UNIT II WATER TREATMENT **12**

Objectives - Unit operations and processes - Principles, functions, and design of water treatment plant units, aerators of flash mixers, Coagulation and flocculation – Clarifloccuator - Plate and tube settlers - Pulsator clarifier - sand filters - Disinfection - softening, removal of iron and manganese - Defluoridation - Softening - Desalination process - Residue Management - Construction, Operation and Maintenance aspects

Objectives

* Available raw waters must be treated and purified before they can be supplied to the general public for their domestic, industrial and anyother uses.

The following are important requirements of water for domestic use :-

1) It should be colourless. It must be free from solids in suspension.

2) It should be of good taste, free from odour

3) It should be reasonably soft

4) It should be plentiful and cheap

5) It should be free from disease producing bacteria or organisms

6) should be free from Objectionable dissolved gases.

7) It should be free from harmful salts.

8) It should be free from Objectionable minerals such as iron, manganese, lead, arsenic and other Poisonous metals

9) It should be free from radioactive substance such as radium, stronsium etc.

10) It should be reasonably free from phenolic compounds, chlorides, fluoride and iodine.

11) It should be non-corrosive.

Unit operations and processes

1) Screening
2) Plain Sedimentation
3) Sedimentation aided with Coagulation
4) Filtration
5) Disinfection
6) Aeration
7) Softening
8) Miscellaneous treatments such as fluoridation, recarbonation liming, desalination etc.

Screening

* To remove large sized particles such as debris, animals, trees, branches, bushes, ice etc.

* Two types of screens

a) Coarse screen

b) Fine screen

* Coarse screen consist of parallel iron rods placed vertically or at a slight slope at about 2 to 10cm centre to centre.

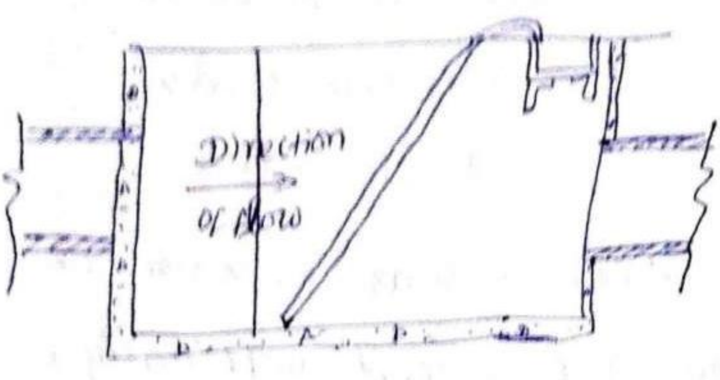
* Fine screens are made up of fine wire or perforated metal with openings less than 1cm wide.

* Coarse screens first remove the bigger floating bodies & organic solids & fine screens remove the fine suspended solids.

* Coarse screens are ~~[illegible]~~ normally kept inclined at about 45° to 60° to the horizontal

* Velocity through screens is 0.8 to 1 m/s.

* Material collected on the upstream side is removed manually or mechanically.



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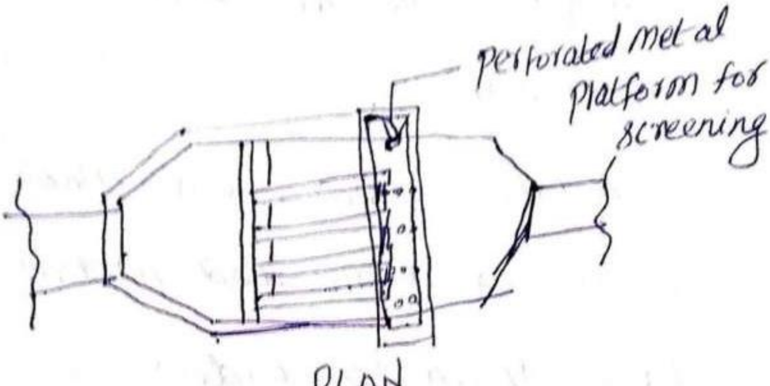


PLAN

Plain Sedimentation

* Suspended impurities in water have specific gravity > 1 (Sp.gr. of water)

* In still water, these impurities will settle down under gravity

* Flow of water is retarded in settling tank (or) sedimentation tank (or) sedimentation basin (or) clarifier.

* suspended impurities settle down at the bottom of the tank

* Theoretical average time for which

the water is detained in the tank is called dentention period

* The settling velocity of a spherical particle by stokes law is

$$\boxed{V_S = \frac{g}{18}(G-1)\frac{d^2}{\nu}} \text{ for } d < 0.1mm$$

V_S - settling velocity of particle in m/sec

d - diameter of particle in m

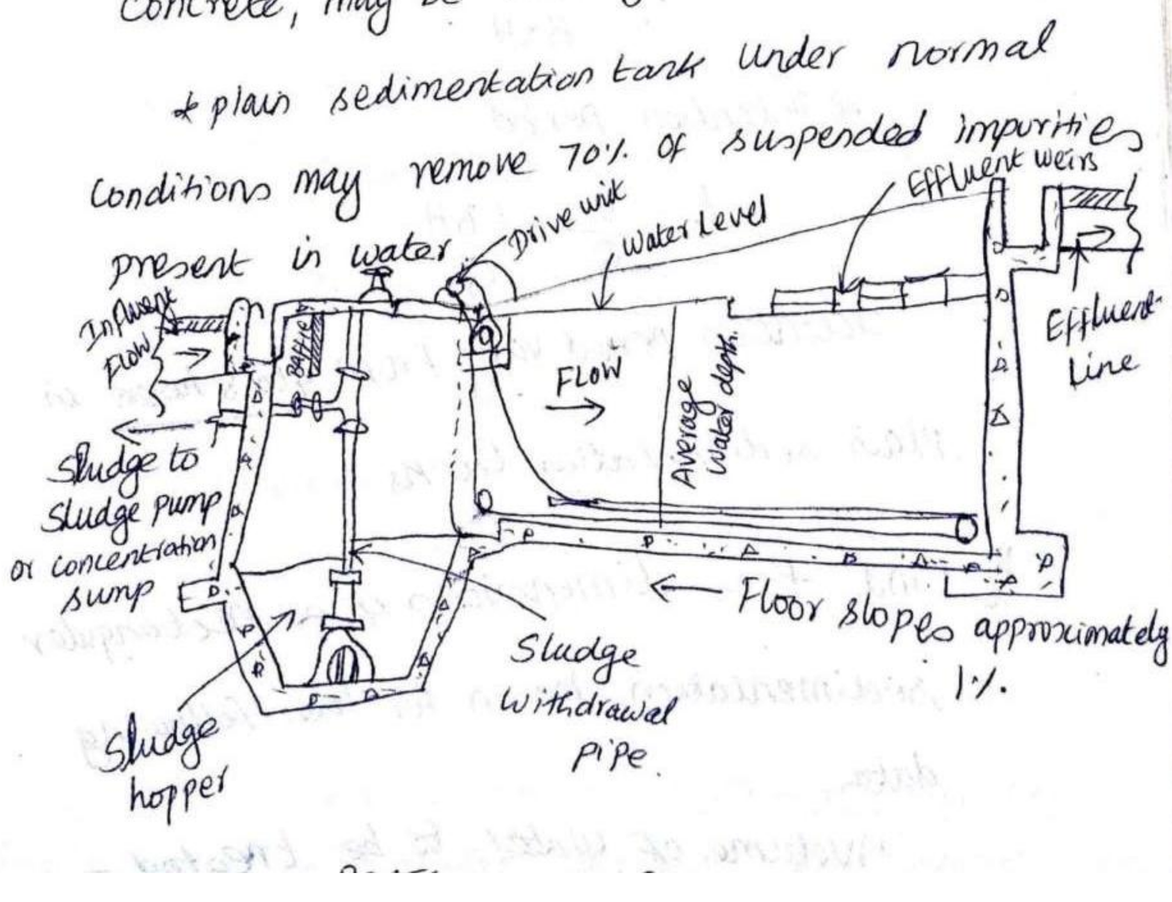
G - Sp. gravity of the particle

= density of particle / density of water

ν - kinematic viscosity of water in m^2/sec

* Sedimentation basins are made of reinforced concrete, may be rectangular or circular in plan.

