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POLLACHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

(Approved by **AICTE** and Affiliated to **Anna University**)

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Department of Civil Engineering

Regulation 2021

II Year – III Semester

CE3303 Water Supply and Waste Water Engineering

UNIT-I

WATER SUPPLY

*) PUBLIC WATER SUPPLY SYSTEM:

* This is used for drinking, cooking, bathing, washing and ~~cooking~~ etc... Average demand of water is 1% is 135 lit/head/day.

PLANNING:

*For planning, search the source of H_2O in the town (or) city.

* S/m of scheme should be selected.

* Evaluate all sources in terms of quantity, quality and cost.

* Then suitable s/m should be designed for collecting transporting and treatment of H_2O.

* The treated H_2O should be finally

distributed to industry residence through a n/w of distribution s/m.

* The essential element for the public H_2O supply scheme is H_2O Treatment plant having screening, sedimentation, filtration, disinfection units etc....

* The value will control the flow of H_2O.

* Hydrance are provided for fire fighting purposes

a) Mains, Submains and branch lines will carry the H_2O to the stream services which carry the H_2O to the individual homes.

OBJECTIVES:-

1. To ensure the quality of Drinking H_2O.
2. To plan and build suitable water supply schemes.
3. Supplying water for domestic and

industrial purposes.

4. Helps in industrialisation and modernisation of the society.

5. Supply H_2O for foundations, gardens. and maintaining better sanitation and beautification of the surroundings

6. To ensure safe against fire.

7. Promoting wealth and welfare of entire humanity.

8. To supply safe and portable water to the consumer.

9. To supply in adequate quantity.

10. To make water easily available to the consumer so as to encourage personal and household cleanliness.

for design purpose, values of maxm dail consumptn and peak hourly demand are essential for adjusting the speed of the pump.

Values are ascertained as follows:

1. Avg. Daily Demand = $\frac{\text{Total yearly consumption in litres}}{365}$

2. Maxm Daily Consumption } = 180% of avg. daily demand

3. Peak Hourly demand = 150% of avg. "

*) WATER DEMAND:-

Amount of water required for domestic purposes, commercial and industrial uses including losses is to be calculated. This value is called as the demand.

Demand has the ability to control the design period of the pump.

Types of Demand:-

I) DOMESTIC DEMAND:

* Quantity of water reqd. in Hous es for Drinking,

* Quality of H_2O depends on social stat climates and customs of people.

* In India, Domestic Demand :

Drinking - 5 lit

Cooking - 35lit

Bathing - 55 lit

Washing (clothes, Utensils, House) - 40 lit

Totally, 135 lits/ day/ capita

II) COMMERCIAL DEMAND:

→ Water demand in commercial centres like office buildings, hotels, restaurents, cinema houses, etc.

* Demand is assumed to be 25 lits to 40 lits/ capita/day.

III) INDUSTRIAL DEMAND:

* Depends on the type of industry in the area. i.e, No. of mills(or) industries should be recorded.

* Water demand for this is assumed ~~to~~ as 20% to 25% of the total water demand of the city.

IV) DEMAND FOR PUBLIC USE:

* Includes the H_2O requirements for public places such as washing and sprinkling on roads, Watering of public gardens, parks etc..

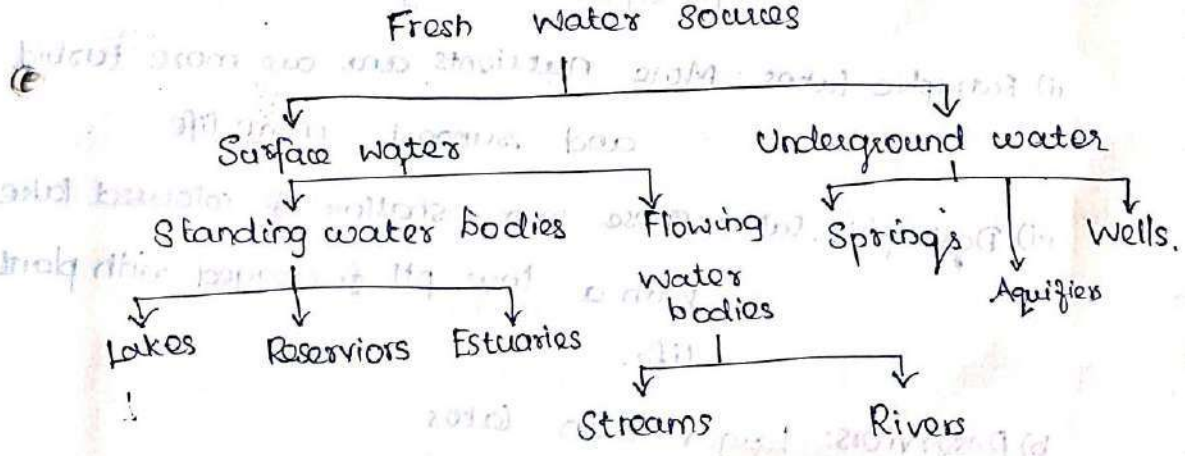
V) FIRE DEMAND:

Amount of H_2O required for fire fighting purposes is called fire demand. The quantity of H_2O reqd. for fighting process is calculated by following formulae.

a) Freeman's formula : $Q = 1136.50 \left[\frac{P}{5} + 10\right]$.

*) SOURCES OF WATER:

Water is an important component of all the living beings. Nearly 80% of earths surface is covered with H_2O. All Organisms are mostly made up of water.



A) Surface Water: The water, which is coming out directly through percipitation and does not percolate down into the ground or doesnot return to the atmosphere by evaporation is known as surface H_2O.

(or)

H_2O stored on the surface of earth.

1. Standing H_2O Bodies:

a) Lakes

i) Oligotropic lakes: These are generally deep, clear & deficient in nutrients without much biological activity.

ii) Eutrophic lakes: More nutrients are are more turbid and support more life

iii) Dystrophic lakes: These are shallow & colocured lake with a low pH & clogged with plant life.

b) Reservions: Larger than lakes

c) Estauries: Deltas formed at the mouth of rivers, where they join the ocean. ie, Mixing

of flesh and saltwater gives estauries.

2. Flowing Water Bodies:

The water, which originate from the point of percipitation and flows in streams and rivers are called flowing water bodies. The flowing water carries sedimentary materials and dissolved materials

B) Underground water:

The water, which is found available deep in the ground due to percolation of surface H_2O is called underground H_2O. It is pure and used for all purpose in the world.

1. Aquifiers:

A layer of highly permeable rock containing H_2O is called an aquifier

(Ex)

* Layers of sand and gravel are good aquifiers (having good permeability)

* Clays and crystalline rocks are not good aquifiers (have poor permeability)

2. Springs

* When underground H_2O reappears at the ground surface by percolation or by underground pressure, then it is known as spring.

* Ground H_2O is brought to the surface by spring. A previous layer sandwiched b/w two imperious layer gives rise to a natural spring.

* Certain springs sometime discharge hot H_2O due to the presence of sulphur in them.

* Hot spring usually emit sulphur mixed H_2O. Hence cannot be used for H_2O supply

Types of spring:

i) Gravity

ii) Surface

iii) Artesian.

3. Wells:

A water well is a hole usually vertical excavated in the earth for drinking ground H_2O to the surface.

Two types of wells are

i) Open wells (or) Dug wells → open well masonry well
→ Bigger diameter storing $18\ m^3/hr$.

ii) Tube wells
↳ consists of G.I pipe
→ Diameter varying from 3.75 cm to 15 cm and Length varying from 7m to 8m.
→ It is a long pipe (or) a tube bored (or) drilled deep into the ground.

CHARACTERISTICS OF WATER:
According to WHO and ICMR (Indian Council for Medical Research)

* It should be clear, colourless and odourless.
* It should be cool & pleasent to taste.
* It should be free from harmful bacteria and suspended impurities.
* It should be free from dissolved gases like CO_2, H_2S, NH_3, ... poisonous materials like lead, arsenic, manganese etc..
* Hardness should be less than 500 ppm.
* Total Dissolved Solids contents also "
* pH value of potable H_2O should be 6.5 - 8.5

*) ~~CHA~~ WATER QUALITY STANDARDS :-

Parameter characteristics	Limits
1. Physical	
i) colour	10-20 (platinum cobalt scale).
ii) Turbidity	5-10 ppm (silica scale)
iii) Taste ~~odour~~	No objectionable taste
iv) Temperature	10°C to 15.6°C
v) odour	0-4 P_0 value
2. Chemical	
Total solids	upto 500 ppm
Hardness	75 ppm - 115 ppm
Chlorides	upto 250 ppm

Iron and Manganese	upto 0.3 ppm
pH value	6.5 to 8
Lead	0.1 ppm
Arsenic	0.05 ppm
B.O.D	Nil
Copper	Less than 3 ppm
Fluorine	Less than 1.5 ppm
Chlorine	0.1 to 0.2 ppm
Dissolved Oxygen	5 to 6 ppm
Nitrites	Nil.

4. Biological Characteristics:-

B. Coli – No B. coli in 100 ml.

Most probable number (M.P.N) = One no. in 100 ml

Radio activity.

i) α-emitters – 10^{-8} microcurie/ml.

ii) β-emitters – 10^{-7} microcurie/ml.

INTAKE STRUCTURES :-

The basic function of the intake structure is to help in safely withdrawing H_2O from the source over a predetermined range of pool levels and then to discharge this H_2O into the withdrawl conduit normally called as intake conduit.

An intake structure constructed at the entrance of the conduit and thereby helping in protecting the conduit from being damaged (or) clogged by ice, trash, debris etc...

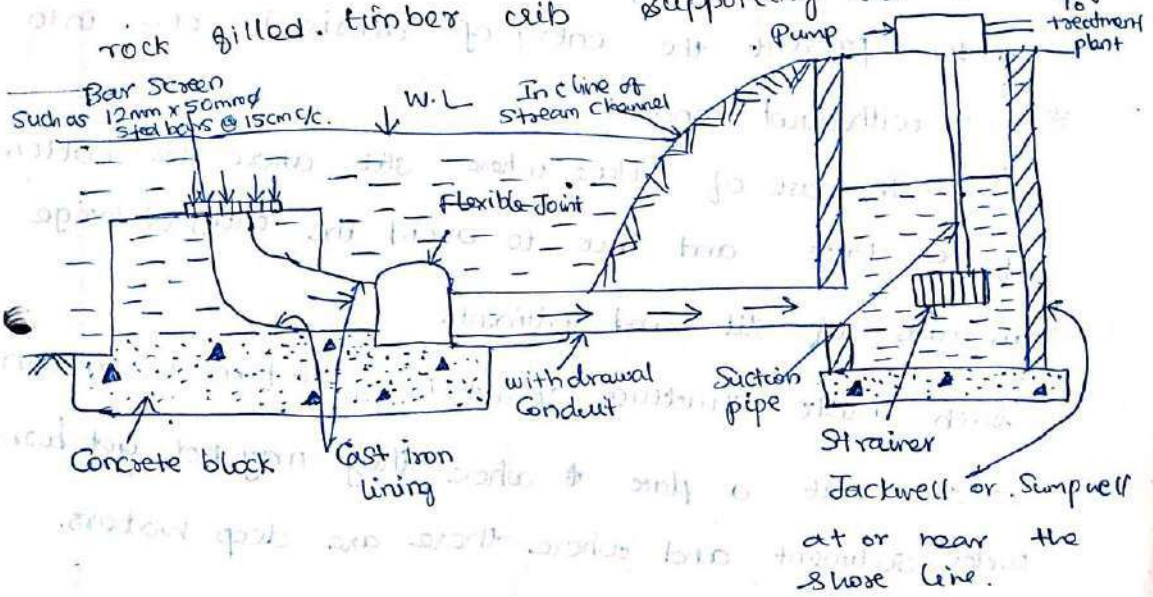
Intake must however be located at the downstream (or) in the vicinity of the point of disposal.

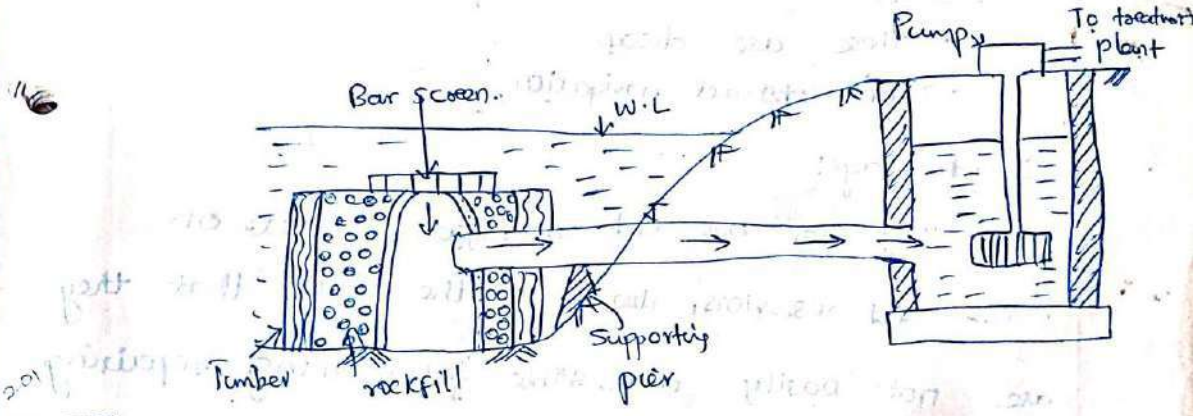
*) FUNCTIONS AND DRAWINGS :-

Types of Intakes :-

1. Simple submerged intakes:

→ consists of a simple concrete block or a rock filled timber crib supporting the starting





and of the withdrawal pipe as shown in fig.

→ The withdrawal pipe is taken up to the sump

well at shore, from where, the H_2O is lifted by pumps.

→ Intake opening is generally covered by screen so as to prevent the entry of debris, ice, etc.. into the withdrawal conduit.

