4 , $\text{Mg}(\text{OH})_2$.
3.	Disadvantages: Sludges are poor conductors of heat. Excess of sludge formation decreases the efficiency of boiler.	Disadvantages: Scales act as thermal insulators. It decreases the efficiency of boiler. Any crack developed on the scale, leads to explosion.
4.	Prevention	Prevention
	(i) Sludge formation can be prevented by using softened water.	(i) Scale formation can be prevented by dissolving using acids like HCl , H_2SO_4 .
	(ii) Sludges can also be removed by "blow-down operation".	(ii) Scale formation can be removed by (a) External treatment. (b) Internal treatment.
	(iii) Blow-down operation is a process of removing a portion of concentrated water by fresh water frequently from the boiler during steam production.	(iii) They can also be removed by applying thermal shocks, scrapers, wire brush, etc.,

12.5.2. Priming and Foaming (carry over)

During the production of steam in the boiler, due to rapid boiling, some droplets of liquid water are carried along with steam. Steam containing droplets of liquid water is called wet steam. These droplets of liquid water carry with them some dissolved salts and suspended impurities. This phenomenon is called carry over. It occurs due to priming and foaming.

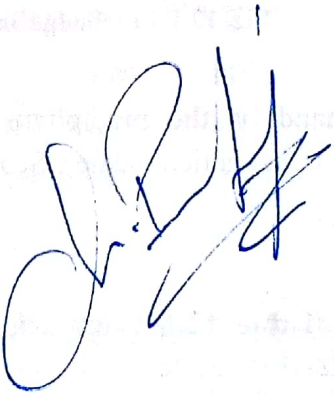
1. Priming

Priming is the process of production of wet steam. Priming is caused by

- (i) High steam velocity.
- (ii) Very high water level in the boiler.
- (iii) Sudden boiling of water.
- (iv) Very poor boiler design.

Prevention

Priming can be controlled by

- (i) Controlling the velocity of steam.
 - (ii) Keeping the water level lower.
 - (iii) Good boiler design.
 - (iv) Using treated water.
- 

2. Foaming

The formation of stable bubbles above the surface of water is called foaming. These bubbles are carried over by steam leading to excessive priming.

Foaming is caused by the

- (i) presence of oil, and grease,
- (ii) presence of finely divided particles.

Prevention

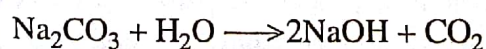
Foaming can be prevented by

- (i) adding coagulants like sodium aluminate, aluminium hydroxide,
- (ii) adding anti-foaming agents like synthetic polyamides.

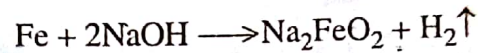
12.5.3. Caustic Embrittlement (Intercrystalline Cracking)

Caustic embrittlement means intercrystalline cracking of boiler metal.

Boiler water usually contains a small proportion of Na_2CO_3 . In high pressure boilers this Na_2CO_3 undergoes decomposition to give NaOH.



This NaOH flows into the minute hair cracks and crevices, usually present on the boiler material, by capillary action and dissolves the surrounding area of iron as sodium ferroate.



This causes brittleness of boiler parts, particularly stressed parts like bends, joints, rivets, etc., causing even failure of the boiler.

Prevention

Caustic embrittlement can be prevented by

- (i) using sodium phosphate as softening agent instead of sodium carbonate.
- (ii) by adding tannin, lignin to the boiler water, which blocks the hair cracks.

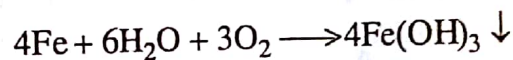
12.5.4. Boiler corrosion

Corrosion in boilers is due to the presence of

1. dissolved oxygen.
2. dissolved carbon dioxide.
3. dissolved salts.

1. Dissolved oxygen

Dissolved oxygen in water is mainly responsible for the corrosion of boiler. The dissolved oxygen in water attacks the boiler material at higher temperature.

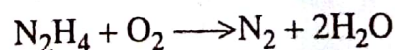
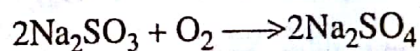


Removal of dissolved oxygen

Dissolved oxygen can be removed by chemical or mechanical methods.

(a) Chemical method

Sodium sulphite, hydrazine are some of the chemicals used for removing oxygen.



Hydrazine is found to be an ideal compound for removing dissolved oxygen in the water, since the products are water and inert N_2 gas.