* plain sedimentation tank under normal conditions may remove 70% of suspended impurities present in water.



* Types of sedimentation Tanks

1) horizontal flow tanks

2) vertical or upflow tanks

* Horizontal flow type rectangular tank is divided into four zones

i) the inlet zone in which the influent stream disperse

ii) the settling zone

iii) the bottom zone or sludge zone

iv) the outlet zone

* Horizontal discharge velocity, V_d

$$V_d = \frac{Q}{B \times H}$$

* Detention period

$$t_0 = \frac{V}{Q} = \frac{LBH}{Q}$$

Detention period vary from 4 to 8 hours in plain sedimentation tanks.

1) Find the dimensions of a rectangular sedimentation basin for the following data:

i) volume of water to be treated = 3 million litres per day

ii) Detention period = 4 hours.

iii) velocity of flow = 10 cm/min.

Detention time = 4 hours = 240 min

velocity of flow = 10 cm/min

∴ Length of tank = 0.1 × 240 = 24 m

Volume of ~~tank~~ water in 4 hours

$$= \frac{3 \times 10^6}{10^3} \times \frac{4}{24} = 500\, m^3$$

∴ cross-section Area

$$A = \frac{V}{L} = \frac{500}{24} = 20.8\, m^2$$

Assume a working depth of 3 m

$$\therefore \text{Width of tank} = \frac{20.8}{3} \simeq 7\, m$$

Provide an extra depth of 1 m for sludge storage and 0.5 m for free board making a total depth = 3+1.5 = 4.5 m

Hence provide a settling tank of size 24 m × 7 m × 4.5 m

Sedimentation with Coagulation :- clarification

* Used when water contains very fine suspended matter and colloidal matter.

* coagulants neutralize the negative charge on colloidal particles and allow them to coagulate.

* Clarification is achieved in three stages

i) Addition of measured quantities of chemicals (Coagulants) to water and their thorough mixing

ii) Formation of precipitate which coagulates and forms a floc

iii) Sedimentation.

Common Coagulants

1) Aluminium sulphate or alum
2) Chlorinated Copperas
3) Ferrous sulphate and lime
4) Magnesium carbonate
5) polyelectrolytes
6) Sodium Aluminate.

Alum is the most Common and universal Coagulant used in waterworks. Its Chemical Composition is $Al_2(SO_4)_3\, 18H_2O$ - Alum is effective when pH of water is between 6.5 to 8.5. Dose of alum varies between 10 to 30 mgs per litre of water.

Filtration

During filtration, the turbidity and colloidal matter of non-settleable type are removed. The following actions take place during filtration:-

i) Mechanical straining
ii) Sedimentation
iii) Biological action
iv) Electrolytic action.

Filters are classified as

1) Slow sand filter
2) Rapid sand filter

Slow Sand filters

* Rate of filtration is slow
* Require large areas of land and are costly to install.
* slow sand filters are not suitable for dealing with waters containing suspended matter.

Slow sand filter consists of the following parts:

1) Enclosure tank
2) Filter media
3) Base material
4) Under drainage system

1- Enclosure Tank

* Rectangular in size, built below ground level.

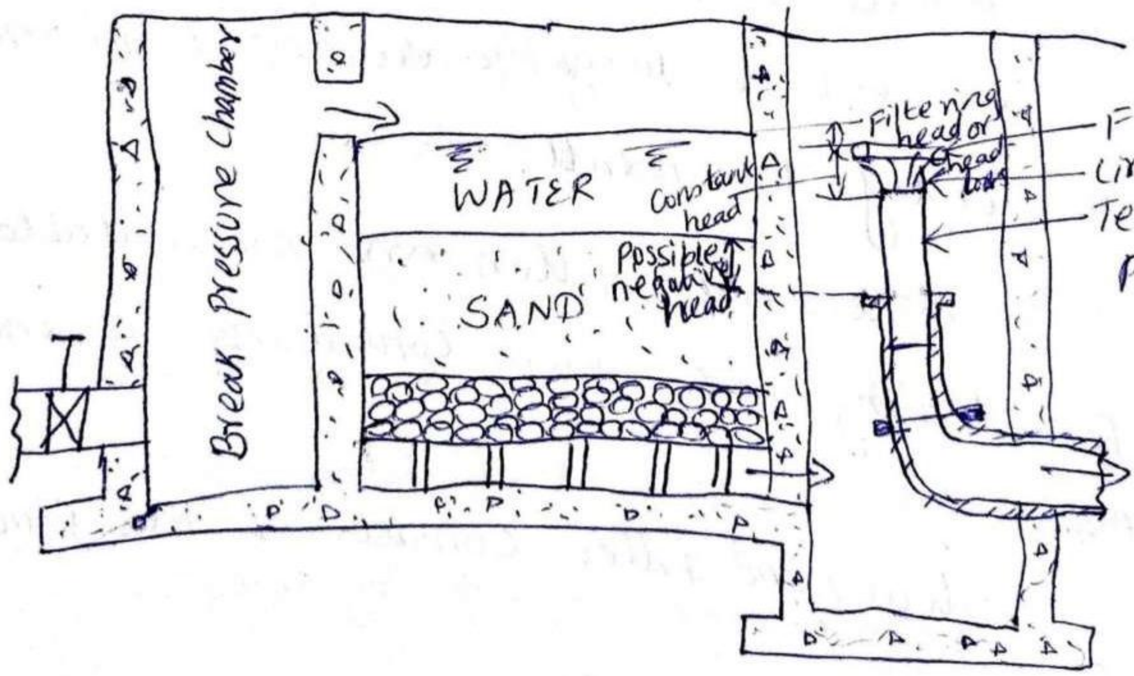
* Constructed in stone or brick masonry with a coating of water proof material

* Floor has bed slope of 1 in 100 to 1 in 200 towards central drains.

* Surface area of tank varies between 50 m^2 to 1000 m^2

* Filtration varies from 100 to 200 litres of water per square meter.

* Depth of tank varies from 2.5 to 4 m.



2) Filter Media

* Filter media consists of sand layer 90 to 110cm thick.

* Effective size of sand varies from 0.2 to 0.35, with a common value of 0.3.

* Coefficient of Uniformity Varies from 2 to 3, the common value being 2.5.