→ In case of lakes, where slit above the bottom of the lake and thus to avoid the entry of large amounts of slit and sediment.

Such intake structures should be placed in streams (or) in lakes at a place where they may not get buried under sediment and where there are deep waters.

Advantages:

→ These are cheap

→ Don't obstruct navigation.

Disadvantage:

They are not used on bigger projects on rivers and reservoirs, due to the fact that they are not easily accessible for cleaning, repairing etc...

Pumping and gravity schemes.

* The raw H_2O after being collected is conveyed to the city by means of conduits.

* When source of supply is near to the city, length of conduits reqd. to carry water from intake to treatment plant is less.

* When source of supply is far away from city, length will be more and it also requires more economy.

Types of conduits:-

1. Gravity conduit
2. Pressure conduit

Gravity conduit:

* H_2O flows under action of gravity.
* Hydraulic gradient line (H.G.L) will coincide with the water surface & ll^el to the bed of the conduit as shown in fig.

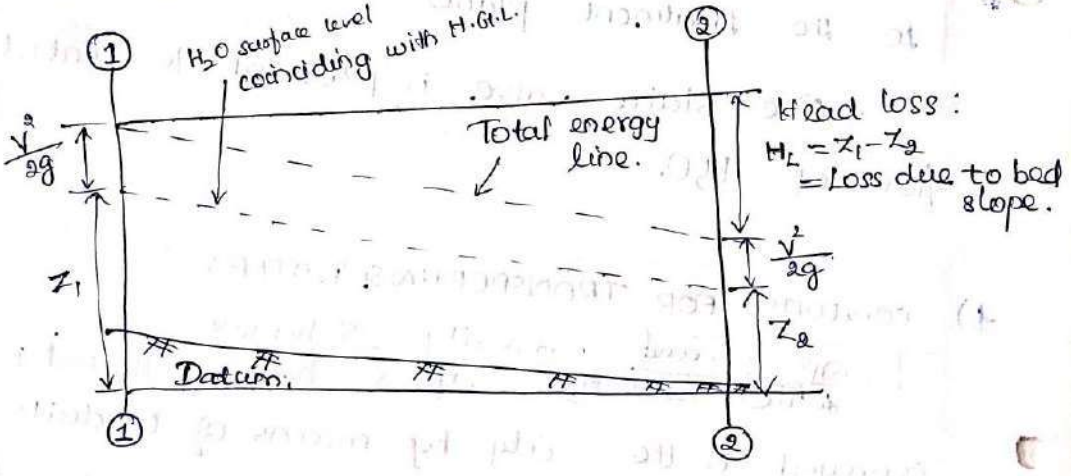


fig: Flow illustration in a gravity conduit

* They may be carried along zig-zag paths like roads, highways etc... Thus requiring enormous length of conduit and increased cost.
* Gravity conduit can be in form of canals, flumes or aqueducts

Canals:-

* Open canals constructed by cutting high grounds and constructing banks on low grounds.

* Cheap to build in suitable soils.

Flumes:-

* Open channels supported above the ground over trestles, etc... are called flumes.

* Used to convey water across valleys and minor depressions

* Made of masonry, R.C.C, metal or wood.

* usually circular (or) rectangular in cross section.

Aqueducts:-

* Artificial channel for carrying water.

* They are closed rectangular (or) circular, or horse shoe section built of masonary or RCC.

2. Pressure conduits:-

* are closed conduits, so no air can enter into them. Water flows under pressure about atmospheric pressure

* H.G.L. line for such a gradient line for such a conduit can be obtained by joining the H_2O surface elevation in piezometer installed in conduit.

* Pressure pipes are economical than canal (or) flumes because they follow shorter roof routes.

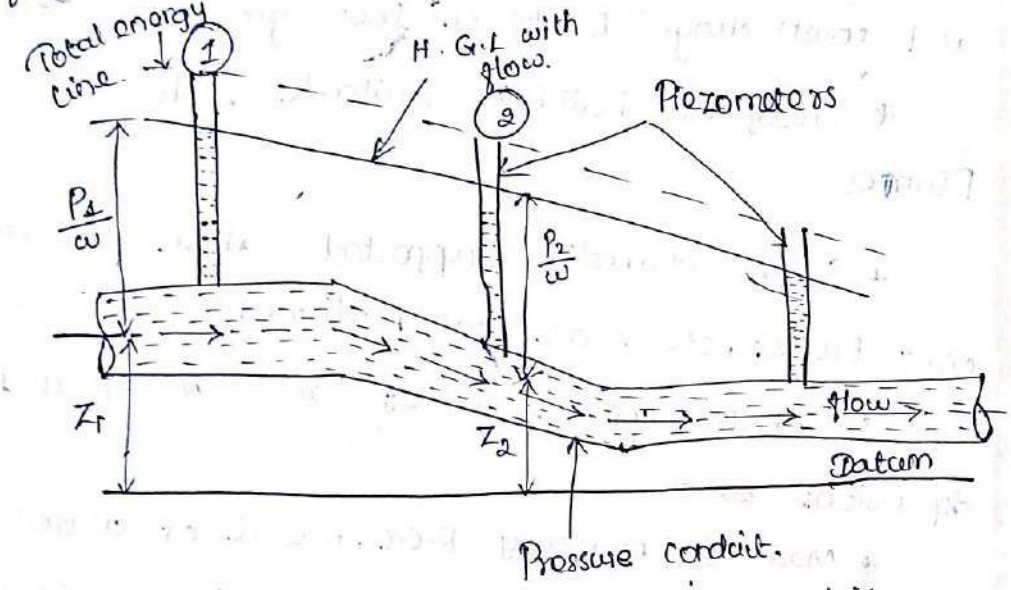


fig: Flow illustration in a pressure conduit.

* The biggest advantage is that the H_2O moving through such a conduit is not exposed any where and hence chances of getting polluted is reduced.

* Adopted for carrying sewage and drainage.

UNIT-II-WATER TREATMENT

WATER TREATMENT

OBJECTIVES:

→ To make the water free from impurities.

→ To make the water useful for domestic purposes

→ To make the water to be cool and pleasant to taste

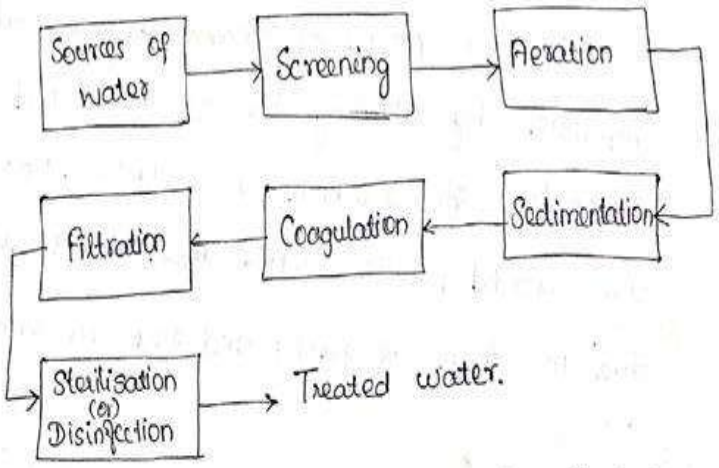
→ To decrease the hardness of water

→ To make the water's pH value b/w 6.5-8.5

→ To make it possible to use.

*) UNITS, OPERATION AND PROCESSES:

Domestic supply of water involves the following stages in the purification processes.



1. Screening :-

→ 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 :-

↳ is a process of mixing H_2O with air, *

Purpose :-

* to remove gases like CO_2, H_2S and other volaite impurities causing bad taste and odour to H_2O.

* to remove ferrous and manganous salts as insoluble ferric and magnic salts.

3. Sedimentation :-

↳ is a process of removing suspended impurities by allowing the H_2O 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, $(Al_2(SO_4)_3)$ etc.., are added to water. When the $Al_2(SO_4)_3$ is added to H_2O, it gets hydrolysed to form a gelatinous percipitate of $Al(OH)_3$. The gelatinous percipitate of $Al(OH)_3$ entraps the finely divided and colloidal impurities, settles to the bottom and can be removed easily.

$$Al_2(SO_4)_3 + 6H_2O \longrightarrow 2\,Al(OH)_3 \downarrow + 3H_2SO_4.$$

5. Filtration:-

→ process of removing bacteria, colour, taste and odour etc... by passing the H_2O through filter beds containing fine sand, coarse sand,

and gravel.

6. Sterilisation (or) Disinfection:

→ process of destroying the harmful bacteria The chemicals used for this purpose are called disinfectants.

Methods of sterilisation:

a) By Boiling

b) By ozonation

c) By using ultraviolet radiations.

d) By chlorination.

Flocculators :-

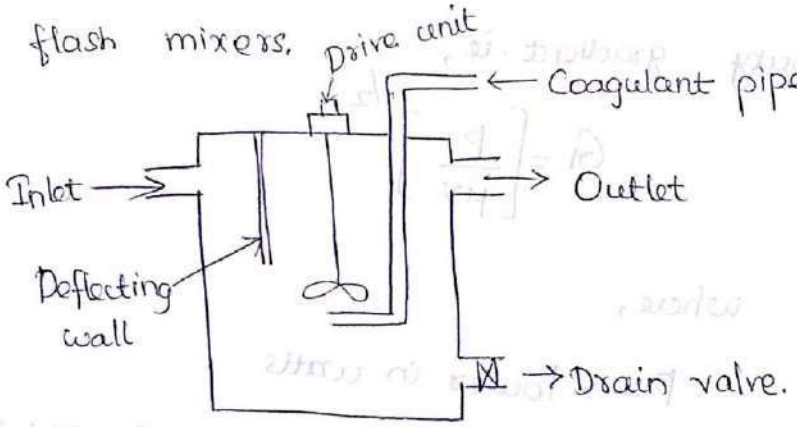
Flocculation is the controlled motion or agitation of water which will assist in the formation of settleable floc. Finer particles must be chemically coagulated to produce larger floc that is removable in subsequent settling and filtration process.

Jar tests are widely used to determine optimum chemical dosages for treatment. This laboratory test attempts to simulate the full scale coagulation-flocculation process and can be conducted for a wide range of conditions. The interpretation of test results involves visual and chemical testing of the clarified waters.

Flocculation can be achieved by various methods which include: Gravitational or hydraulic methods ; mechanical methods & pneumatic methods.

Principles, functions design and drawing of Flash mixers:-

The mechanical means used for mixing coagulants with raw water is known as flash mixers.



Design requirements:

1. Inlet
2. Deflecting wall
3. Paddle
4. Coagulants pipe
5. Outlet

The mixing is achieved by rotating the paddle situated at the end of the

vertical shaft. The speed ranges between 100 to 120 rpm. The detention period is ½ to 2 minutes.

Power input is mixing and flocculation is expressed in terms of temporal mean velocity gradient. ie,

$$G = \left[\frac{P}{\mu V}\right]^{1/2}$$

where,

P → Power in watts

μ → Dynamic viscosity of raw water.

V → Volume of raw H_2O to which 'p' is applied.

G → unitless, It ranges between 30,000 to 60,000.

3*) DISINFECTION :-

The filtered H_2O obtained after filtration process may normally contain some harmful disease causing bacteria in it. These bacteria must be killed inorder to make the water safe for drinking. The chemicals used for killing these bacteria are known as disinfectants and the process is known as disinfection (or) Sterilisation.

Disinfection not only removes the existing bacteria from the water at treatment plant, but also ensures their immediate killing even afterwards, in the distribution system.

Methods of Disinfection :-

1. Boiling of water

The water can be boiled for 15 to 20 minutes. Thus, the disease causing bacterias are killed & the H_2O becomes safe for use. But this process kills only the existing bacteria & never gives protection for future contamination.

This method is costly and it is not suitable for large scale purifying.

2. Treatment with uv rays

* Turbidity and colour of water should be removed first. The H_2O is allowed to pass through the bulbs producing uv rays. These rays penetrate in H_2O and kill the bacteria. This is very costly.

3. Treatment with Iodine & Bromine.

This kills the pathogenic bacteria. Quantity of Iodine & Bromine should not exceed 8 ppm and they can kill bacteria in min^{n} contact period of 5 minutes.

* These are available in ~~terms of pills~~ (or) the form of tablets (pills).
* These pills are added to H_2O & they kills the pathogenic ~~bacteria~~ bacteria.
* It is costlier. So, it is used for cleaning H_2O in an individual estate (or) industry.

4. Disinfection with ozone

Ozone is an excellent disinfectant. Ozone is produced by passing a high electric current through a stream of air in a closed chamber.

$$O_2 \xrightarrow[\text{Voltage}]{\text{High}} O_3.$$

This O_3 is unstable & once again split up into O_2 & nascent Oxygen.

ie, $O_3 \longrightarrow O_2 + O$ (Nascent Oxygen).

Nascent Oxygen is powerful disinfectant and kills the bacteria. This is used only if electricity is easily and cheaply available at water works.

5. Disinfectanion by Potassium Permanganate ($KmnO_4$)

$KmnO_4$ is a powerful oxidising agent. It oxidises the organic matters present in H_2O & hence the bacteria are killed. But this is not suitable in large scale for public H_2O supply schemes. This is mostly used for disinfecting

the H_2O of wells in village area, swimming pools, ponds etc... The dose of this chemical is about 2-3 ppm and the contact period is generally 2-3 hours.

6. Disinfection with silver

Silver is found very effective in killing bacteria. It's foils are spread over the filter, media and water is passed. H_2O absorbs some portion of silver which kills bacteria. As silver is costly, it is not suitable for public water supply schemes. It is suitable for domestic use only.

1. Metallic silver ions are introduced into the water by passing it through solid silver electrodes.

2. It kills bacteria. But the process is costlier.

* AERATION:-

Aeration is a process of mixing water with air. It is one of the major step involved in the water treatment. The following are the main purpose of aeration.