(b) Mechanical de-aeration

Dissolved oxygen can also be removed from water by mechanical deaeration (Fig. 12.2).

In this process, water is allowed to fall slowly on the perforated plates fitted inside the tower. The sides of the tower are heated, and a vacuum pump is also attached to it. The high temperature and low pressure produced inside the tower reduce the dissolved oxygen content of the water.

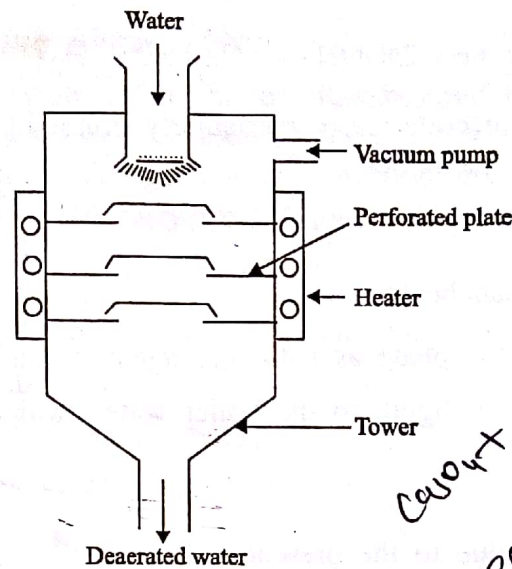
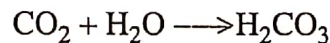


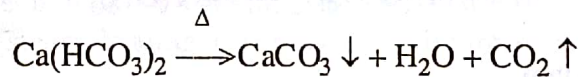
Fig. 12.2 Mechanical deaeration of water

2. Dissolved carbon dioxide

Dissolved carbon dioxide in water produces carbonic acid, which is acidic and corrosive in nature

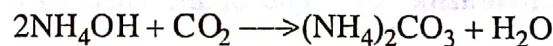


Carbon dioxide gas is also produced from the decomposition of bicarbonate salts present in water.



Removal of dissolved Carbon dioxide

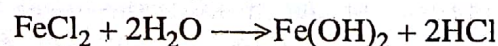
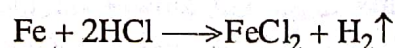
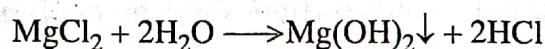
- (a) Carbon dioxide can be removed from water by adding a calculated amount of NH_4OH into water.



- (b) Carbon dioxide along with oxygen can also be removed mechanically by de-aeration method.

3. Dissolved MgCl_2

Acids, produced from salts dissolved in water, are also mainly responsible for the corrosion of boilers. Salts like MgCl_2 , CaCl_2 , etc, undergo hydrolysis at higher temperature to give HCl , which corrodes the boiler.



Removal of acids

Corrosion by acids can be avoided by the addition of alkali to the boiler water.

**12.6 REQUIREMENTS OF BOILER FEED WATER**

	Specifications	Disadvantages
1.	Boiler feed water should have zero hardness.	Scales and sludges will be produced, which prevents efficient heat transfer.
2.	It must be free from dissolved gases like O_2 , CO_2 .	It leads to boiler corrosion.
3.	It should be free from suspended impurities.	Produces wet steam.
4.	It should be free from dissolved salts and alkalinity.	Produces caustic embrittlement, which causes brittleness of boiler parts.

12.7 SOFTENING OR CONDITIONING METHODS

Water used for industrial purposes should be free from hardness producing substances, suspended impurities and dissolved gases etc. The process of removing hardness producing salts from water is known as softening (or) conditioning of water.

Softening of water can be done in two methods

1. External conditioning.
2. Internal conditioning.

12.8 EXTERNAL CONDITIONING

It involves the removal of hardness producing salts from the water before feeding into the boiler. The external treatment can be done by the Demineralisation or Ion-exchange process.

12.8.1 Ion Exchange (or) Demineralisation process

This process removes almost all the ions (both anions and cations) present in the hard water.

The soft water, produced by lime-soda and zeolite processes, does not contain hardness producing Ca^{2+} and Mg^{2+} ions, but it will contain other ions like Na^+ , K^+ , SO_4^{2-} , Cl^- etc., On the other hand **D.M. (Demineralised) water** does not contain both anions and cations.

Thus a soft water is not demineralised water whereas a demineralised water is soft water.