3. Base Material

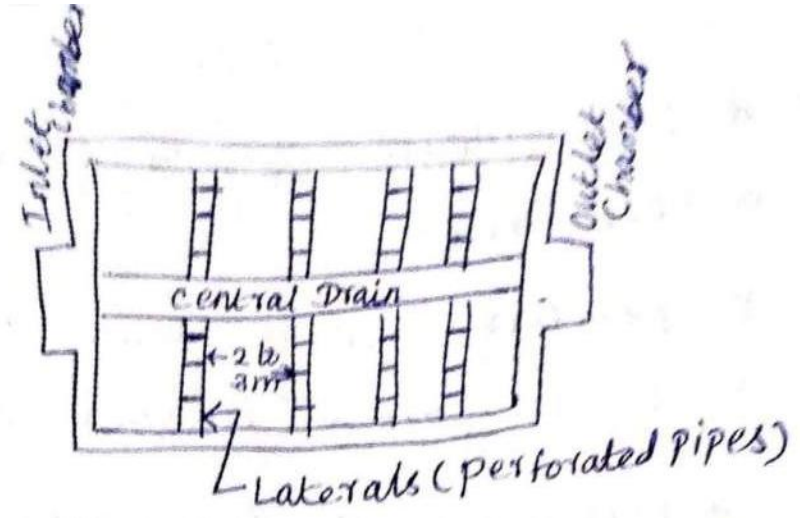
* Filter media is supported on base material consisting of 30 to 75cm thick gravel bed.

* Gravel is laid in layers of 15cm with topmost layer of finer size and bottom most layer of coarse size.

	Depth	Size
Topmost layer	15cm	3mm to 6mm
Intermediate	15cm	6mm to 20mm
layers	15cm	20mm to 40mm
Bottom layer	15cm	40mm to 65mm

4. Under drainage system

* Under drainage system collects filtered water and send it to clean water reservoir



* It consists of a central drain collecting water from a number of lateral drains

*. Lateral drains are perforated pipes of 7.5 to 10cm dia spaced at 2 to 3m centre to centre.

Working

* only plain sedimentation is done before filtering.

*. The water passes downwards through the sand bed, through the gravel and is then collected by the underdrainage system.

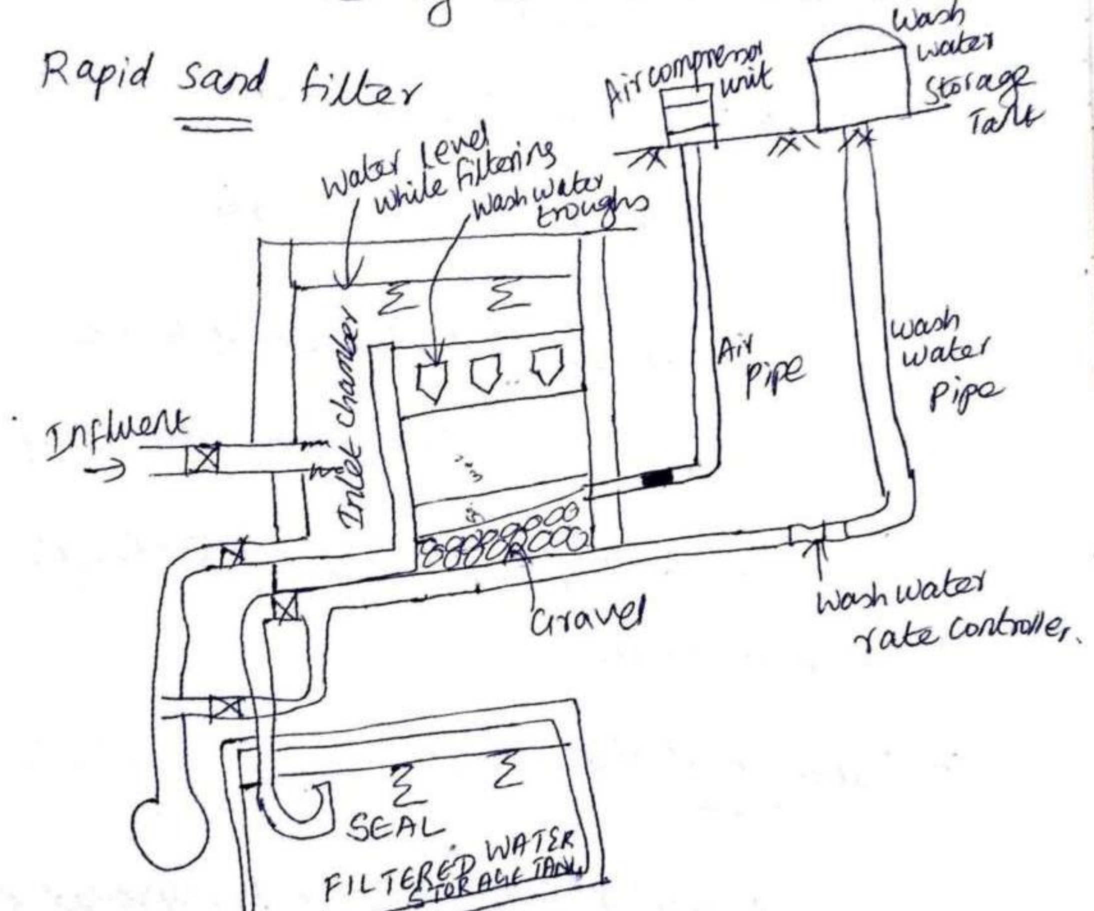
* Slow sand filter works by a combination of both straining as well as microbiological action.

*. The top layer of sand is scraped manually & removed through a depth of 15mm to 30mm.

* Rate of flow in slow sand filter may be 100 to 200 litres per hour per m^2 of the filter area

*. 98 to 99% of bacteria in water can be removed by slow sand filter.

Rapid sand filter



1) Enclosure Tank
2) Filter media
3) Base Material
4) Under drainage.

1) Enclosure Tank

* Rectangular

* Masonry or Concrete construction

* Depth of tank is 2.5 to 3.5m

* Surface area is 20 to 50 m^2

2) Filter media

* Sand should be free from dirt, organic matter & other suspended matter.

* Effective size of sand is 0.35 to 0.6mm

common value is 0.45mm

* C_U is between 1.2 to 1.7

Common value is 1.5

* Depth of sand media is 0.6 to 0.9m

3) Base Material

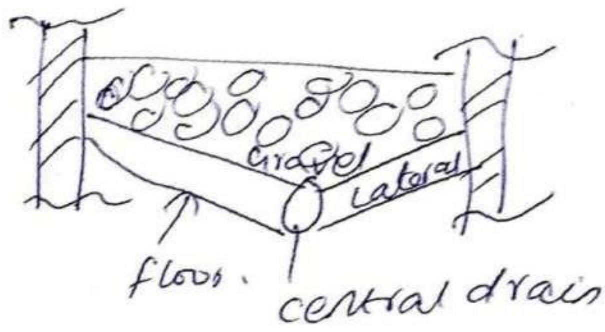
* Filter sand media is supported on base material of gravel layers.