1. By using spray Nozzles
2. By permitting water to trickle over Cascades

* To remove gases like CO_2, H_2S and other volatile impurities causing bad taste and odour to water.

3. By air diffusion
4. By using trickling beds.
5. Treatment by activated Carbon.

* To remove ferrous and manganous salts as insoluble ferric and manganic salts.

*) REMOVAL OF IRON AND MANGANESE FROM WATER:-

Iron and Manganese salts are found dissolved together in well water or anaerobic reservoir waters, is invisible in dissolved state. When exposed to air, these reduced forms slowly

transform to insoluble visible oxidized ferric iron and manganic manganese. When their contents exceed about 0.3 mg/l, and 0.05 mg/l respectively, they become objectionable due to the following reasons:

1. They cause discolouration of clothes washed in such water due to deposition of red/brown coloured oxides of iron/manganese.

2. They cause incrustation of the water-mains due to deposition of ferric hydroxide and manganese oxide.

3. They make the water unpleasent in taste.

4. The reduced iron in water promotes the growth of autotrophic bacteria in the distribution mains.

* Periodic ~~fluctuat~~ flushing of small distribn pipes may be effective in removing accumulations of rust particles. However, elimination of iron bacteria is generally difficult and expensive.

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The iron and manganese may be present in water either in combination with organic matter or without such combination. When present without combination, they can be easily removed by aeration, followed by coagulation, sedimentation and filtration. During aeration, the soluble ferrous and manganous compounds present in the water may get oxidised into insoluble ferric and manganic compounds, which can be sedimented out easily.

On the other hand, when iron and manganese are present in combination, it becomes difficult to break the bond b/w them and to cause their removal. However, when once this bond is broken, they can be removed as above. This bond may be removed either by adding lime, and thereby increasing the pH value of water to about 8.5 to 9; or by adding chlorine or potassium permanganate.

Manganese zeolite, a natural green sand, coated with manganese dioxide, can also be used for removing soluble iron and manganese from solution. After the zeolite becomes saturated with metal ions, it can be regenerated by back washing with potassium permanganate.

*) DEFLUORIDATION:

Fluoride mainly enters the human body through drinking water. 96-99% of it combines with bones, since fluoride has affinity for calcium phosphate in the bones. Excess intake of fluoride can lead to dental fluorosis, skeletal fluorosis etc...

To remove fluoride from drinking water, we uses defluoridation technique. There are 4 types. Namely,

1. Adsorption by activated alumina
2. Ion exchange adsorption method
3. Nalgonda technique
4. Reverse Osmosis Process.

1. Adsorption by Activated Alumina (AA), commonly known as Prashanti Technology

Water is passed through the insoluble granular beds of substance like Activated Alumina or Bone char or activated carbon; which absorbs fluoride from the percolating water, giving out defluoridated water.

Activated Alumina is found to be an excellent medium for removal of excess fluoride. The adsorption process is best carried out under slightly acidic conditions (pH = 5-7); the Lower pH is more effective for its removal.

AA, after becoming saturated with adsorbed fluoride, can be cleaned and regenerated by backwashing with 1% caustic soda soln. (NaOH).

2. Ion exchange adsorption method:

This uses a strong base anion exchange resin (zeolite) in the chloride form. As water passes through the bed of the resin contained in a pressure vessel, fluorides and other anions like arsenic, nitrates, etc.., present in the water are

exchanged with the chloride ions of the resin, thus releasing chlorides into water and adsorbing fluoride ions into the resin. The arsenic and nitrate ions also get removed in the process.

The ~~ions~~ resins gets saturated with anions and be indicated by their ↑ed concentrations in water. The same can be cleaned and regenerated with 5-10% NaCl soln, and the bed is returned to service.

During regeneration, the exchange process gets reversed, as the anions absorbed on the resin get replaced by chloride ions and discharged to waste water with excess chloride ions.

The safe disposal of waste water from regeneration, containing high concentrations of toxic fluoride, nitrate and arsenic ions, etc. again poses serious problems.

3. Nalgonda Technique:-

In India, Ground water containing excess fluoride is treated by Nalgonda technique. This

technique is found to be simpler and economical than the above mentioned fixed bed ion-exchange processes, since it does not involve regeneration of media, and employs chemicals which are readily available, and easy to operate and maintain, using local skills.

6 Nalgonda technique uses aluminium salt for removing fluoride. The raw water is firstly mixed with adequate amount of lime (CaO) or sodium carbonate (Na_2CO_3) and thoroughly mixed.

Alum solution is added and water is stirred

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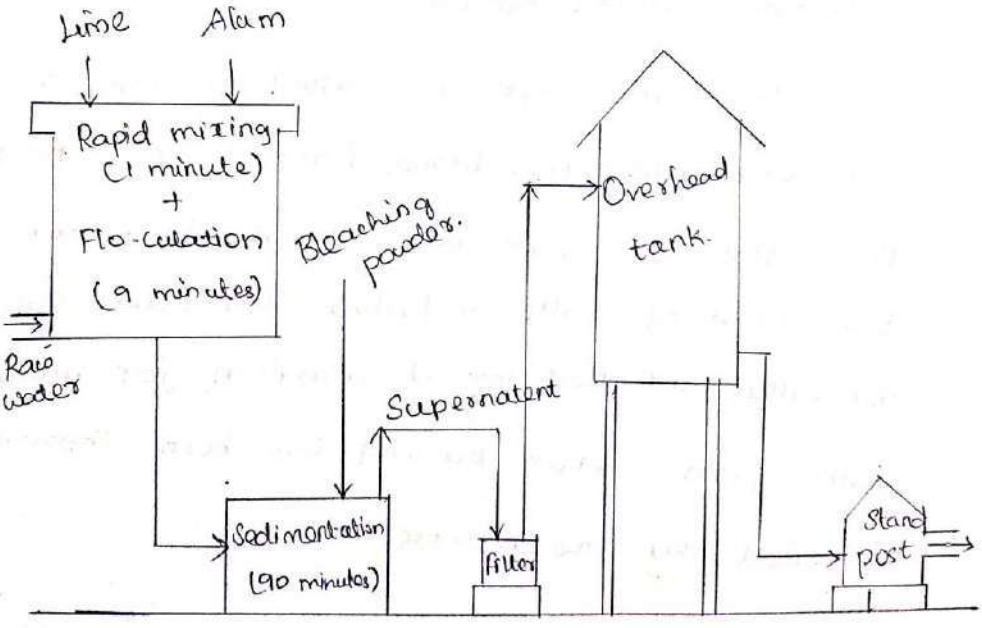

slowly for about 10 minutes, & allowed to settle for nearly one hour. The percipitated sludge is discarded, and the clear supernatant containing permissible amount of fluoride is withdrawn for use. The line diagram is clearly explained in the above fig.

Bleaching powder is also generally added with lime prior to the addition of alum, to achieve simultaneous disinfection of treated water, & also to keep the system free from undesirable biological growth.

4. Reverse Osmosis Process:

The raw H_2O is passed through a semipermeable membrane barrier, which permits the flow of clear H_2O through itself and blocks the flow of salts including fluorides. This is generally adopted for desalination for removing salt from water ~~ba~~ and has been thoroughly examined by the process.

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DEMINERALISATION FOR REMOVING HARDNESS:

Demineralisation means removing the minerals from the water. This de-mineralised water, is called as de-ionised water, is as pure as distilled water.

This complete removal of minerals can be carried out by first passing the water through a bed of cation exchange resins and then through a bed of anion exchange resins.

The cation exchange resins, are phenol aldehyde condensation products, which on sulphonation produces resinous mass having base exchange properties.

Chemical reaction is;

H → hydrogen ions
R → organic part of the substance.

Ex1; $CaCl_2 + \underbrace{H_2R}_{\text{Fresh cation exchange resin}} \longrightarrow \underbrace{CaR}_{\text{Exhausted resin}} + 2HCl.$

2. $MgSO_4 + H_2R \longrightarrow MgR + H_2SO_4$

3. $2NaCl + H_2R \longrightarrow Na_2R + 2HCl.$

The water coming out of the cation

exchanger will now contain diluted carbonic acid, HCl, H_2SO_4 etc.., & can be removed by passing the H_2O through abed of anion-exchange resin.

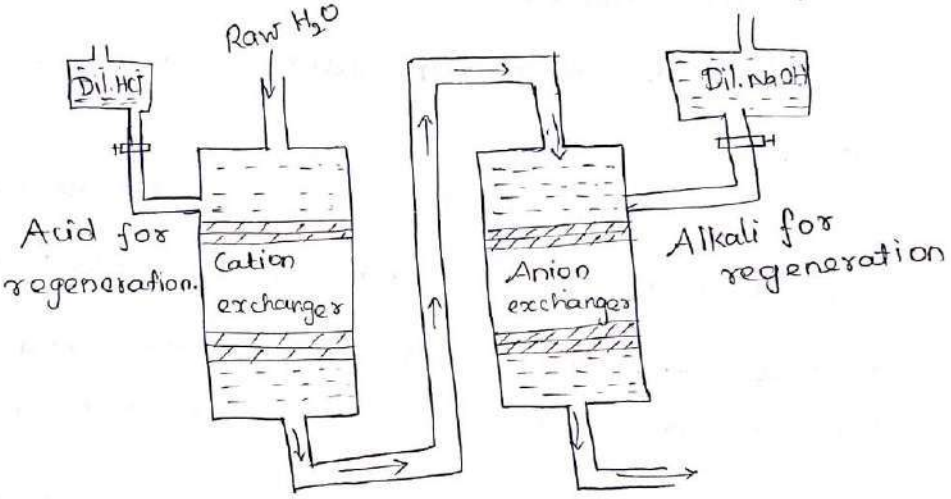


fig: Demineralisation process.

The anion exchange resins, are formed by the condensation of amines with formaldehyde, and are capable of replacing the anions with hydroxyl ions. Chemical reaction.

Ex, 1. $ROH + HCl \longrightarrow RCl + HOH$

2. $2ROH + H_2SO_4 \longrightarrow \underbrace{R_2SO_4}_{\text{Exhausted Resin}} + \underbrace{2HOH}_{\text{water.}}$

Fresh anion exchange resin

R → organic part of substance.

OH → Hydroxyl ions.

The H_2O coming out from this will be free from minerals.

When the use of resins have been in progress for a sufficient time, they become exchausted, and can be regenerated as follows:

Regeneration of cation exchange resin:

This can be regenerated by passing a soln. of dil. HCl (or) dil. H_2SO_4.

Ex: 1. $CaR + 2HCl \longrightarrow H_2R + CaCl_2$.

2. $CaR + H_2SO_4 \longrightarrow H_2R + CaSO_4$

Regeneration of anion exchange resin:

This can be regenerated by passing NaOH.

$RCl_2 + 2NaOH \longrightarrow R(OH)_2 + 2NaCl$.

Advntges:

1. Highly acidic H_2O can be treated
2. H_2O obtained will have low hardness (2 ppm).

Disadvtgs:

1. H_2O containing turbidity, Fe and Mn cannot be treated.
2. Equipment is costly & more expensive chemicals are needed.

*) WATER SOFTENING:

The removal of hardness from H_2O is known as water softening. The hardness in H_2O may be of temporary (or) permanent.

Temporary Hardness ~~can be removed~~ is caused by the carbonates & bicarbonates of calcium and magnesium and can be removed by boiling or by adding lime.

Permanent Hardness is caused by the Sulphates chlorides & nitrates of calcium and magnesium and can be removed only by special methods.

Methods to remove Hardness

A) Temporary
1. Boiling
2. Adding lime

B) Permanent
1. Lime-Soda
2. Zeolite (Base exchange)
3. Demineralisation.

A) To remove Temporary Hardness:

1. Boiling:

* Calcium carbonate, being only slightly soluble in water, will usually exist in water as calcium bicarbonate; bcoz it easily dissolves in natural H_2O. When such a H_2O is boiled, the CO_2 gas will get out.

$$Ca(HCO_3)_2 + \text{Heat} \longrightarrow CaCO_3 \downarrow + CO_2 \uparrow + H_2O$$

Cal. bicarbonate. Cal. carbonate (insoluble)

* These are cannot be removed satisfactorily, since $MgCO_3$ is fairly soluble in water.

* Large scale boiling of public supplies is practically unfeasible and hence boiling is not adopted for softening.

* Also, $MgCO_3$ & $Mg(HCO_3)_2$ are removed by percipitating them as insoluble $Mg(OH)_2$, by treating the hard H_2O with lime; which also helps in the removal of $Ca(HCO_3)_2$ as $CaCO_3$ by supplying OH ions.

Example reaction is written below. (lime)

2. Addition of Lime :-

Lime (CaO), generally hydrated lime [$Ca(OH)_2$] is added to the H_2O. Following reaction

$$MgCO_3 + Ca(OH)_2 \longrightarrow Mg(OH)_2 \downarrow + CaCO_3 \downarrow$$

$$Mg(HCO_3)_2 + Ca(OH)_2 \longrightarrow Ca(HCO_3)_2 + Mg(OH)_2 \downarrow$$

$$Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3 \downarrow + 2H_2O$$

The $CaCO_3$ & $Mg(OH)_2$ are percipitated. and can be removed in sedimentation tank.

B) Method of removing Permanent Hardness :-

1. Lime – soda process :-

$Ca(OH)_2$ & Na_2CO_3 are added to the H_2O, which react with the Calcium & Magnesium Salts, so as to form insoluble percipitates of $CaCO_3$ & $Mg(OH)_2$. These can be sedimented out in a sedimentation tank. The chemical reaction is;

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 \downarrow + 2H_2O.$$

$Mg(HCO_3)_2 + Ca(OH)_2 \longrightarrow Ca(HCO_3)_2 + Mg(OH)_2 \downarrow$.

Thus lime helps in removing the entire carbonate hardness. It reacts with non-carbonate hardness of Ca.