This process is carried out by using ion exchange resins, which are long chain, cross linked, insoluble organic polymers with a microporous structure. The functional groups attached to the chains are responsible for the ion exchanging properties.

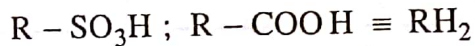
1. Cation exchanger

Resins containing acidic functional groups ($-\text{COOH}$, $-\text{SO}_3\text{H}$) are capable of exchanging their H^+ ions with other cations of hard water. Cation exchange resin is represented as RH_2 .

Examples

(i) Sulphonated coals.

(ii) Sulphonated polystyrene.



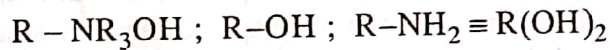
2. Anion Exchanger

Resins containing basic functional groups ($-\text{NH}_2$, $-\text{OH}$) are capable of exchanging their anions with other anions of hard water. Anion exchange resin is represented as $\text{R}(\text{OH})_2$.

Examples

(i) Cross-linked quaternary ammonium salts.

(ii) Urea-formaldehyde resin.



Process

The hard water first passed through a cation exchange column, (Fig. 12.3) which absorbs all the cations like Ca^{2+} , Mg^{2+} , Na^+ , K^+ , etc., present in the hard water.

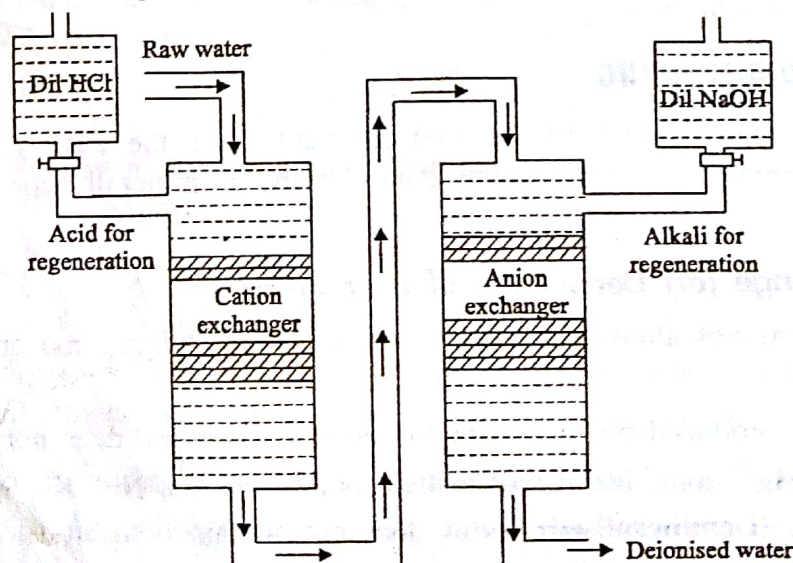
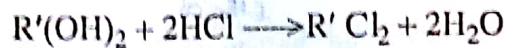


Fig. 12.3 Demineralisation process



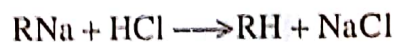
The cation free water is then passed through a anion exchange column, which absorbs all the anions like Cl^- , SO_4^{2-} , HCO_3^- , etc., present in the water.



The water coming out of the anion exchanger is completely free from cations and anions. This water is known as demineralised water or deionised water.

Regeneration

When the cation exchange resin is exhausted, it can be regenerated by passing a solution of dil HCl or dil H_2SO_4 .



Similarly, when the anion exchange resin is exhausted, it can be regenerated by passing a solution of dil NaOH.



Advantages of ion-exchange process

- (i) Highly acidic or alkaline water can be treated by this process.
- (ii) The water obtained by this process will have very low hardness (nearly 2 ppm).

Disadvantages of ion-exchange process

- (i) Water containing turbidity, Fe and Mn cannot be treated, because turbidity reduces the output and Fe, Mn form stable compound with the resin.
- (ii) The equipment is costly and more expensive chemicals are needed.

12.9 INTERNAL CONDITIONING OR INTERNAL TREATMENT OR BOILER COMPOUNDS

It involves the removal of scale forming substance, which were not completely removed in the external treatment, by adding chemicals directly into the boiler. These chemicals are also called **boiler compounds**.

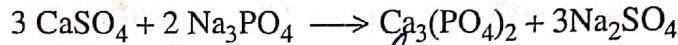
1. Carbonate conditioning

Scale formation can be avoided by adding Na_2CO_3 to the boiler water. It is used only in low pressure boilers. The scale forming salt like $CaSO_4$ is converted into $CaCO_3$, which can be removed easily.