* Depth is 45 to 60cm

	Depth	Grade size
Top most	15 cm	2mm to 6mm
Intermediate	15 cm	6mm to 12mm
	15 cm	12mm to 20mm
Bottom most	15 cm	20mm to 50mm.

4) Under-drainage system

* collects filtered water uniformly over the area of gravel bed.



Back washing

Rapid gravity filters are washed by sending air and water upwards through the bed by reverse flow.

Rapid sand filter reduce the turbidity to less than 1 P.P.M. Rapid sand filter removes colour below 3 on cobalt scale. 90 to 99% of bacteria is removed by rapid sand filter.

(42) 1) A city has a population of 1,00,000 with an average rate of demand of 160 litres per head per day. Find the area of rapid sand filters.

Max. daily demand = 1,00,000 × 160 × 1.5

= 2 40,00,000 litres.

Let us assume an average filtration rate of 4500 litres per hour per m^2 of filter area.

∴ Area of filters $= \frac{24000000}{4500 \times 24}$

$= 222.2 m^2$.

Let the size of each filter unit be 9m × 5m

∴ No. of units required $= \frac{222.5}{9 \times 5}$

= 5

Keeping one unit as standby, provide a total of 6 units.

Disinfection

* Water coming from filter plants, contain bacteria and other micro-organisms
* It is necessary to disinfect water to kill bacteria and other micro-organisms.
* Disinfection follows filtration.

Suitability of disinfectant

1) should be effective in killing micro-organisms.
2) Readily available at reasonable cost
3) Safe to handle.
4) should not render water toxic.

Methods of disinfection

1) Boiling method

Boiling of water kills all bacteria and micro-organisms.

Not possible for public water supplies

2) Excess lime treatment

P_H of water > 9.5, E-coli will die

* Lime is added to bring P_H ~~to the~~ >9.5

* 100% or 99.93% bacteria will be removed.

* Dose of lime 10 to 20ppm of CaO.

* Excess lime removed by recarbonation.

3) Silver treatment

* Water can also be disinfected with Silver by electro-catadynic action.

* Contact time varies from 10 to 60 minutes

4) Ultra-violet Ray Treatment

* Effective method for Sterilization of water.

* Sun is the powerful source of UV rays

5) potassium permanganate Treatment

* Used in rural areas, as water supply is from wells which has less bacteria

* 1 to 2mg/l $KMnO_4$ is added

* Well water should not be used for first 48 hours of addition of $KMnO_4$.

6) Chlorination

* Chlorine is universally used for disinfecting public water supplies.

* It is cheap, reliable, easy to handle, easily measurable, residual disinfecting effects for long periods, thus giving complete protection against future recontamination of water in the distribution system.

When chlorine is added to water, it forms hypochlorous acid or hypochlorite ions, which have an immediate and disastrous effect on microscopic organisms.

$$Cl_2 + H_2O \xrightarrow{P_H > 5} HOCl + HCl$$

Hypochlorous acid

The hypochlorous acid is unstable and may break into hydrogen ions and hypochlorite ions.

$$HOCl \underset{P_H < 7}{\overset{P_H > 8}{\rightleftharpoons}} H^+ + OCl^-$$

Hydrogen ions   Hypochlorite ions

Hypochlorous acid is the most destructive, 80 times more effective than hypochlorite ions.

Amount of chlorine required for water depends upon the inorganic and organic impurities present in it.

Optimum dose of chlorine for a ~~the~~ given water is determined by adding varying amounts of chlorine to a given sample & observing residual left after a contact period of about 10 minutes.

Chlorine dose should be increased during rainy season & epidemics.

Forms of application of Chlorine

1) As bleaching powder or hypochlorite
2) As chloramines
3) As free Chlorine gas
4) As chlorine dioxide

Bleaching powder (calcium hypochlorite or $Ca(OCl)_2$)

& contains 33 1/3 % of available chlorine when freshly made.

* Bleaching powder is not stable & it loses its strength during storage or exposure of air.

* used only on small installations or under emergency conditions.

2) Chloramines

* Chloramines are compounds of ammonia and chlorine

* In this treatment, ammonia as NH_3 is added to the water just before the chlorine is applied.

3) Free chlorine

* Generally applied in gaseous form or in liquid form

* chlorine gas is greenish-yellow poisonous substance, 2.48 times heavier than air.

* liquid chlorine is amber coloured oily liquid & about 1.44 times as heavy as water.

* chlorine gas is respiratory irritant.

4) Chlorine Dioxide

* Bactericidal properties of chlorine dioxide is greater than chlorine.

* chlorine dioxide gas is unstable

* used in oxidation of iron, manganese, ... algae.

1) Calculate the quantity of bleaching powder required per day for disinfecting 4 million litres/day. The dose of chlorine has to be 0.5 p.p.m and the bleaching powder contains 30% of available chlorine.

Chlorine required @ 0.5 p.p.m

$$= \frac{0.5 \times 4 \times 10^6}{10^6} = 2 \text{ kg.}$$

Since the bleaching powder contains 30% of chlorine, amount of bleaching powder

$$= \frac{2 \times 100}{30} = 6.67 \text{ kg.}$$

Forms of Chlorination

1) plain chlorination
2) pre-chlorination
3) post-chlorination
4) Double or multiple chlorination
5) Break point chlorination
6) super chlorination
7) Dechlorination.

1) Plain chlorination

* It is the application of chlorine to raw water supply

* Applied to clean water with turbidities less than 20 to 30 P.P.M

* Normal dose is between 0.5 to 1 PPM

2) Pre-Chlorination

* Application of chlorine to water before its treatment (before filtration)

* Dose of chlorine should be adjusted that water has a residual of 0.1 to 0.5 p.p.m when it enters the filter plant

* For satisfactory disinfection, prechlorination is done so as to maintain 0.3 to 0.4 mg/l free available chlorine throughout the treatment

3) post-chlorination

* Application of chlorine to water after its treatment

* Dose of chlorine should be so adjusted that the residual chlorine is about 0.1 to 0.2 PPM

4) Double or multiple Chlorination

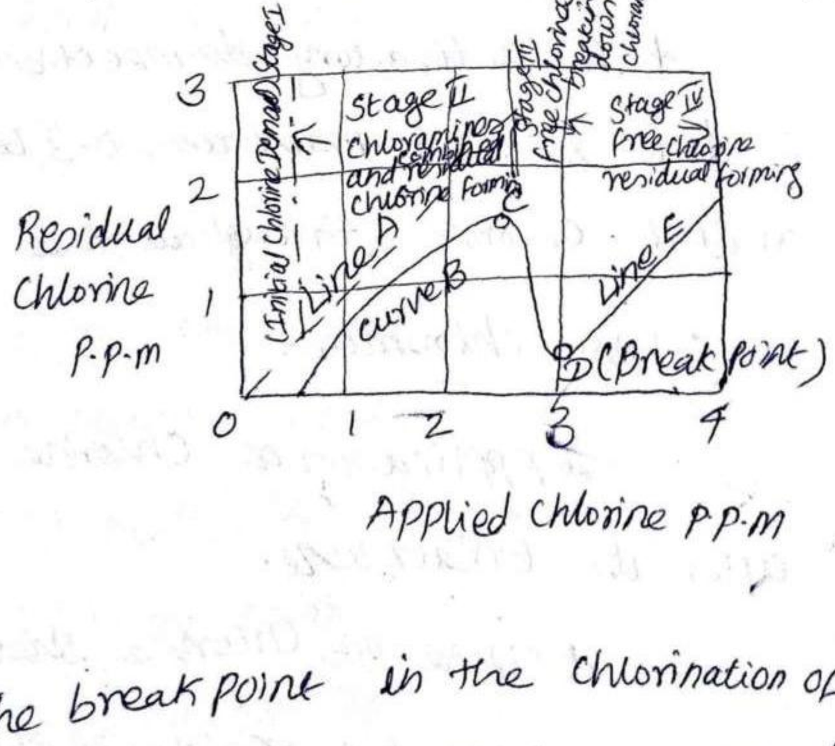
* Double or multiple chlorination refers to the application of chlorine at two or more points in the purification process

5) Break point Chlorination

When chlorine is applied to water, two actions take place one after the other:

i) It kills bacteria and disinfection is effected.

ii) It oxidizes the Organic matter.