To prevent incrustation of filter media, it is necessary that H_2O be recarbonated by passing CO_2 gas through it, as it leaves the sedimentation tank. In the recarbonation process, the insoluble carbonates combine with the CO_2 to again from the soluble bicarbonates.

Advantages:

* Economical.
* Lesser quantity of coagulant is generally required.
* Reduces the total mineral content of water

Disadvantage:

* Large quantity of sludge will be formed.

2. Zeolite (Permutite) process (Base exchange)(cation Exchange)

These zeolite resins have the excellent property of exchanging their cations; and hence during softening, the sodium ions of the zeolite

get replaced by the Calcium & magnesium ions present in hard waters.

$$Na_2Z + \begin{matrix} Ca \\ Mg \end{matrix}\left\{\begin{matrix} (HCO_3)_2 \\ SO_4 \\ Cl_2 \end{matrix}\right. \longrightarrow Na_2\left\{\begin{matrix} (HCO_3)_2 \\ SO_4 \\ Cl_2 \end{matrix}\right. + \begin{matrix} Ca \\ Mg \end{matrix}\Big\}Z.$$

Sod. zeolite — Cal. or Mg. salt — Sod. salts which don't cause hardness — Ca or Mg. zeolite.

Where,

Z → complex zeolite radical.

The Calcium & magnesium zeolite can be regenerated into active sodium zeolite by treating it with 5-10 % solution of NaCl.

$$\text{ie, } \begin{matrix} Ca \\ Mg \end{matrix}\Big\}Z + 2NaCl \longrightarrow Na_2Z + \begin{matrix} Ca \\ Mg \end{matrix}\Big\}Cl_2$$

Used zeolite. — Sod. chloride soln. — Regenerated zeolite

Advantages:

* H_2O of zero hardness can be obtained.
* The plant is compact.
* No sludge is formed.
* It can able to remove ferrous iron & mangane from wates.

- Disadvantages:

* Not suitable for treating highly turbid H_2O.
* This leaves $Na(HCO_3)_2$ in water which causes priming and foaming in industrial (or) boiler feed waters.

*) DESALINATION :-

The process of removing common salt (NaCl) from the water is known as Desalination. Water containing dissolved salts with a peculiar salty or brackish taste is called brakish water.

Depending upon the Quantity of dissolved salts water is graded as

1. Fresh H_2O -> < 1000 ppm
2. Brackish H_2O -> > 1000 but < 35,000 ppm.
3. Sea H_2O -> > 35,000 ppm.

Sea H_2O, Brackish H_2O can be made available as drinking water through Desalination process. It is carried out by the following

methods. They are

1. Desalination by Electrodialysis method.
2. Desalination by Reverse osmosis method.

1. Desalination by Electrodialysis method:

The hydrogen bonds b/w the H_2O molecules and Na^+ & Cl^- ions must be broken up, inorder to separate the salt from water.

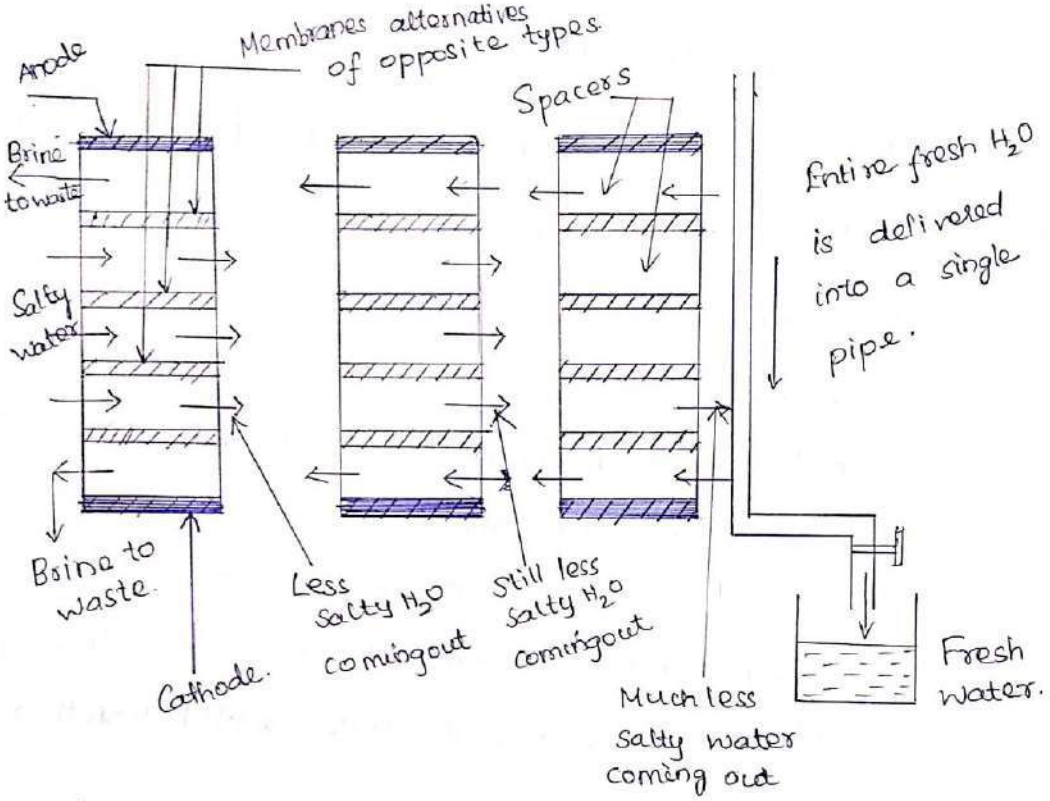
Method used is electrodialysis. So, electricity is used.

If an electric current is passed through the salt solution, the Na^+ & Cl^- ions get freed from H_2O molecules, & start moving towards their oppositely charged electric poles.

The segregation is achieved by means of thin plastic like sheets called 'membranes'. By choosing the right kind of resin, membranes could be made that would pass either +ive or -ive ions but not both.

For a big plant, number of stacks are

connected together as shown in fig.



In this, a large no. of small separations are hooked up together in parallel ; & alternate kinds of membranes are stacked with thin spacers in b/w each pair of opposites.

Pores give excess ~~of~~ at each level, so that salt water could be forced in b/w the membranes while less salty water could be pumped out at the other side, which can be recirculated

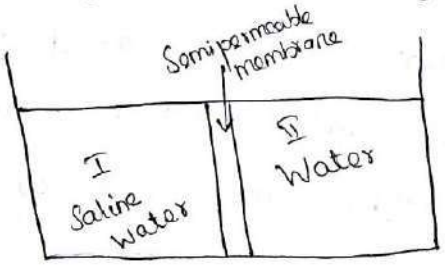
through other stacks of membranes. Since one stack of membranes usually removes 50% salinity, very fine H_2O could be produced in this manner using 3 to 4 stacks.

Advantage :-

* Compact machine.
* Cost of buying & erecting the plant is small
* Easy to operate.
* It also helps to remove mineral.
* They can be assembled for diff. o/p's just by changing the no. of units added together.

2. Desalination by Reverse Osmosis process :-

In this, the H_2O molecules and the salt ions are separated by forcing the salt soln. against a 'semi-permeable membrane' barrier, which permits the flow of H_2O through itself and stops the salt as shown in fig.



When two sdns. of diff. concentrations are separated by a semi-permeable membrane, ~~Solvent~~ water flows from a region of lower concentration to higher concentration. This process is called osmosis. This ~~phen~~ driving force in this phenomenon is called osmotic pressure.

But in reverse osmosis process, the natural osmotic pressure is opposed by exerting an external pressure on ~~one~~ the side containing the salt solution.

The osmotic pressure is proportional to the TDS of the water, and a pressure of atleast twice the osmotic pressure is reqd. to achieve an economically feasible flow. The semi-permeable membrane used in this process is hence thin but dense and strong enough to withstand the high external pressure. It is supported by a grid, and the salty water circulates against one surface of it. This surface has a thick and a tough skin, while the body of the

membrane is softer and less dense. Reverse osmosis does not work below 60,000 kN/m^2 and is usually operated at about 1,00,000 kN/m^2.

As a fact, semi-permeable membranes like the ones found in numerous numbers in human body, have been used for separating the materials according to their physical & chemical properties, when a pressure differential (as in electrodialysis) is applied across the membrane.

Pressure driven processes can be broadly classified according to the membrane pore size and size of particles removed, These processes are

1. Micro filtration
2. Ultra filtration
3. Nano filtration
4. Reverse osmosis.

Nano filtration & Reverse Osmosis helps in filtration of dissolved salts. Hence it is

considered as a part of reverse osmosis, & is known as low-pressure reverse osmosis. Both help in removal of ions (dissolved salts) by osmosis. MF and UF are micro porous membranes which remove suspended small size particles by physical separation. MF and UF are therefore, low pressure processes, while NF and RO are high pressure processes.

Reverse Osmosis can be used for desalinatio with low pressure membranes of moderately sal waters and with high pressure membranes for severely saline waters containing TDS above 10000 mg/l. Sufficiently good quality H_2O containing TDS within 500 mg/l can be obtain in this method.

UNIT-III

*) REQUIREMENTS OF WATER DISTRIBUTION:-

1. The system should be capable of supplying water at consumers tap at reasonable pressure head.

2. The system should be capable of meeting the fire demand

3. It should be completely water tight

4. It should be easy to operate and maintain

5. Water should be available even during breakdown period.

6. The initial cost of the distribution should be as low as possible.

7. The system should be so laid that during repairs, it does not cause obstruction to traffic.

8. It should be safe against any future pollution of water. This aim may be achieved

by keeping the water pipe lines above and away from the sewerage and drainage lines by sufficient amounts, and also by improving the general sanitary conditions of the area through which the distribution pipes have to pass.

*) COMPONENTS OF DISTRIBUTION SYSTEM:-

* The distribution system consists of supply mains, ~~bra~~ sub mains, branches and Laterals. Usually made up of cast iron and joined by means of "spigot and socket joints".

* These water mains and submains are usually laid sloping from the high level to low level areas, so as to achieve the max^{m} advantage of the available head and thus to keep their sizes minimum.

Sluice valves:

→ are placed along the straight length of the pipes at suitable intervals, and also at all the junctions and branching off points, so as to control the flow of water into the different sections.

Drain valves:

→ are placed at all the low points in the distribution system, so as to drain off the H_2O from the pipes for carrying out any repairs, etc... These drain valves are connected properly to the sewers through check valves, etc... so as to avoid contamination by backflow.

Air valves:

→ are placed at all the high points, so as to remove air from the pipe during the filling operations, and also to admit air while emptying the pipe.

In smaller cities and towns, the distribution mains generally take off from the treatment plant itself, and distribute the water into different branches.

Generally, sewer lines run on one side of the street, which is cross-connected to the main lateral at suitable intervals.

The sizes of the distribution pipes mainly depend upon the amount of flow to be carried, and the permissible loss in the pressure head. The methods of solving the pipe networks for determining their sizes shall be dealt later.

*) SERVICE RESERVIORS:-

→ Service reservioirs provide service storage to meet the widely fluctuating demands often imposed in a distribution system.

→ It is used for the fighting and emegencies and to equalize operating pressures.

→ It is classified as,

1. Surface reservioirs
2. Elevated reservioirs.

→ The main duty of reservioir is

*) It observes the hourly variations in demand

*) It is possible to run the pumps at uniform rate.

1. Surface Reserviors (or) Underground Reserviors.

→ are circular (or) rectangular tanks, constructed at ground level (or) below ground level. So, they are also called underground reserviors.

→ The storage capacity depends on the water requirement of the scheme.

→ Water is stored in the ground service reservior, and then directly sent from these into the distribution system.

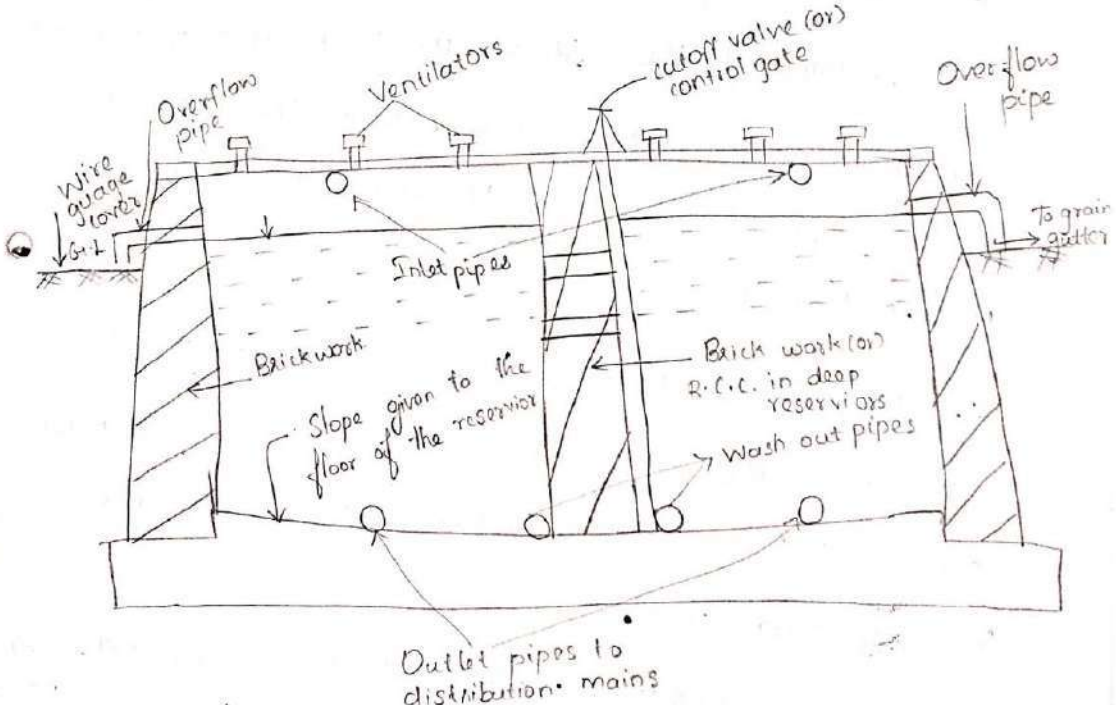


fig: surface reservior

As shown in fig, surface reservior is ~~clo~~ divided into two compartments, so that one may be cleaned and repaired, while the other is in use. Two may be connected with each other by shut off valve or sluice valves.