2. Phosphate conditioning

Scale formation can be avoided by adding sodium phosphate. It is used in high pressure boilers. The phosphate reacts with Ca^{2+} and Mg^{2+} salts to give soft sludges of calcium and magnesium phosphates.

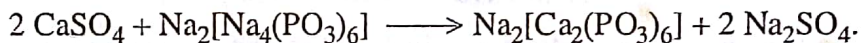


Generally 3 types of phosphates are ^{used} employed.

- (a) *Trisodium phosphate* - Na_3PO_4 (Too alkaline) - used for too acidic water.
- (b) *Disodium hydrogen phosphate* - Na_2HPO_4 (weakly alkaline) - used for weakly acidic water.
- (c) *Sodium dihydrogen phosphate* - NaH_2PO_4 (acidic) - used for alkaline water.

3. Calgon conditioning

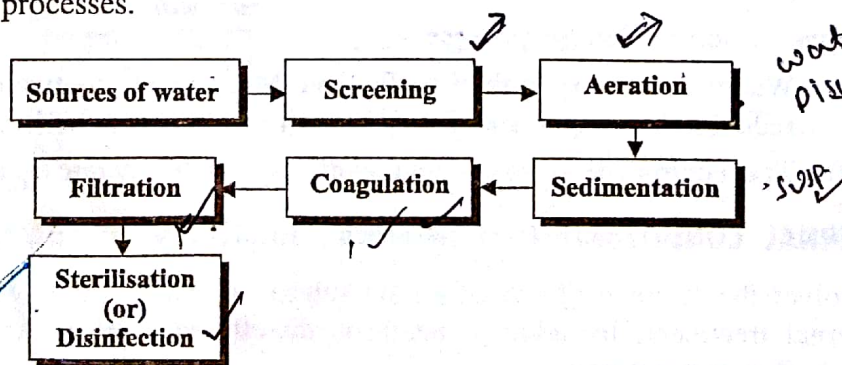
Calgon is sodium hexa meta phosphate $\text{Na}_2[\text{Na}_4(\text{PO}_3)_6]$. This substance interacts with calcium ions forming a highly soluble complex and thus prevents the precipitation of scale forming salt.



The complex $\text{Na}_2[\text{Ca}_2(\text{PO}_3)_6]$ is soluble in water and there is no problem of sludge disposal.

12.10 TREATMENT OF WATER FOR DOMESTIC SUPPLY

Rivers and lakes are the most common sources of water used by municipalities. These water should be free from colloidal impurities, domestic sewages, industrial effluents and disease producing bacterias. Hence domestic supply of water involves the following stages in the purification processes.



1 Screening

It is a process of removing the floating materials like, leaves, wood pieces, etc. from water. The raw water is allowed to pass through a screen, having large number of holes, which retains the floating materials and allows the water to pass.

2 Aeration

The process of mixing water with air is known as aeration. The main purpose of aeration is

- (i) to remove gases like CO_2 , H_2S and other volatile impurities causing bad taste and odour to water.
- (ii) to remove ferrous and manganous salts as insoluble ferric and manganic salts,

3 Sedimentation

It is a process of removing suspended impurities by allowing the water to stand undisturbed for 2-6 hours in a big tank. Most of the suspended particles settle down at the bottom, due to forces of gravity, and they are removed. Sedimentation removes only 75% of the suspended impurities.

4 Coagulation

Finely divided clay, silica, etc. do not settle down easily and hence cannot be removed by sedimentation. Such impurities are removed by coagulation method.

In this method certain chemicals, called coagulants, like alum, $\text{Al}_2(\text{SO}_4)_3$ etc., are added to water. When the $\text{Al}_2(\text{SO}_4)_3$ is added to water, it gets hydrolysed to form a gelatinous precipitate of $\text{Al}(\text{OH})_3$. The gelatinous precipitate of $\text{Al}(\text{OH})_3$ entraps the finely divided and colloidal impurities, settles to the bottom and can be removed easily.

5 Filtration

It is the process of removing bacteria, colour, taste, odour and suspended particles, etc., by passing the water through filter beds containing fine sand, coarse sand and gravel. A typical sand filter is shown in the figure 12.4.