The break point in the chlorination of water is the point on applied residual chlorine curve at which all residual chlorine is free chlorine.

Application of Chlorine at or higher than break point concentration will have the advantages

1) It will remove taste & odour

2) It will have adequate chlorine residual

3) It will leave a desired chlorine residual

4) It will complete the oxidation of ammonia & other compounds

5) It will remove colour due to organic matter by about 30%

6) It will remove manganese.

* Break point can be determined by orthotolidine test.

* Break point lies between 3 to 7 PPM of Chlorine dose.

5) Super-Chlorination

* application of Chlorine Beyond break point

* To remove odour & taste

* Adopted when epidemic in the locality

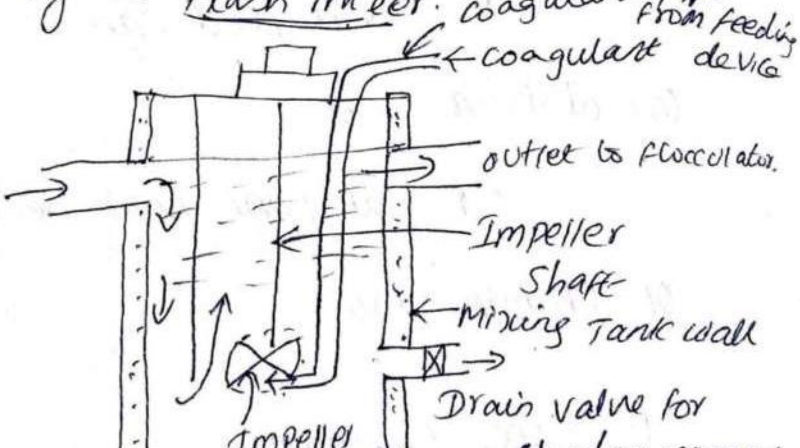
7) Dechlorination

* process of removing excess chlorine from water

* Done by either aeration or by use of chemicals such as sodium thio-sulphate, sodium bisulphate, sodium sulphite, activated carbon, potassium permanganate or sulphur dioxide.

Flash Mixers

*In sedimentation with coagulation, the chemical added to raw water is mixed by a flash mixer.



*It consists of a rectangular tank which is provided with an impeller fixed to an impeller shaft.

* The impeller is driven by an electric motor & it revolves at a high speed inside the tank

* The coagulant is brought by the coagulant pipe & is discharged under the rotating fan.

* Impeller speed is 100 to 120 r.p.m

* Detention period is $\frac{1}{2}$ to 2 minutes.

* Raw water is brought from inlet end and deflected towards the moving impeller by a deflecting wall.

Flocculation

* Flocculation is to force agitation in the fluid and induce coagulation.

* Flocculation is a slow mixing or agitating process in which destabilised colloidal particles are brought into intimate contact to promote their agglomeration.

* It is <u>hydrodynamic</u> process which forms large settleable flocs

* Slow mixing is acheived by flocculator

* Rate of flocculation depends on type & concentration of turbidity, type of coagulant & its dose

CLARIFICATION

* After flocculation, water enters the settling tank, called clarifier

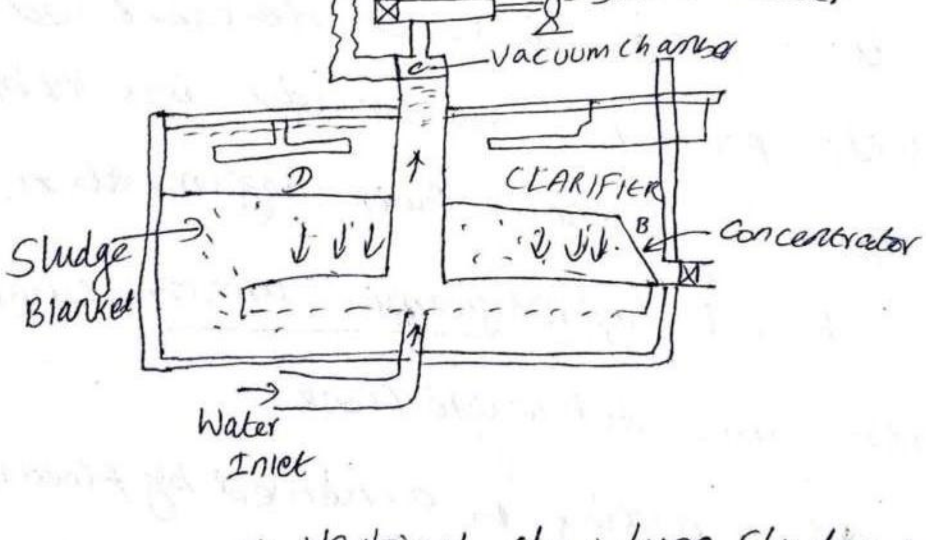
* Water stay for some period to allow settlement of floc at the bottom.

* Detention period is 2½ to 3 hours

* Sludge is scraped by mechanical means.

* Nowadays, flocculator & clarifier are provided in one single unit called clariflocculator.

Pulsator Clarifier



*. Vertical flow type sludge tank is pulsator clarifier

* Pulse is generated at interval of 30 seconds to give rapid flow for 5 to

10 seconds

* Water enters through the inlet at the bottom of the sludge blanket.

*. Air valve A is closed & water rises in vacuum chamber C. At this stage water in the Clarifier D is at rest and the sludge settles.

*. In next half cycle, water in the vacuum chamber C rises upto upper contact and Air valve A is opened. Due to this, water in C falls rapidly & enters the clarifier, raising the sludge which enters concentrator B.

* When water falls to the lower contact in C, air valve A is again closed.

~~Tubbt~~

Tube Settler

* It is a new innovation in the sedimentation process.

* Reduce the detention period to only a few minutes.

*. These settlers use tubes of 25 to 50mm diameter, having large wetted perimeter, providing laminar flow conditions

for sedimentation.