→ Overflow pipes are provided to ~~control the flow of~~ maintain a constant water level.

→ Ventilators are provided to affect free circulation of air.

→ Although, the stored H_2O is treated, yet some sludge may settle down. Hence, the cement concrete floor is sloped towards the central washout pipes.

2. ELEVATED RESERVIORS: (OVERHEAD RESERVIORS):

→ are the rectangular, circular, or elliptical overhead tanks at suitable elevation above the ground level.

→ The height of this reservior depends on

the pressure head to be developed to supply water to all points of the distribution zone.

→ water is pumped in to these elevated tanks from the filter units and then supplied to consumers.

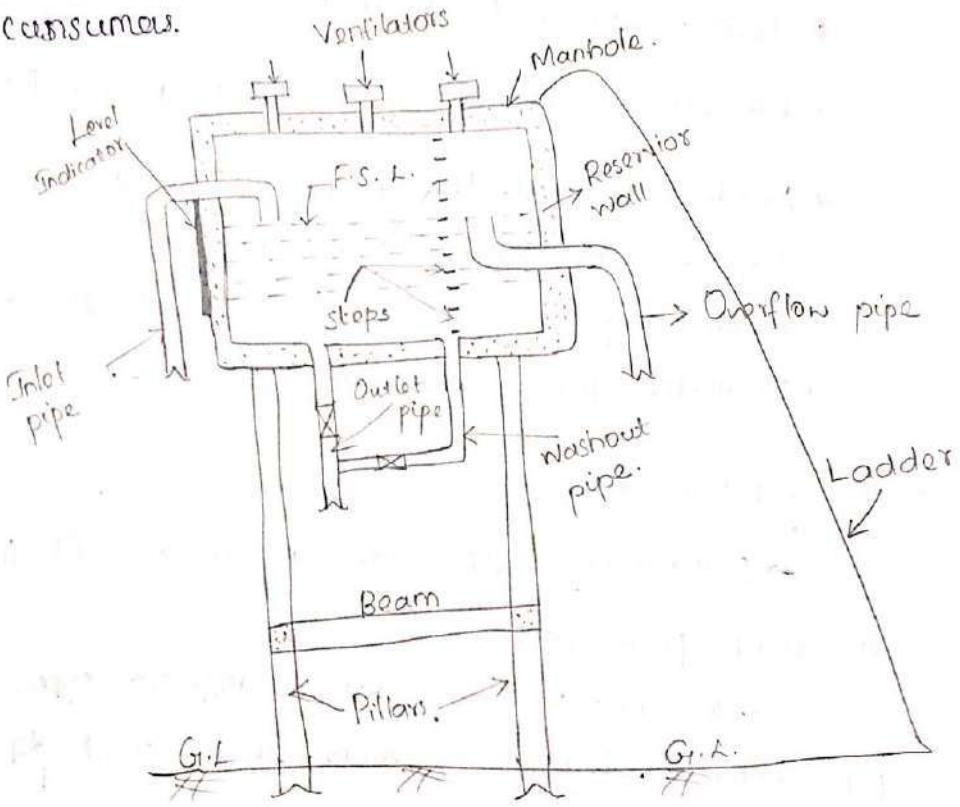


fig: rectangular elevated tank

→ This is designed for six hours avg. supply of city. They are provided with top cover, ladder and manholes for inspection and cleaning.

Major criterias of this reservior are listed below:

* Inlet and outlet pipe along with washout pipes.
* Overflow pipe to maintain constant level of H_2O.
* Level indicator to indicate the depth of H_2O.
* Automatic devices to stop pumping when the tank is full.
* Ladders to reach the top of the reservoir and step into the reservior upto the bottom.
* Manholes for providing entry into the tank.
* Ventilator for fresh air circulation.

*) DISTRIBUTION NETWORKS :

→ Distribution pipes are generally laid below the road pavements.

→ In general, there are 4 different types of pipe networks. Anyone of them can be used depending upon the condition

1. Dead end system
2. Grid iron system
3. Ring system
4. Radial system.

1. Dead end system:- (Tree system)

→ Here, only one main supply, from which originates a no. of submain pipes at right angles.

→ Each submain (S), then divided into branch pipes (B), called laterals. From this, connection to customers

→ This layout may have to be adopted for older towns developed in a haphazard manner, without properly planned roads

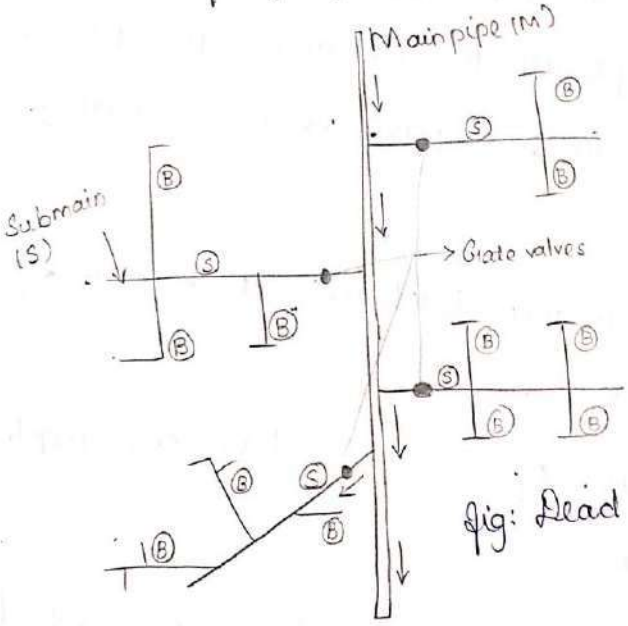


fig: Dead end (or) Tree system

→ The water supply mains have then to be taken along the main roads, and branches taken off wherever needed, thus resulting in

the formation of dead ends [The termination (or) end points of the pipe is known as dead end].

→ Thus, this is suitable for unplanned areas.

Advantages:-

* The pipe diameters can be easily designed.
* cheap and economical design.
* Laying of pipe is simple.
* The number of cut off valves are less.
* Design calculations are simple and easy.
* It is possible to determine the discharge and pressure in each pipe very accurately.

Disadvantages:-

* Due to many dead ends, stagnation of water occurs in pipes.
* Large no. of scour valves are reqd. at the dead ends
* In case of repairs, the whole of the portion beyond that point to the end will be required to be cut off completely.

* The s/m is less successful in maintaining pressure in the remote parts.

* The discharge for fire fighting will be limited.

2.) Grid-Iron System:- (Reticulation system) (Interlaced)

→ Here, Mains, submains and branches all are interconnected with each other.

→ In a well planned area, the roads are also like this; so the pipe n/w can also be implemented easily

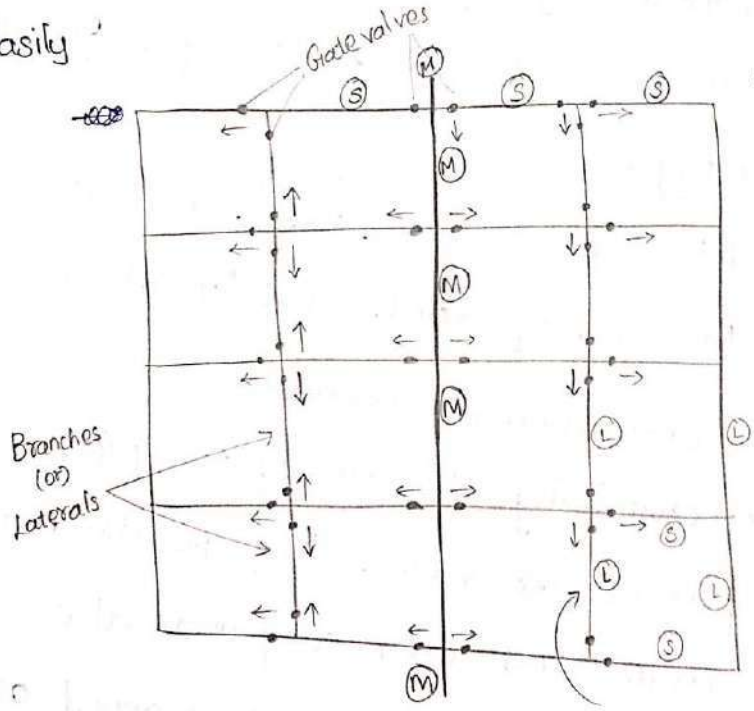


Fig: Grid Iron System

→ Thus, it can be obtained from Dead-end system by closing the loop also.

Advantages:-

* Friction loss & size of pipe get reduced
* In case of repairs, only very small area of the distribution system is affected.
* Since no dead ends are there, water is allowed to circulate continously and freely without any stagnation.
* Enough water is available for fire fighting

Disadvantages:-

* This requires more length of pipe lines and large no. of sluice valves (ie, cut-off valves).
* Construction is costlier
* Determining the size of the pipes and pressure at various key points may requ experts and even computers also.
* It is suitable only for planned areas.

3. Ring system:- (circular system)

→ The distribution area is divided into rectangular (or) circular blocks and the main water pipes are laid on the periphery of these blocks.

→ It is also possible for wellplanned cities.

→ Sometimes, this system is used as a "Looped feeder placed centrally around a high demand area" along with grid iron system. and will improve the pressure at various points.

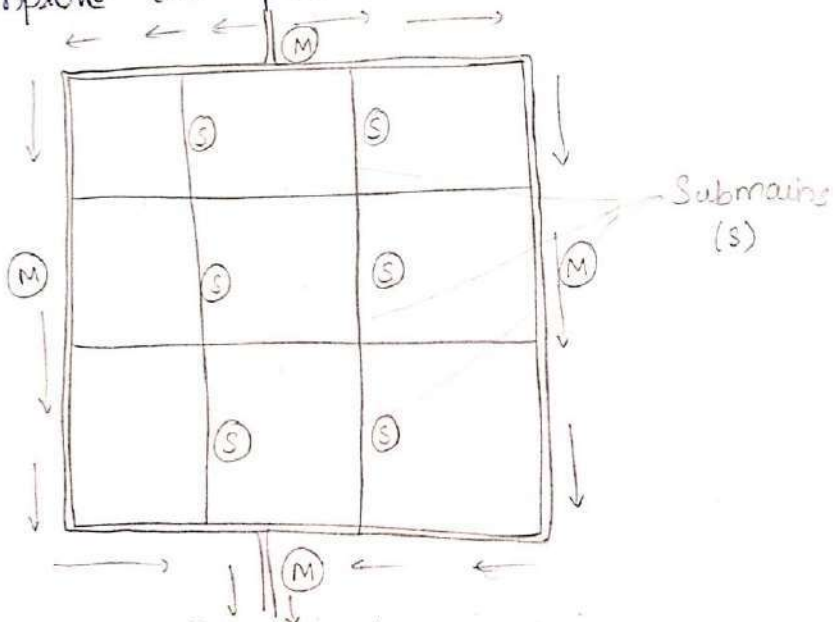


Fig: Ring system

Advantage & Disadvantage: ///r to grid iron system.

4) Radial System:-

→ If a city (or) town is having a system of radial roads emerging from different centres, the pipe lines can be best laid in a radial method by placing the distribution reservoirs at these centres.

→ H_2O is taken from H_2O mains and pumped into the distribution reservoirs placed at different centres as shown in fig.

→ This is one of the most efficient distribution network.

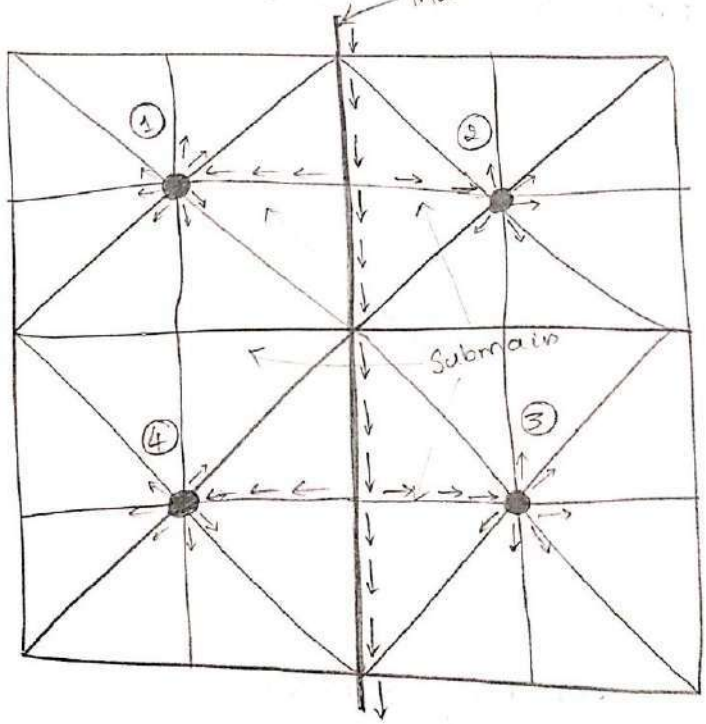


Fig: Radial Systems

Advtgs:

* Design calculations are simple & ensures high pressure
* It gives quick service, without much loss of head

Disdvtgs:

* Each zone should have a distribution reservoir

*) APPURTENANCES IN THE DISTRIBUTION SYSTEM:

Various appurtenances are required to be fitted in the pipe n/w or the distribution s/m for its efficient and controlled functioning. Some of them are

1. Air valves
2. Scour valves
3. Sluice valves
4. Fire hydrants
5. Check valves or Reflux valves.

1. Air valves:

→ These are used at every summit of rising mains, at every change of gradient for

releasing the air from the main which collects at these places and often blocks the passage of H_2O.