The sand filter consists of a tank containing a thick top layer of fine sand followed by coarse sand, fine gravel and coarse gravel. When the water passes through the filtering medium, it flows through the various beds slowly. The rate of filtration decreases slowly

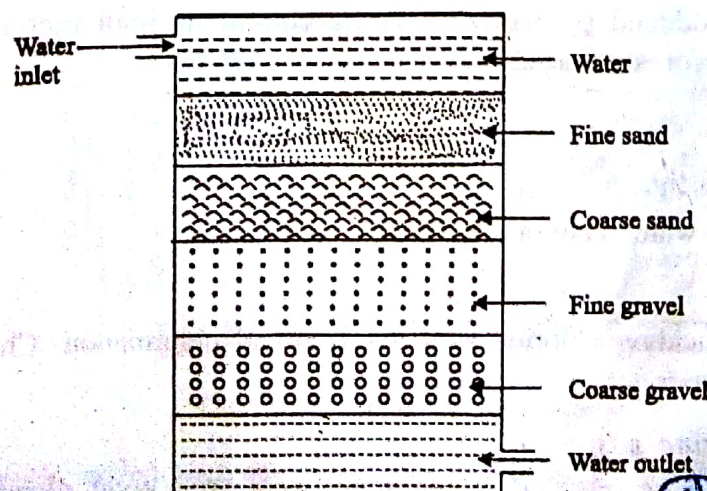


Fig 12.4 Sand filter

due to the clogging of impurities in the pores of the sand bed. When the rate of filtration becomes very slow, the filtration is stopped and the thick top layer of fine sand is scrapped off and replaced with clean sand. Bacterias are also partly removed by this process.

6 Sterilisation (or) Disinfection

The process of destroying the harmful bacterias is known as sterilisation or disinfection. The chemicals used for this purpose are called disinfectants.

Methods of sterilisation

Sterilisation can be carried out by the following methods.

1. By boiling

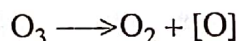
When water is boiled for 10-15 minutes, all the harmful bacterias are killed and water becomes safe for use.

Disadvantages

- (i) Boiling alters the taste of drinking water.
- (ii) It is impossible to employ it in municipal water-works.

2. By ozonation (using ozone)

Ozone is a powerful disinfectant and is readily absorbed by water. Ozone is highly unstable and breaks down to give nascent oxygen.



The nascent oxygen is a powerful oxidising agent and kills the bacterias.

Disadvantages

- (a) This process is costly and cannot be used in large scale.
- (b) Ozone is unstable and cannot be stored for long time.

3. By using ultraviolet radiations

UV rays are produced by passing electric current through mercury vapour lamp. This is particularly useful for sterilizing water in swimming pool.

Disadvantages

- (i) It is costly.
- (ii) Turbid water cannot be treated.

4. By chlorination

The process of adding chlorine to water is called chlorination. Chlorination can be done by the following methods.

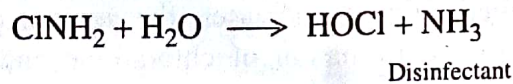
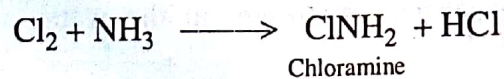
(a) *By adding chlorine gas*

Chlorine gas can be bubbled in the water as a very good disinfectant.



(b) By adding chloramine

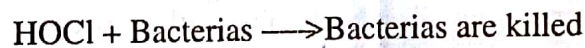
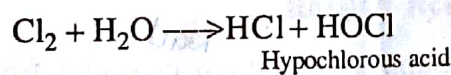
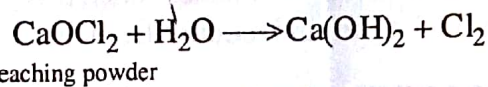
When chlorine and ammonia are mixed in the ratio 2:1, a compound chloramine is formed.



Chloramine compounds decompose slowly to give chlorine. It is a better disinfectant than chlorine. chloramine gives good taste to the treated water.

(c) By adding bleaching powder

When bleaching powder is added to water, it produces hypochlorous acid (HOCl). HOCl is a powerful germicide.

**Break point Chlorination**

Water contains the following impurities

- (i) Bacterias.
- (ii) Organic impurities.
- (iii) Reducing substances (Fe^{2+} , H_2S , etc.).
- (iv) Free ammonia.