* Two tube settlers are in use

i) Horizontal tube settler

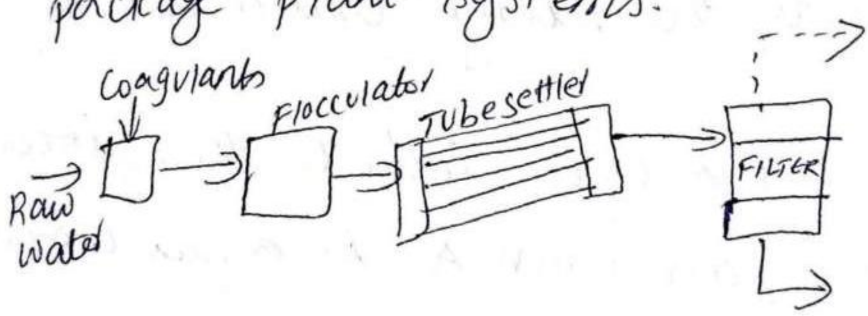
ii) steeply inclined tube settler

Horizontal tube settler

* Tubes are inclined at 5° in the direction of normal flow

* Sludge is drained by filter backwash.

* used in small plants and in package plant systems.



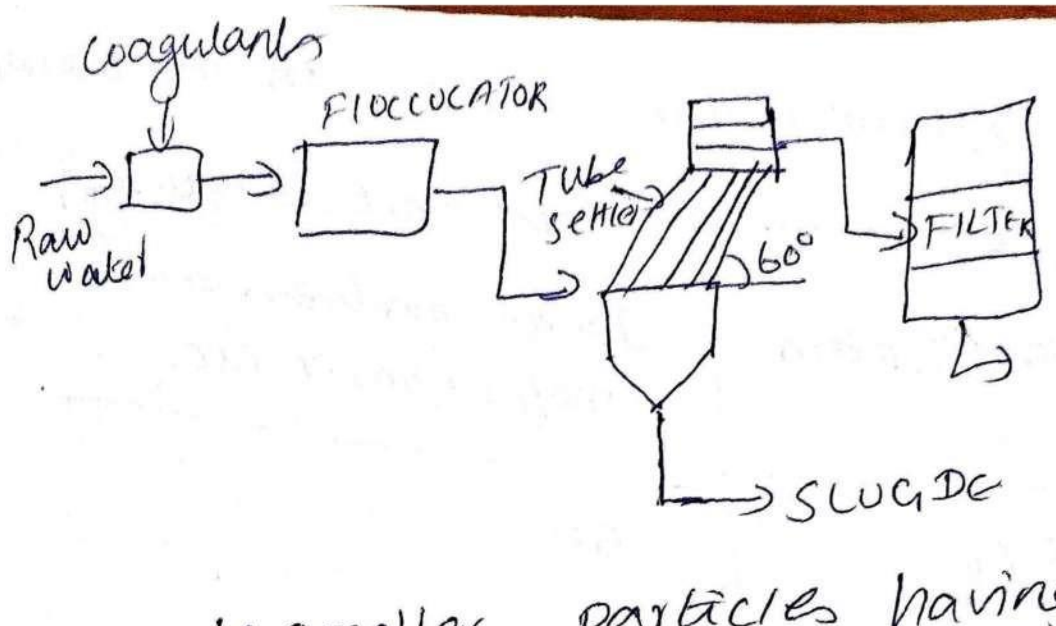
steeply inclined tube settler

* Tubes are square 50 x 50mm

* Made of plastic baffles

* Inclined at 60° to the horizontal

* Solids settle at tube bottom



* smaller particles having falling speed $< \frac{Q}{A}$ can be removed by tube settlers.

Water Softening

Water is 'hard' if it Contains large amounts of bicarbonates, carbonates, sulphates and chlorides of calcium and magnesium.

Hardness causes

1) More Consumption of soap

2) Affect working of dyeing system

3) Cause difficulty in paper making, canning, ice manufacturing, rayon industry etc.

4) Chokes house plumbing

5) Formation of scales on

6) It makes food tasteless, to urge

Classification	Total hardness as mg/l (ppm) of $CaCO_3$
1) Soft	50
2) Moderately hard	50 – 150
3) Hard	150 – 300
4) very hard	300.

Hardness is of two types is

i) Temporary Hardness

ii) permanent Hardness

Temporary hardness is also called carbonate (or) bicarbonate hardness

↓

Deposited when water is boiled or adding lime.

Permanent hardness is also called non-carbonate hardness

↓

Due to presence of sulphates, chlorides and nitrates of calcium and magnesium

Removed by lime soda process, zeolite process, Demineralization or deionization process.

Lime Soda process

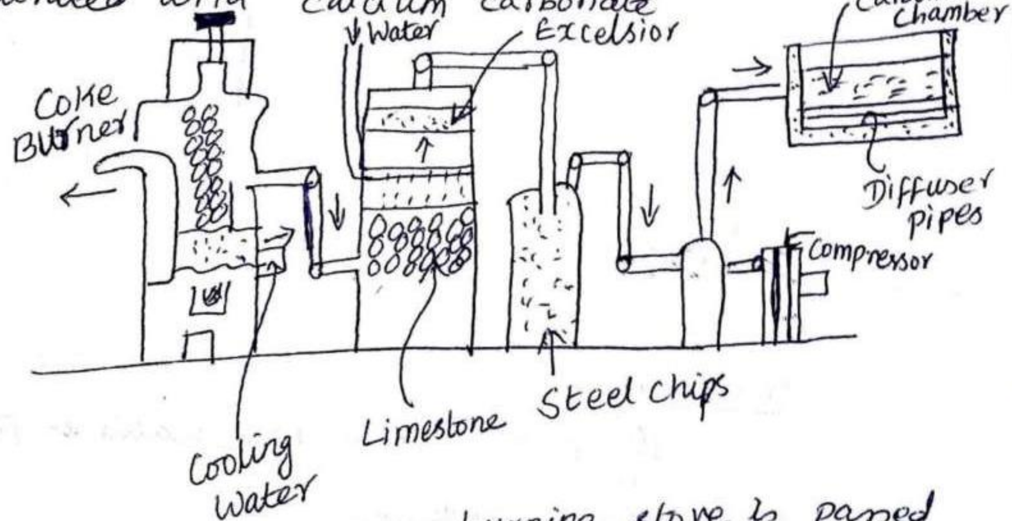
* Lime and soda are added to the raw water
* This process involves thorough mixing of the chemicals with water, followed by slow agitation for 30 to 60 minutes
* Precipitated chemicals are removed by sedimentation or filtration
* Lime used may be hydrated lime or quick lime

Lime-Soda softening plant includes

1) Feeding and mixing devices
2) Settling basin

   Detention periods is 2 to 4 hours
3) Recarbonation or stabilization plant

   The effluent from settling basin is super-saturated with calcium carbonate



* CO_2 produced in coke burning stove is passed through a chamber containing limestone over which water trickle
* The gas then passes through excelsior or moisture trap for its partial drying
* It is then passed through a dryer containing steel turnings, to remove remaining water and active oxygen
* It is then diffused at the bottom of carbonation chamber, with the help of a compressor
* Reaction time is recarbonation basin is 20 minutes

4) Filters

Recarbonated water is passed through rapid filtration.

Zeolite process (Base exchange or Ion Exchange process)

* Hard water is passed through zeolite
* zeolite removes calcium & magnesium from water and add sodium in their place
* zeolite is green in colour
* Artificial zeolite is permutit.