→ are used to prevent the formation of vacuum in case of rapid flow, following a burst at some lower point of an the pipeline.

1. In normal cdtn, the chamber remains full of H_2O. The float touches the roof of the chamber and ~~to~~ the poppet valve remains in closed position.

2. As the air goes on accumulating on the top of the chamber, a pressure goes on developing there.

3. This pressure causes the water level to go down and hence the float moves downward which pulls the lever down. Thus poppet valve is opened and the air is allowed to escape.

4. When the air is released completely, the H_2O level rises again and the normal working cdtn. revives.

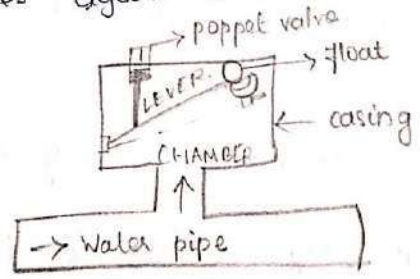


fig: Air valve

2. Scour valves:

→ The fn. of this valve is to remove the sand, silt, etc.. from the pipe line. The valve is opened by turning the spindle and the muddy water is allowed to flow out. When the washing is completed, the valve is closed by turning the spindle.

→ These valves are also called the "wash out valves' or 'blow-off valves'

→ They are provided at every depression and dead ends to drain out the waste H_2O or sediment that may collect there.

→ These are operated by hand

→ When the valves are opened, the H_2O with sediment etc.. may be discharged into the low land or surface drain.

3. Sluice valves:- (Gate valves) (Stop valves)

→ are provided to control the flow of water in the distribution sln, at street corners and where the pipe lines are intersect.

→ The valves are spaced at short intervals

inorder to cause mechanical dislocation of the service, a portion of the pipeline is to be shut off.

→ This valve is made up of cast iron with brass mountings & the ends may be screwed.

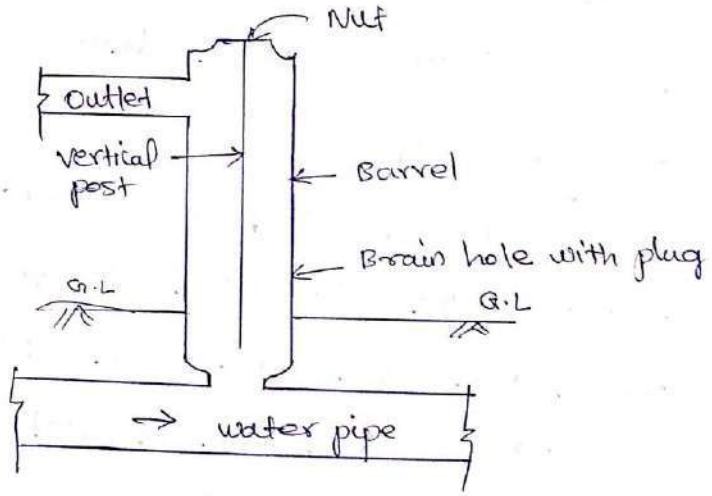
→ valve is opened or closed by the help of handle, which moves the stem and wedge shaped valve.

A) Fire Hydrants:-

→ are the outlets from a H_2O main to form a connection for fire house for extinguishing fire.

→ are provided at all street crossings and turnings at a distance of 150- 300m.

→ are partly (or) wholly underground.



→During a fire breakout, a nearby hydrant is connected to the fire house and the H_2O obtained from the hydrant is used for extinguishing the fire. For fire fighting, the H_2O reqd. at high pressure than for domestic use.

→Such high pressures are generally developed by hydrant outlet to the fire engine.

→fire engine will draw H_2O from the hydrant, boost its pressure within the engine, the other end of the pipe will finally carry the H_2O to the building at a pressure of atleast 32 m of H_2O head.

Available H_2O pressures at the fire hydrants should be as follows: 2 marks

1.7 to 14 m head of H_2O, when H_2O has to be pumped with motor pumps.

8.35 to 50 m head of H_2O, when the direct flow from the hydrant is to be used.

In case of serious fires, pump mounted on trucks are used.

Requirements of good hydrants are

1. It should be such as to connect the hose or the motor pump easily to it
2. Should be easily detectable during panicky atmosphere of fire.
3. should not get out of order during operation
4. On being fully opened, it should allow undisturbed water flow.

Thus, fire hydrants are used for withdrawing H_2O for filling the municipal H_2O tankers.

* Post fire hydrant and flush fire hydrant are the most commonly used fire hydrants.

5. Check valves (or) Reflux valves: (Non-Return valves)

→ They are used at the foot of the rising main along the slope to prevent back running of H_2O.

→ They open in the direction of flow and automatically close in case of accidents and the flow is reversed in direction.

→ Reflux valve is typically shown in figure.

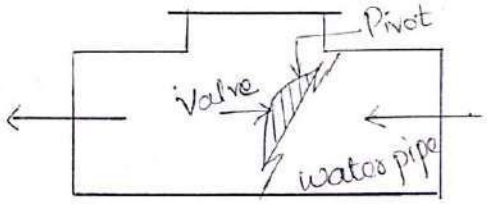


fig: Reflux valve

→ It consists of a flat disc within the pipe line, ~~pro~~ pivoted in such a manner that it opens in one direction and shuts automatically against a gunmetal seating to check the back-flow.

→ It operates by pressures alone and has no means of control. These valves may be of horizontal, vertical or angle flow type.

6) Water meters:

→ are the devices which are used for measuring the quantity of water flowing under pressure through a pressure conduit.

→ This measurement of H_2O supplied to the general public is necessary; in order to charge

the consumers according to the quantity of H_2O supplied to them.

→ The qstn. as to whether the consumers should be charged as per the quantity of H_2O supplied to them or at a flat rate, is highly debatable.

→ There are points in favour of both, as per "Policy of Metering and methods of charging.

Mainly, velocity meter and positive meters are used.

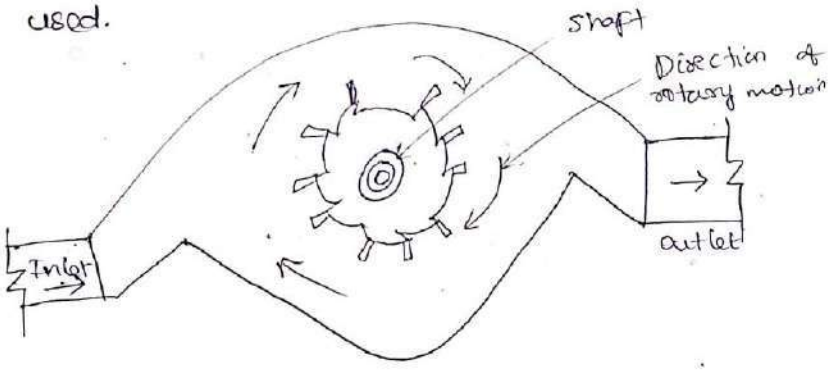


fig: Rotary meter (a type of velocity meter).

Requirements of Good Water meter:-

* It must record the entire water passing through it, and so it is capable of recording even slight discharges.
* Its maintenance and repair should be easy.

* It should prevent the back flow passing through it and should not be liable to clogging.

* OPERATION AND MAINTENANCE :-

The distribution pressure can be maintained by adopting the following measures.

1. The service reservoir should be constructed at the centre of supply zone.

2. A surge tank should be provided on the main water line at a suitable place. When rate of supply is more than water demand, the excess water is stored in this tank. Again, when the H_2O demand is more than the rate of supply, the H_2O from the surge tank flows to the distribtn. s/m to meet the excess demand.

3. To supply H_2O to distant zones, booster pumps may be installed at regd. points.

The distribtn. Slm of H_2O supply should be maintained so that equipments employed and the processes followed can work smoothly without interuption.

Following are the important items, which are to be intended during the maintenance of distbtn. Slm of H_2O supply.

1. Flushing of H_2O pipes should be carried out wherever necessary.

2. The hydrants, valves, and various other appurtenances installed on the water mains should be checked out regularly.

3. The records regarding the length of pipes laid, length of pipes repaired, no. of hydrants & all other data should be well maintained for ready reference.

4. Wastage of water especially of leakage through pipe joints should be brought down to the minimum by adopting suitable preventive measures.

5. Water pipes should be cleaned periodically.

6. The meters installed in the distbtn. s/m should be checked from time to time.

7. Up-to-date maps showing the latest layout of distribtn. of H_2O pipes should be maintained in the office.

*) LEAK DETECTION - METHODS :-

Detection of leakage in the underground main is difficult. In sandy soils, the leaks are difficult to trace. The leakage through pipes about 1.0 m diameter, underground in loamy (or) clayey soil usually appears above the surface.

Methods are

1. By Direct observation.

This method is used in places where the soil under which the pipe is laid, such that the leaks appear on the surfaces.

2. By metal Rod.

A metal rod is inserted into the ground along the pipe line and withdrawn to

find out whether its point is wet.

3. By the use of water meters

A meter placed in a small chamber at the head of a supply zone and the supply is passed through it at night. The meter registers the flows at all hours on a drum with a square paper corapped round the drum. Any $\uparrow^{se}$ or $\downarrow^{se}$ in the flow can be easily detected by this meter.

4. By Water Stethescope

It is an acoustic instrument and leaks are identified by their sound. In night, the valves are closed. The stem of the stethescope is placed against the spindle of the valve. Flow through the valve is indicated by a sizzling sound.

5. By plotting Hydraulic gradient.

If the pressure at several points on a pipeline are determined when the H_2O supply is stopped, the hydraulic gradient may

be plotted. The change of direction of gradient indicates the position of leaks.

6. Compressed Air

This air can be blown through the H_2O pipes The air bubbles will be seen at the point of leakage.

*) HOUSE WATER CONNECTION:

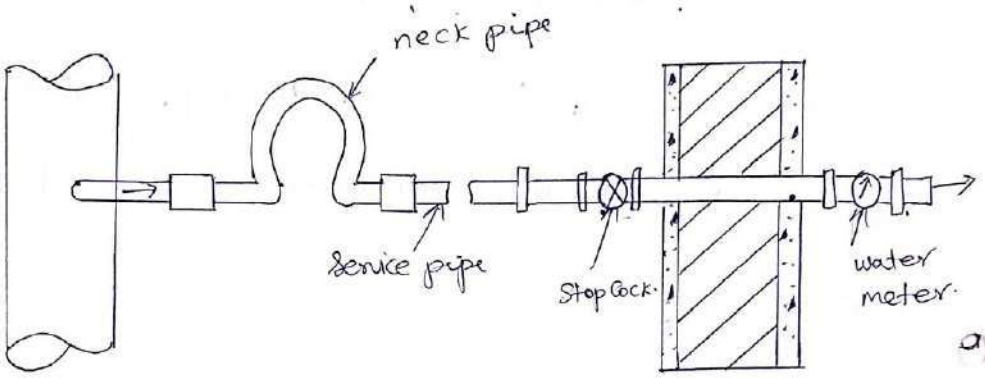
In installing a H_2O supply plumping s/m in a building, the first and main step, obviously is, to obtain a 'water connection' from the municipal H_2O main, bcoz the H_2O supply to a house (or) a building can start only from this point.

A typical H_2O connection, connecting the service pipe with the municipal H_2O main, is shown in fig. As is evident, the water connection consists of

1. a Ferrule
2. a goose neck
3. a service pipe

4. a stop cock

5. a water meter



water Connection Plan

1. a Ferrule:

→ is a right angled sleeve made of brass or gun metal, and is joined to a hole drilled in the water main, to which it is screwed down with a plug. Its size usually varies b/w 10 to 50 mm dia. For all other connections of more than 50 mm dia, a tee branch connection, off the water main, is used.

2. Goose neck:

→ is a small sized curved pipe made up of a flexible material (lead) and is about 75 cm

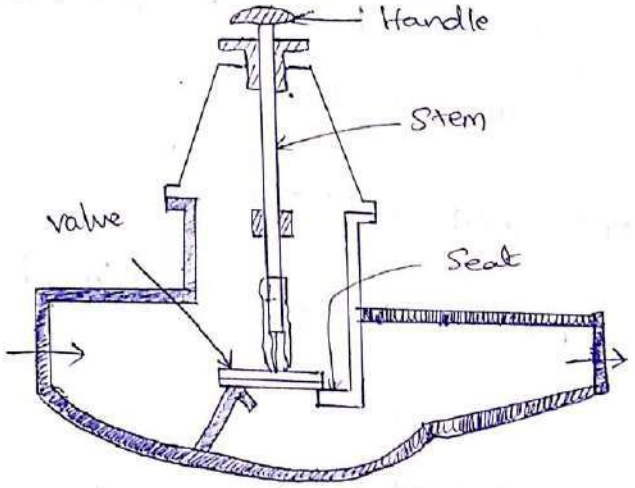
in length forming a flexible connection b/w the H_2O main and the service pipe.

3. Service pipe:

→ is a galvanised iron pipe of size less than 50 mm dia. It should be laid underground in a trench in which no sewer or drainage pipe is laid. The service pipe which supplies H_2O to the building through municipal main is thus connected to the main through the goose neck and ferrule

4. Stop cock:

→ is provided ~~from~~ before the H_2O enters the H_2O meter in the house. The details of stop cocks are given in the next article.



→ Stop cock is a screw down type of sluice valve which is used in smaller sized pipes in

service connections for stopping or opening the supply. When provided just prior to the H_2O meter in each house connection, they should be enclosed in a proper cast iron box having a hinged cover.

→ When the valve is closed, it rests against the seat, and thereby closing the orifice. They are extensively used in pipes upto 50 mm sizes.