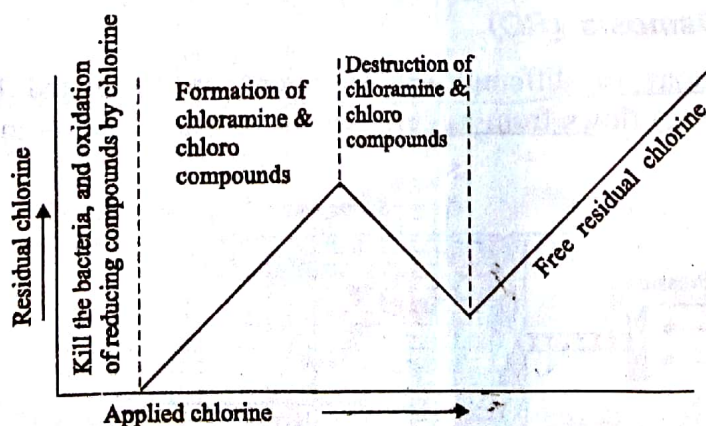


Fig 12.5 Break point chlorination

Chlorine may be added to water directly as a gas or in the form of bleaching powder. When chlorine is applied to water, the results obtained can be depicted graphically in the

Fig. 12.5. The graph shows the relationship between the amount of chlorine added to water and the residual chlorine.

It is seen from the graph that initially the applied chlorine is used to kill the bacteria and oxidises all the reducing substances present in the water and there is no free residual chlorine.

As the amount of applied chlorine increases, the amount of combined residual chlorine also increases. This is due to the formation of chloramine and other chloro compounds.

At one point, on further chlorination, the oxidation of chloramines and other impurities starts and there is a fall in the combined chlorine content. Thus the combined residual chlorine decreases to a minimum point at which oxidation of chloramines and other impurities complete and free residual chlorine begins to appear this minimum point is known as, "break point chlorination".

Thus, the break point chlorination eliminates bacteria, reducing substances, organic substances responsible for the bad taste and odour, from the water.

12.11 DESALINATION OF BRACKISH WATER

The process of removing common salt (sodium chloride) from the water is known as **desalination**. The water containing dissolved salts with a peculiar salty or brackish taste is called **brackish water**.

Depending upon the quantity of dissolved solids, water is graded as

- (i) **Fresh water** - Contains < 1000 ppm of dissolved solids.
- (ii) **Brackish water** - Contains > 1000 but < 35,000 ppm of dissolved solids.
- (iii) **Sea water** - Contains > 35,000 ppm of dissolved solids.

Sea water and brackish water can be made available as drinking water through desalination process. Desalination is carried out either by reverse osmosis or electro dialysis.

12.11.1 Reverse Osmosis (RO)

When two solutions of different concentrations are separated by a semi-permeable membrane, solvent (water) flows from a region of lower concentration to higher concentration.

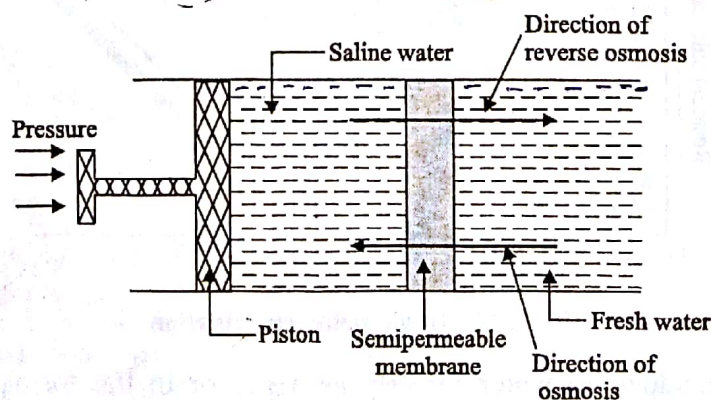


Fig. 12.6 Reverse osmosis

This process is called **osmosis**. The driving force in this phenomenon is called **osmotic pressure**.

If a hydrostatic pressure in excess of osmotic pressure is applied on the higher concentration side, the solvent flow is reversed i.e solvent flows from higher concentration to lower concentration. This process is called **reverse osmosis** (Fig. 12.6). Thus, in the process of reverse osmosis pure water is separated from salt water. This process is also known as super-filtration. The membranes used are cellulose acetate, cellulose butyrate, etc.

Advantages

- (i) The life time of the membrane is high, and it can be replaced within few minutes.
- (ii) It removes ionic as well as non-ionic, colloidal impurities.
- (iii) Due to low capital cost, simplicity, low operating, this process is used for converting sea water into drinking water.