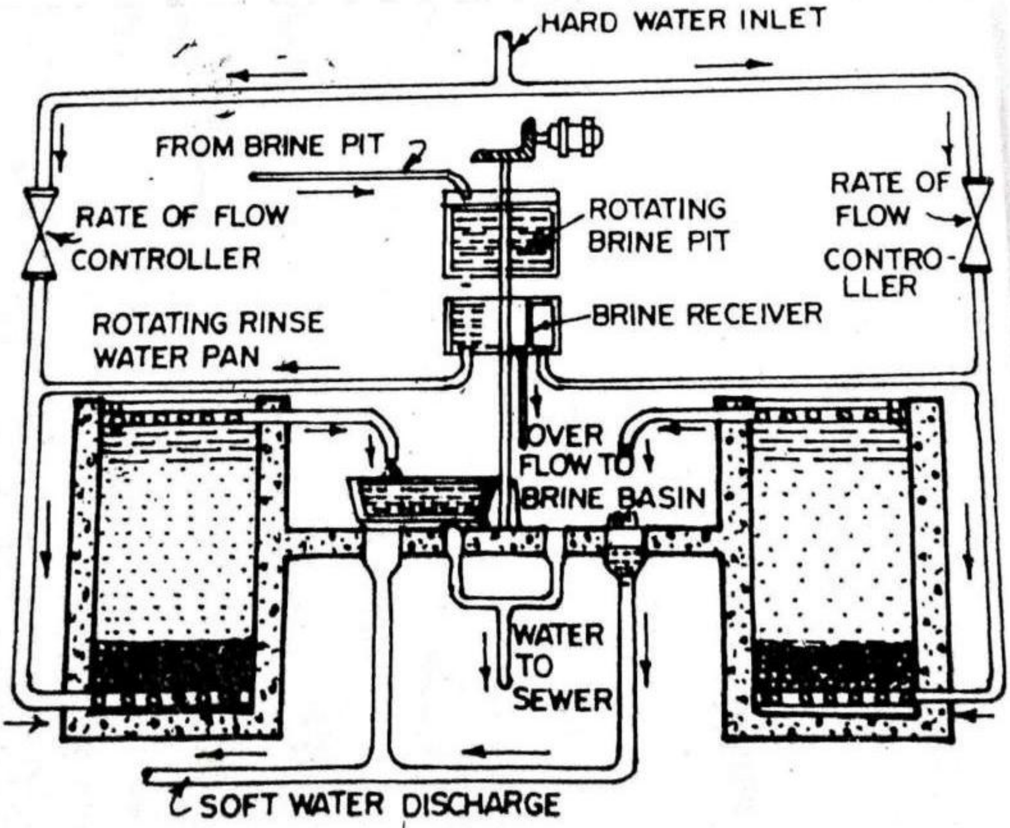


FIG. 12.3. AUTOMATIC GRAVITY ZEOLITE SOFTENER

Demineralisation or Deionisation process

* zeolites exchange the sodium cations for the cations of calcium, magnesium and iron in the water.

* In demineralisation or deionization process another zeolite is used which exchanges all the cations for hydrogen.

* These zeolites are available under the names zeo-karbs, catex & organolite are called carbonaceous zeolites since they are made from coal and lignite. such a zeolite is also called a hydrogen exchanger.

* Such zeolites are regenerated by the use of sulphuric acid or hydrochloric acid.

* The acidity in the water treated by hydrogen zeolite is un-desirable.

* It is removed by i) Diluting treated water with raw water ii) neutralizing treated water with alkaline substance iii) absorbing with De-acidite

* The effluent ~~from~~ produces only water & CO_2.

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* It is found useful for manufacturing soft drinks and in industrial process where water free from mineral salts is required.

* The water to be treated should have a turbidity of less than 5 to 10 p.p.m.

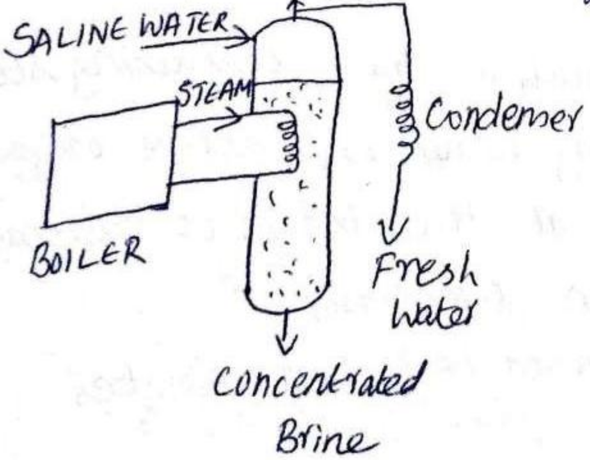
Desalination

Only 0-5% of earth's water is potable

Desalination methods

1) Distillation
2) Reverse osmosis
3) Electrodialysis
4) Freezing
5) Solar evaporation

1) Distillation Method



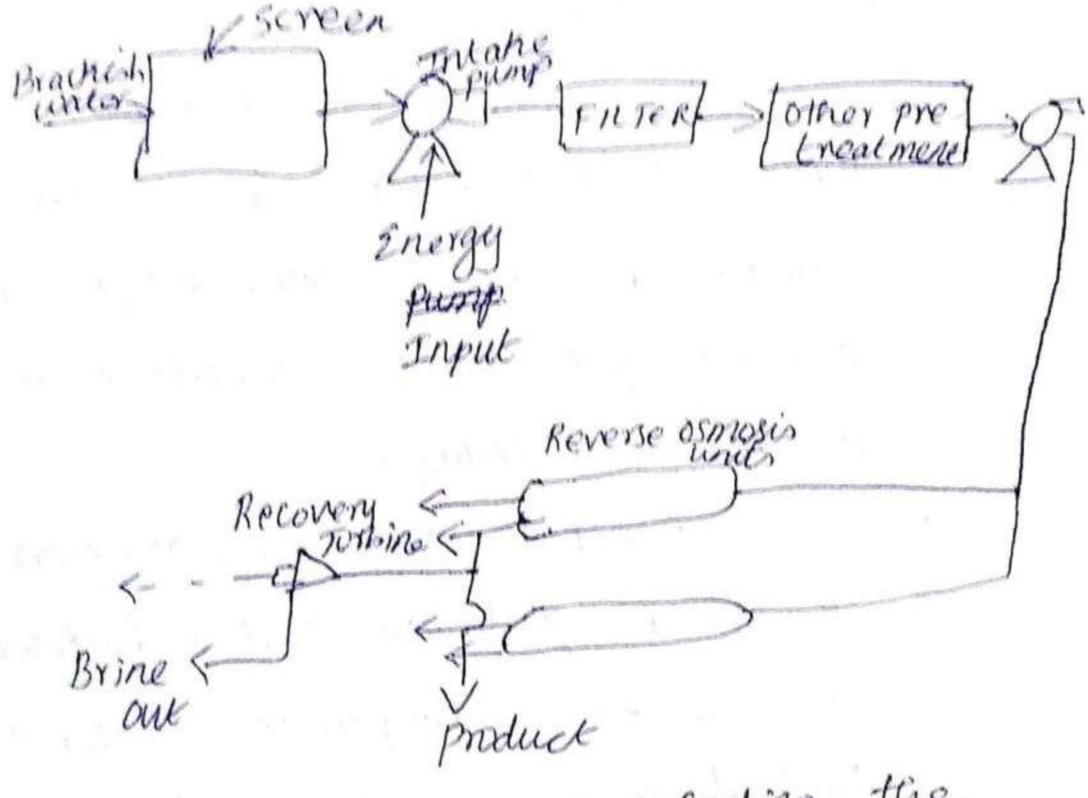
* Most commonly used method of converting saline water to potable water
* Saline water is boiled or evaporated to produce vapours of pure water
* Vapours are condensed to potable water
* Principal factor is conservation of energy.

ii) Reverse osmosis Method

* Suitable for brackish water than sea water

* Brackish water is forced across a permeable membrane by mechanical forces

* The pressure applied must be greater than osmotic pressure



* India is also now feeling the necessity of desalinating its sea water especially in coastal cities like Chennai.