5. Water meter:

→ measures and records the quantity of H_2O consumed in the house. It is generally fixed in an iron box covered with a movable iron cover.

→ The domestic type H_2O meter generally employed for houses is fitted into the service pipe with unions.

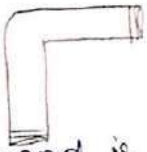
* FIXTURES AND FITTINGS :

Main fittings used in buildings are,

1. Stop cocks
2. Water taps
3. Bends.

Other fittings are:

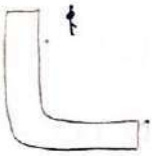
1. Bend



* when the direction of a pipe line is to be changed, bend is used.
* The bend has threads externally at both ends

2. Elbow

* When the direction of the pipe line is to changed at right angles, elbow is used.

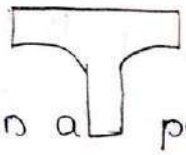


* Elbow has internal threads at both ends.

3. Coupling or socket

* has internal threads.
* To connect two pipes of the same dia, straight couplings are used.
* To connect two pipes of diff. dias, reducer couplings are used.

4. Tee



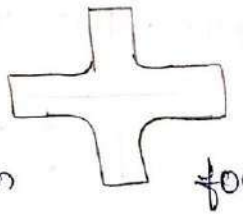
* Tees are used when a pipe line is to be branched off from another pipeline.

* Tee has internal threads at all the 3 ends.
* Y-Branch Tee → if branch pipe takes off at an acute angle.
* Equal Tee → if the pipes are of same diameter.
* Reducer Tee → if the branch line is smaller in dia

5. Nipple

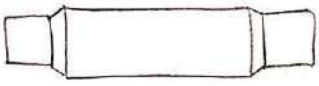
* When the pipe line is to be extended or adjusted, nipple is used.
* Nipple is straight piece having external thread
* While connecting valves and taps, nipples are needed.

6. Cross



* Cross is used when four pipes are to be connected at a junction.
* It has internal threads at all the 4 end

7. Union



* To start any branch line, union is used.
* During repairs, to split the pipes without unscrewing all the pipes a provision

should be made. To provide this, unions are used.

8. Plug

* To seal off open ends in a pipeline, plugs are used.
* For closing socket end, plugs are used.
* They have external threads

9. Caps

* To close the pipe ends, caps are used.
* Caps have internal threads

10. Flange

* To connect pipes of equal dias of more than 75 mm, flange is used.
* It has circumferential holes for fixing bolts.
* The flanges are screwed to pipes and joined by bolts and nuts.

UNIT-IV

PLANING AND DESIGN OF SEWERAGE SYSTEM

Estimation of Sewage flow :-

The Sewage Consists of two Categories

a) Dry weather flow

b) wet weather flow.

Dry weather flow :

It is the flow of domestic Sewage and Industrial Sewage, and mentioned as DWF.

The quantity of DWF is determined by Considering the Following four factors.

a) population

b) Rate of water Supply

c) Industries & its types

d) Infiltration & exfiltration.

(4)

(2)

Estimation of Storm runoff :-

a) Rational method.

b) Empirical method

Rational method :-

According to this method, the run off 'Q' depends on following factors,

a) Catchment area

b) Intensity of rainfall

c) Impermeability Factor (or) run off Co-efficient.

a) Catchment area :-

The Catchment area by stream water sewer is measured directly from the local map available.

It is denoted as A and measured in hectares.

b) Intensity of Rainfall :

A rainfall at a place can be calculated from the rainfall intensity duration and frequency of rainfall.

Characteristics & Composition of sewage & their significance :-

1. Physical Characteristics :-

The most important physical characteristics of water is its total solids content, consisting of floating matter, matter in suspension colloidal matter and matter in solution. other physical characteristics of waste water are,

a) Odour
b) Colour
c) Temperature
d) Turbidity.

a) Odour:

Normal fresh sewage has a musty odour, which is normally not offensive, but after sometimes it becomes offensive. Due to this, the elimination of odours has become major consideration.

b) Colour :

Fresh sewage is yellow in Colour. Sometimes grey or light brown also indicates the fresh sewage. If the sewage Colour is black or dark, It indicates decomposed or stale sewage. other Colours are formed due to the presence of some chemicals From industries.

c) Temperature :-

Temperature variations Cause the biological activity of sewage, Solubility of gases and viscosity of sewage.

If temperature increases, the viscosity of sewage decreases, The reduction in viscosity causes increases efficiency of treatment unit.

d) Turbidity :

The sewage is generally turbid and it is caused by the presence of suspend matter. The turbidity of sewage can be calculated as same is the case of water.

Chemical characteristics :-

* The stage of sewage decomposition.
* Sewage strength
* Extent of treatment
* Type of treatment for safe disposal.

chemical analysis is carried out on sewage in order to determine its chemical characteristics

1. pH value
2. Chloride Content
3. Nitrogen
4. Fat, grease & oil Content.

5. Sulphides, Sulphates & H_2S gas.
6. Dissolved oxygen
7. Chemical oxygen demand
8. Bio chemical oxygen demand etc.

1. pH value:

pH of sewage is defined as the negative log of hydrogen ion Concentration present in sewage.

$$pH = -\log(H^+)$$

pH is an indicator of the alkalinity

SEWER DESIGN.

Sewerage :

A sewarage system consists of a network of sewers, for carrying the sewage from individual units (homes & industries) to the sewage treatment plant.

This system (network) consists of

1. House sewers
2. Lateral sewers
3. Branch sewers
4. Main sewers
5. Trunk sewers
6. Manholes
7. Catch basins, etc.

Sewer appurtenances

1. Man holes
2. Lamp holes
3. Drop manholes
4. Catch basins
5. Inlets
6. Traps (grease & oil traps)
7. Flushing tanks
8. Regulators
9. Inverted siphons &
10. Clean outs.

1. Man hole

A Manhole is a structure constructed to provide access to the sewer for facilitating inspection, cleaning or usual maintenance operations.

2. Lamp Hole :

i) A lamp hole is a small opening in sewers constructed for lowering a lamp inside it.

ii) the lamp hole consists of a stoneware or cast iron pipe of 20 to 30 cm dia connected to the sewer through a T- Junctions.

iii) The pipe is surrounded by Concrete to make it stable.

iv) A manhole cover is provided on the lamp hole at ground level.

3 Catch Basins

It is a structure in the form of a chamber which is provided along the sewer line to admit clear rain water free from silt, grit, debris, etc, into the combined sewer.

Pumps

Types of Sewage pumps

1. Centrifugal pumps
2. Reciprocating pumps
3. Pneumatic ejectors
4. Airlift pumps

1. Centrifugal pump

Sewage lifting can be easily done by using Centrifugal pumps, because of the Easy installation.

Centrifugal pumps Can be easily installed in pits and pumps.

Centrifugal pumps also work the sewage with suspended matter without clogging of pumps.

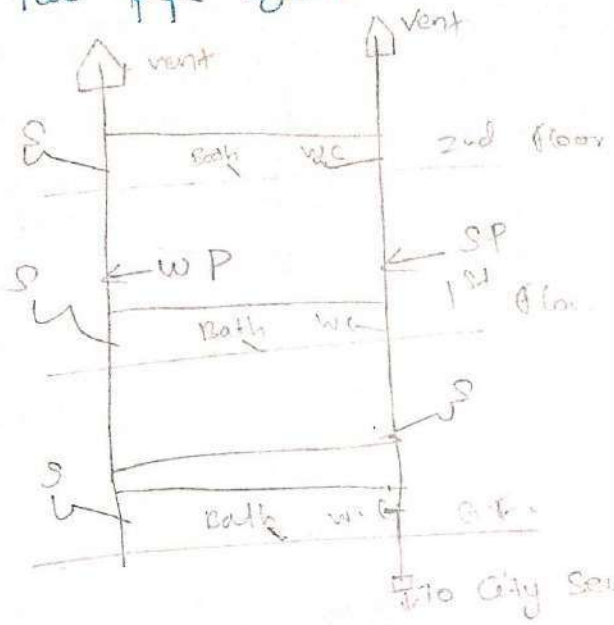
2. Reciprocating pump :-

These pumps are nowadays not in use for sewage pumping, because they are clogged by solids or fibrous material, even though sewage may have passed through Coarse screens.

Also, their initial cost is higher and efficiency is lower than the Centrifugal pump. But in some cases, reciprocating pumps are used in low heads and used in difficulty sludges with the use of 20mm spacing screens.

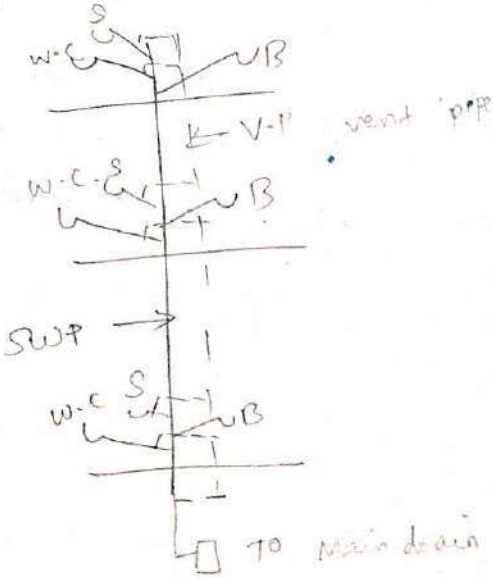
Plumbing System

1. Two pipe System

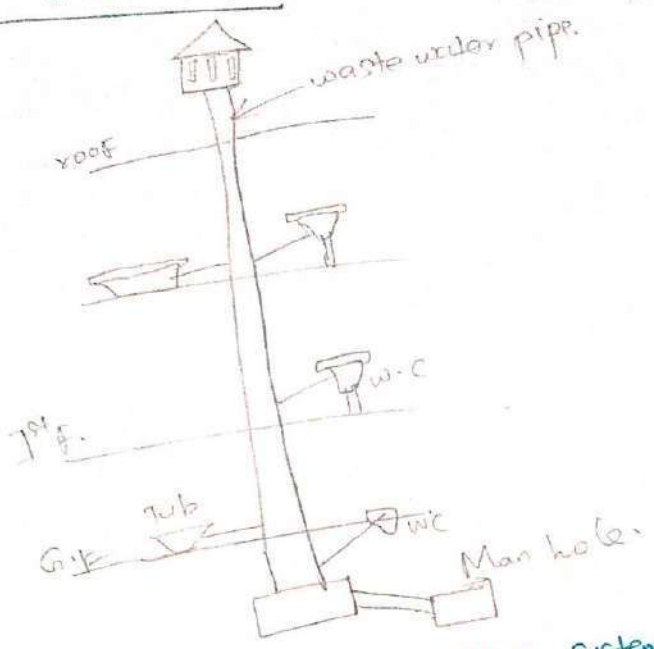


SP → Soil Pipe
WP – waste pipe.
SWP – Soil waste pipe.

2. one pipe System



Single Stack System



Partially ventillated Single Stack System

Traps of the water closets are separately ventilated by a Seperate vent pipe called relief vent pipe. Sullage Fixtures are not ~~Collected~~ Connected.

Plumbing System for Buildings

There four types.

a) two pipe system

b) one pipe system

c) single stack system

d) partially venturated single stack system.

a) two pipe system:-

In two pipe system two pipes are used. night soil Collect main pipe is soil pipe. pipes are collecting Sullage is Sullage pipe.

* Additional two vent pipes are used
* number of pipes are high
* uneconomic.

b) one pipe System:

one pipe used night soil and Sullage Collect the waste pipes branches pipe to main pipe

* cost is low
* Smell creates.

* Flexiblity of operation
* Area requirement for pumping house
* Cost factors
(Initial Cost, operating & maintanence Cost).

Pumps :

Pumps are defined as the hydraulic machines, which Convert the mechanical energy into hydraulic energy.

In other words, pumps are the hydraulic machines used to lift the fluid from lower level to higher level.

A pump may serve to move liquid, as in a cross-country pipeline; to lift liquid, as from a well or to the top of a tall building, or to put fluid under pressure, as in a hydraulic's brake.

These applications depends predominantly upon the discharge characteristics of the pump.

A pump may also serve to empty a Container, as in a vacuum pump or a Sump pump, in which case the application depends primarily on its intake characteristic.

Small Bore Sewerage System

Simplified sewerage, also called small-bore system, is a sewer system that collects all household waste water (black water & grey water) in small dia pipes laid at fairly flat gradients.

Simplified sewers are laid in the front yard or under the pavement, rather than in the center of the road as with conventional sewage.

Design & Construction:

Laying small dia pipes at fairly flat gradients requires careful construction techniques.

Plastic pipes are best used as they are more easily jointed correctly. This reduces waste water leakage from the sewer and groundwater infiltration into it.

UNIT-V

SEWAGE TREATMENT AND DISPOSAL

Activated Sludge process :-

The sewage effluent from the primary sedimentation tank is mixed with 25% of its own volume of activated sludge.

The activated sludge contains a larger concentration of highly active aerobic micro-organism.

The mixture of sewage effluent and activated sludge enters an aeration tank, where micro-organism are mixed together with a large quantity of air, for a period of 4 to 8 hours.

Under this conditions, the micro-organisms will oxidize the organic matter tend to coagulate and form a precipitate.

This precipitate settles down in the secondary sedimentation tank instantly.

The settled sludge, called activated sludge is again recycled to the head of aeration tank and again mixed with raw sewage.

Activated sludge is being produced Continously by this process, and a portion of produced activated sludge is utilized in aeration tank.

The excess of activated sludge is disposed of properly along with the sludge collect during primary treatment, after digestion.

Operation of Activated sludge process

a) Mixing of activated sludge
b) Aeration
c) Settling in the secondary clarifier

a) Mixing of activated sludge:

The activated sludge is mixed with raw (or) settled sewage properly.