12.11.2 Electrodialysis

Principle: Electrodialysis is the process of separating ions of the salt from the salt water through ion-selective membranes by passing direct current.

Description: An electrodialysis cell consists of alternate cation (C) and anion (A) selective membrane. An ion selective membrane has permeability for only one kind of ions with specific charge. Therefore cation selective membrane is permeable to cations only but not to anions while anion selective membrane is permeable to anions only but not to cations. The cathode is placed near the cation selective membrane and the anode is placed near the anion selective membrane. (Fig. 12.7)

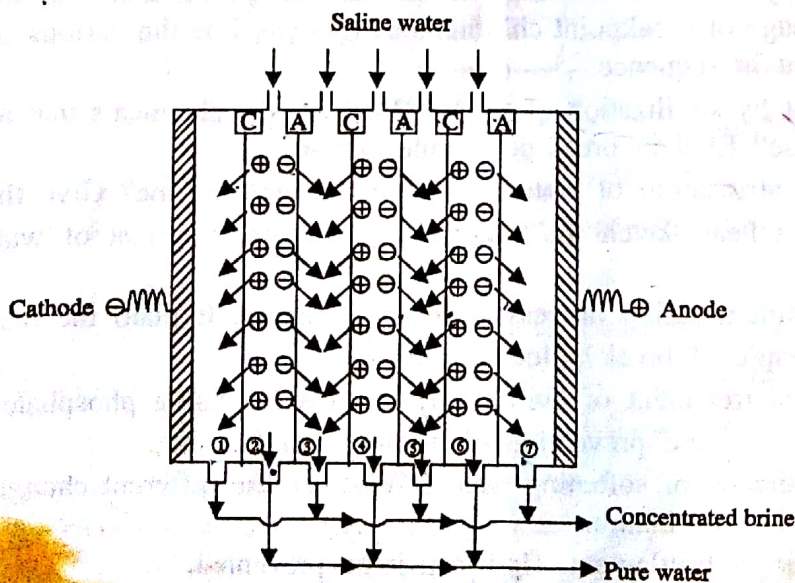


Fig. 12.7 Electrodialysis

Process

Saline water is fed into the electro dialysis cell and direct current is applied through the electrodes perpendicular to the direction of water flow. As the current passes through the electrodes, from the compartment 2,4 and 6, cations (Na^+) move towards the cathode through cation selective membrane (C) and anions (Cl^-) move towards the anode through anion selective membrane (A). The net result is the decrease of ions (salt) from 2, 4 and 6 compartments while the concentration of ions (salt) in the adjacent compartment 1, 3, 5 and 7 is increased. Now the compartments 2, 4 and 6 are filled with pure water and the compartments 1, 3, 5 and 7 are filled with concentrated brine solution. Thus, the salinity is removed from salt water.

Examples

Cation selective membrane - poly styrene containing sulphonic acid group.

Anion selective membrane - poly styrene containing tetra ammonium chloride.

12.12 QUESTIONS

1. What is meant by carbonate and non-carbonate hardness of water? Explain with examples
2. What is break-point chlorination? State its significance
3. Define the term desalination with a neat diagram, describe desalination by reverse osmosis' method.
4. What are boiler troubles? How are they caused? Suggest steps to minimize the boiler troubles.
5. Describe briefly the different steps in the purification of water for drinking purposes. What is the usage of breakpoint chlorination? (or) Out line the various stages of domestic water treatment in sequence.
6. What is meant by sterilization of water? What are the chemicals that are normally used for this purpose? Explain break-point chlorination.
7. Explain how sterilisation of water carried out using chlorine? Give the mechanism.
8. Explain with a neat sketch the various steps in the treatment of water for municipal supply.
9. Describe de-mineralisation process of water softening. Explain the reactions involved.
10. Give the principle of break point chlorination.
11. How is internal treatment of boiler water carried out using phosphate and calgon.
12. Discuss the causes and prevention of priming and foaming.
13. What is the purpose of softening water? What are the different chemicals used for this purpose. Explain chlorination.
14. What is caustic embrittlement. How can it be prevented.
15. What are scales and sludges. Describe the disadvantages of scale and sludge formation.
16. What are the various methods by which disinfection of domestic water is carried out. Explain.
17. What are the problems one would face when hard water is used in boiler industries.