* Cost of desalination is high

* Desalted water is 100 times costlier than the treated surface water supplies.

Desalination

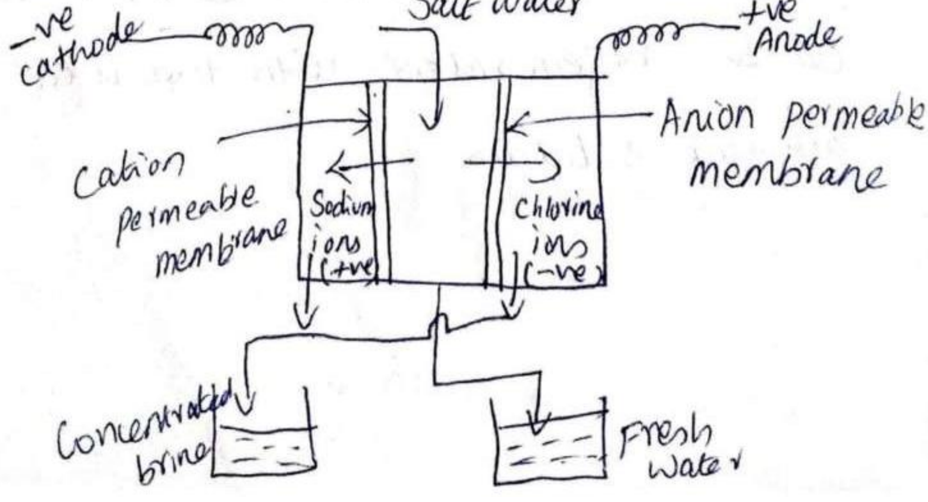
3) Electro dialysis method

* If an electric-current is passed through the salt-solution, the sodium and chlorine ions get freed from water molecules and they start moving towards their oppositely charged electric poles.

* +ve charge sodium ions will move towards -ve pole (cathode) & -ve charged chlorine ions will move towards +ve pole (anode)

* The separation of ions is got by means of thin plastic like sheets called 'membranes'.

* Membranes are made up of 'ion exchange resins' and they are very very thin ($\frac{1}{180}$th of a cm)



4) Freezing process :-

* When salt water freezes, the ice formed is free from salt.

* This ice when melted give us good water.

* Cost of production is high
* Quality of water obtained is satisfaction

5) Solar distillation method

* Solar heat is a free heat.

* Everyday the sun vaporises billions of tonnes of sea water and lifts the vapour into clouds.

* If this vapour can be caught and distilled to form pure water, we get cheaper water

Iron and Manganese Removal

* Iron and manganese present in water supplies either in suspension as hydrated oxides or in solution as bicarbonates.

* Water has iron dissolved in it as the result of CO_2 coming in contact with iron ore to form soluble ferrous bicarbonate.

* Iron in natural waters may be in ferric or ferrous condition, soluble, colloidal or insoluble

* When manganese is also with iron, removal is more difficult

* Iron & manganese if it is greater than 0.3 p.p.m, the following effects may be noted
i) unpleasant taste & odour ii) cause staining of plumbing fixtures, clothing & textiles iii) accumulation of precipitated iron in water mains iv) cause troubles in various manufacturing processes.

* Iron cause reddish tinge in water and manganese cause brownish tinge in water

* If Iron & manganese present in water without organic matter, they can be removed by aeration, coagulation, sedimentation & filtration,

* By aeration, iron is oxidized to ferric oxide which is insoluble in water.

* Dissolved manganese compounds are converted to insoluble manganese compounds

* precipitated floc can be settled down in settling tanks

* The bond between iron and manganese is broken by adding lime.

* The aerated water is allowed to trickle over contact beds of coke, gravel

* It is then sedimented & filtered

* When water does not contain large amounts of iron and manganese,

 these can be removed by means of a manganese zeolite.

* oxidation of iron compounds may be obtained by chlorination followed by sedimentation & filtration

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Defluoridation

* Fluoride concentration of 0.7 to 1.2 ppm in water is beneficial for the prevention of dental caries in children.

* Higher levels of fluoride (>3 p.p.m) is responsible for mottling (black to brown stains) in teeth, or dental fluorosis.

* It is essential to maintain fluoride content of 1 to 1.2 p.p.m in water. The process of raising the fluoride content of water is known as fluoridation.

* When fluoride concentration is more than 1 to 1.5 p.p.m it should be removed from water.

* The process of reducing the fluoride concentration of water is known as defluoridation

Methods of defluoridation

1) Calcium Phosphates

* Bone can be used in the filter to remove fluorides.

* Bone is calcinated at 400°c to 600°c for 10 minutes followed by mineral acid treatment

* It is then pulverised to pass 40 to 60 mesh and is used in the filter bed.

* The filter is regenerated with alkali and acid.

* One cubic metre of bone can treat 1 million litres of water containing 3.5 p.p.m of fluoride

2) Bone Charcoal

* It is tri-calcium phosphate and carbon used for the removal of fluorides

3) Synthetic tri-calcium phosphate

* It can be prepared ~~by~~ from milk of lime and Phosphoric acid

* This material has been used in contact filters for removal of fluorides.

* Regeneration can be done by 1% caustic soda followed by dilute HCl or CO_2

4) Fluorex

* Fluorex is a mixture of tri-calcium Phosphate and hydroxyapatite.

* It is used as filter medium

* can be regenerated by washing with 1.5% of caustic soda.

* It can be next mixed with twice its volume of water.

5) Ion-exchanger

* Fluorides in water can be removed by successive passage through beds of cation-exchanger of the sulphonate coal type and an anion resin "Nalcite B".

* Alum treated cation exchange resin from avaram bark can be used as an effective material for removing fluorides from water

6) Lime

* Lime can be used to reduce fluoride in water.

* The water must be treated to a caustic alkalinity of 30 p.p.m and a PH value of 10.5

* The process is suitable for hard waters containing less than 4 p.p.m of fluorides.

7) Aluminium compounds

*. Filter alum is having high absorption capacity & it can be improved by activated silica & clays.

*. Fluorides are removed by formation of an aluminium fluoride complex or by absorption on the floc.

*Dehydrated aluminium oxide (calcined alumina) can be used in contact beds for removal of fluorides

8) Activated carbon

* Activated carbon can be used to remove fluoride at pH 3.

* No removal takes place at pH 8 or above.

* The carbon when used as a contact bed can be regenerated with the weak acid and alkaline solution