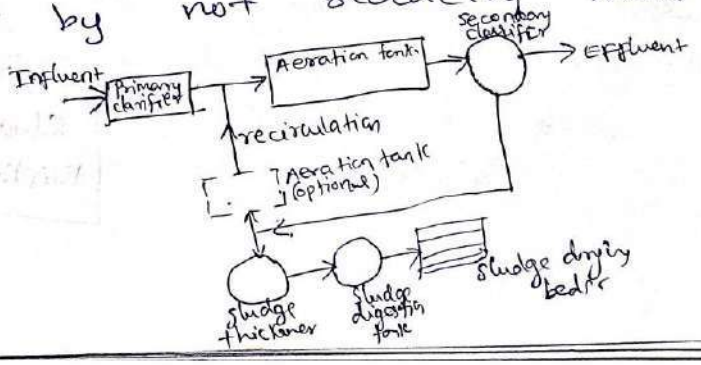
b) Aeratoin:

The mixed liquor containing activated sludge and effluent is agitated or aerated in the aeration tank

This is the operation activated sludge process and the various methods are found out to acheive it successfully.

The removal of grit and larger solids by screening, grit chambers and primary sedimentation tank is necessary for aeration.

The pre-removal of these ~~suit~~ settleable solids is helpful in preventing deposits on aeratoin devices, and these by not reducing their efficiencies.



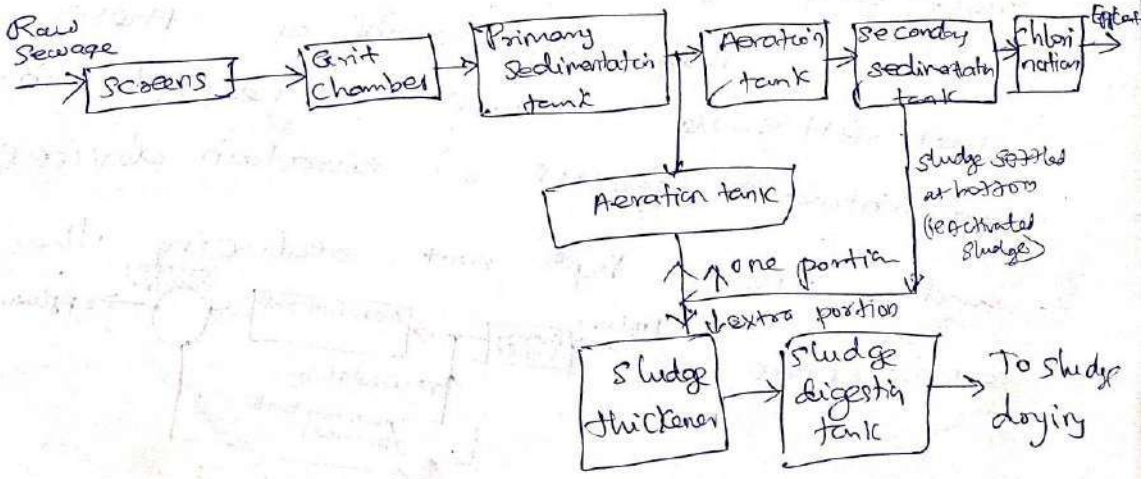
c) Settling in the secondary clarifier :-

The mixed liquor after agitation is taken to the secondary clarifier.

The sludge is allowed to settle down in this tank.

The settled sludge is the activated sludge and a portion of the settled sludge is sent for recirculation.

The removing activated sludge is taken to the sludge digestion tank and then to the sludge drying beds for further treatment.

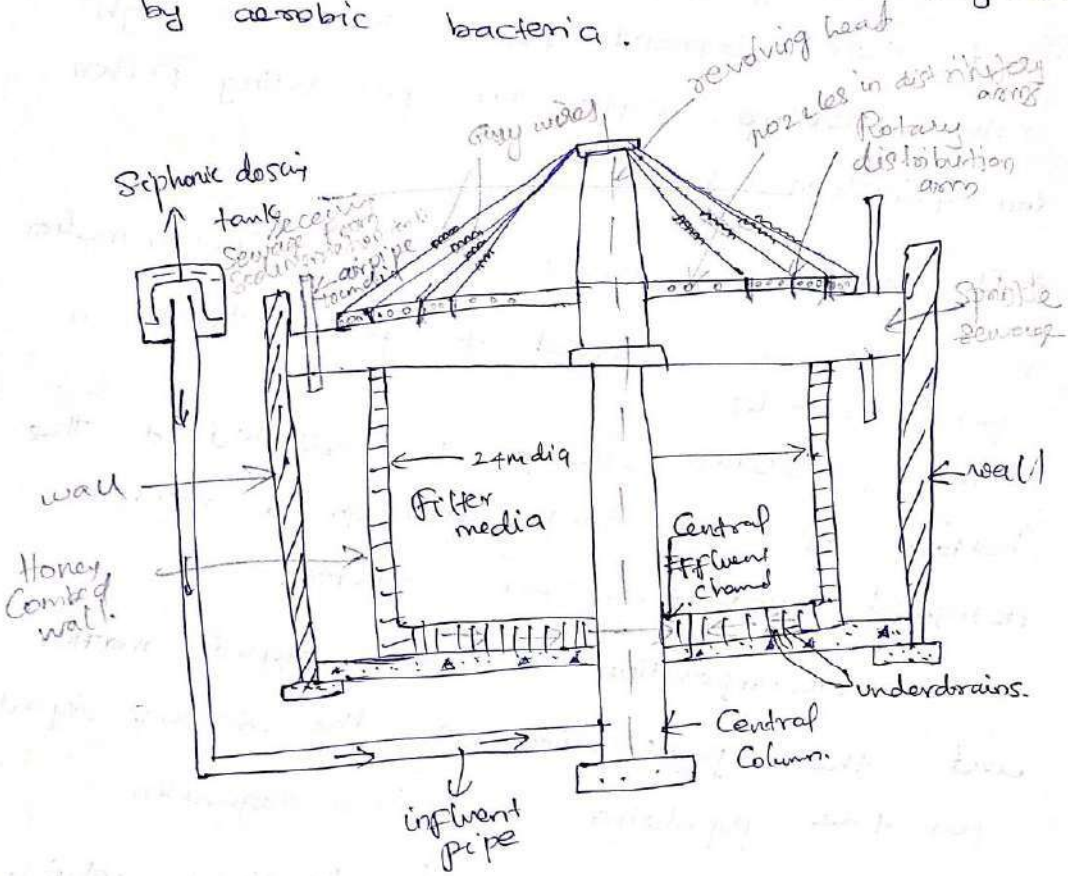


Trickling Filter:

The Conventional trickling filters and their improved forms known as high rate trickling Filter (or) percolating filter (or) Sprinkling Filter.

* It Consist of tanks of Coarse filtering media
* Sewage is allowed to pass through a Spray nozzles.
* The percolating sewage is collected at the bottom of the tank through a well designed under-drainage system.
* The decomposition of the organic matter and the purification of the sewage depends upon the population of micro organism.
* The micro organism and bacteria, which are naturally present in sewage, get attached to the filter media.
* The organic matter from the sewage influent is also adsorbed on the biological film, which is formed by the micro-organism around the filter media particles.

* In the outer portions of this film of biological mass, organic matter is degraded by aerobic bacteria.



Types of trickling filter

1. Convention trickling filter
   - ⇒ ordinary trickling filters
   - ⇒ filtering capacity is low.
   - ⇒ low rate trickling filter.

2. High rate trickling filters.

* Already discussed type is the high rate filter.

* The Recirculation of sewage through the filter by pumping a part of the filter effluent to the primary settling tank.

* The high rate filters make it possible to pass sewage at greater loading, thus requiring lesser space and lesser filter media

Types of high rate trickling filter.

a) Accelo - Filter system

b) Aero - Filter System

c) Alternating double filtration

d) Biofiltration

e) Enclosed Filtration.

Oxidation ditches.

The Conventional activated sludge plant has been modified to eliminate the primary sedimentation tank and sludge digestion tank, in a process called the oxidation ditches.

The main aims at providing an aeration tank with a longer aeration time.

* The oxidation ditches commonly used in Europe Countries.
* Package plants available for small installation
* Compared to the Conventional activated sludge plant or trickling filter plant, it is suitable for 1.5 lakh population in the city.

Construction

* Construction of large number of ditch channel, place together side by side, depth of about 1.5m.

* The width is limited to the type and availability of the aeration ~~ter~~ rotors used and may vary between 1 to 5m.

* The oxidation ditches constructed by brick or stone masonry with vertical walls.

* The water tightness is essential.

* The velocity is more than 0.3m/sec.

* The aerated sewage is settled at the bottom of the settling tank by stoping the rotors for about 2 hours.

* A part of settled sludge is used for recirculation and the excess settled sludge which is well stablized due to long detention periods, can be easily dried on sand beds.

* The BOD removal 98%. the SS removal at about 95%.

* the power requried is higher than activated sludge process

U.A.S.B.

~~U.S.A.B.~~

[Upflow Anaerobic Sludge blanket].

* The waste water flow upward direction.
* The sludge is digested by anaerobic digestion process.
* Maintains a high Concentration of biomass through the formation of highly Settleable microbial sludge.
* The top of the reactor, three phase seperation between gas - solid - liquid.
* Any biomass leaving the reaction zone directly recirculated from Settling zone.
* The process is suitable for both Soluble waste water as well as waste water Containing particulate matter.
* The waste water enters the tank from the bottom and reach to the sludge bed. Already waste water having sludge particles in these sludge particles settled in the sludge bed, the clear water flow upward.

* The settled sludge degraded by anaerobic digestion by the presence of bacteria.

* The creation of biogas during the anaerobic decomposition helps in providing gentle mixing and stiring of the biomass.

* The biogas is collected at the top of the tank in a gas collector.

* The water sludge mixture is made to enter a settling tank where the sludges settle down and flow back into the bottom of the reactor.

* No packing material is needed.

* The treated effluent is collected in gutters and discharged out of the reactor.

* The sludge is shifted into the drying beds to be used as a soil conditioner.

* The biogas is used for industrial purpose such lighting, heating, pumping

[This process involves the conversion of high rates of the concentrated liquid wastes into methane gas by maintaining a high concentration of micro-organisms in a reactor and preventing them to escape along with effluent

Waste Stablizatoin ponds :-

Aerobic Stablization unit

oxidasation ponds & stablizatoin ponds

* Stablizatoin ponds are open flow through earthern basins.
* It is Commonly used of sewage and biodegradable industrial waste water.
* Long detention periods
* waste Stablized by the actoin of natural forces.
* Stablizatoin ponds classified into three,
    1. aerobic ponds
    2. Anaerobic ponds
    3. Faaultative ponds.

1. aerobic ponds:

* The Stablizatoin is brought about by aerobic bacteria.
* The algae is growing in the presence of ~~sludge~~ sunlight, produce oxygen by actoin of photosynthesis.

* The oxygen is utilized by the bacteria for oxidising the waste organic matter.
* The end product of the process are CO_2, ammonia, phosphates.

2. Anaerobic pond:

* The stablization of waste is mainly brought about by the usual anaerobic condition.
* The organics wastes are converted into CO_2, CH_4, gaseous end product.
* Smell & odour is the main problem depth 2.5m to 4m.

Oxidation pond:

* oxidation ponds orginally referred to that stablization pond which received partially treated sewage.
* The pond receive raw sewage is called sewage lagoon.
* The reduction of BOD.

* The algae are more stable than the organic matter in waste water and degrade slowly in the river stream into which the effluent is discharged.

* The oxidation ponds, throwing their effluents in rivers, the algae is present in the effluent settle at the bottom and increates anaerobic environment. So avoid disposal into the rivers.

Construction:

* It is an earthem pond, dug into the ground, with shallow depth.

* The defention time in the pond is usually 2 to 6 weeks, depending upon the sunlight and temperature.

* Better efficiency is obtained by several ponds are placed in series.

* The sewage flows progressively from one to another unit, until finally discharged.

Reclamation and Reuse of Sewage

The reuse of reclamation of wastewater may be needed for following purposes

* Agricultural irrigation of Crops and irrigation of parks, etc
* Industrial reuse of the reclaimed water in cooling system, boiler feed, etc.
* fire protection, air conditioning, etc.
* potable reuse of water.

Waste water Reclamation Techniques:

a) Industrial reuse of reclaimed water

b) Agricultural irrigation

c) Ground – water recharge.

a) Industrial waste re-use:

The reuse of reclaimed water in industries includes, Cooling agent for cooling towers, heating agent for boiler feed and for other selected and specific unit operations and unit process.

Reuse of Cooling water :-

It is the most common application of reclaimed water, for industries such as electric power generating stations, oil refining and other type of manufacturing plants. The Cooling tower operation involves a closed - loop system in which the reclaimed wastewater after receiving advanced tertiary treatment is used as the makeup water.

b) Agricultural Irrigation :-

For Irrigation of Crops with reclaimed water, It is important to establish the quality of Irrigation water. This includes the Control of Salinity, Sodium toxity, water infiltration rate of the applied water and physical Condition of the soil.

c) Ground water recharge with reclaimed water

This method includes surface spreading in basins and direct ground water recharge.

a) Surface spreading

It is the most commonly used method of ground water recharge. A number of shallow rectangular recharge basins are provided in parallel. The waste water receiving secondary treatment is applied to the basins intermittently basins drained for 7 days and dried for additional 7 days before being start in service. The recharge water percolates from the spreading basins through the unsaturated groundwater zone, down to the ground water and undergoes filtration during the course of its travel.

b) Direct ground water recharge

It is achieved, when water is conveyed and injected directly into the ground water aquifer. The highly treated reclaimed water is injected directly into a well-confined aquifer.

This method is suitable, where the groundwater is deep or where the topography of the existing land makes surface spreading is impracticable.

This method is particularly effective in creating fresh water barriers in coastal aquifers against intrusion of salt water from sea.