Under ground Sources :- Module-1

- Under ground waters are high in quality but less in quantity.

- They are categories into :-

 (i) Springs

 (ii) wells

 (iii) Infiltration galleries.

Springs :-

- Sometimes ground water reappears at the ground Surface in the form of Springs.

- Springs generally can supply small quantity of water, hence these can not be used as Source of water to big tow

- Due to Presence of Sulphur in certain Springs, they discharge hot water. Such hot water Springs are only useful for taking dips for the cure of certain skin disease Pati

- Generally Springs are formed under following Circumstances

 (a) When the surface of the earth drops sharply below the normal ground water table.

 (b) When due to an obstruction ground water is collected in the form of reservoir and forces the water to overflo at Surface.

 (c) When fissure in an impervious stratum allows artesian water to flow in the form of Springs.

Infiltration Galleries:-

- We have seen earlier that ground water travels thr[ough] lakes, rivers or streams. This water which is travelling can be intercepted by digging a trench or by constructi[ng] a tunnel with holes on sides at right angles to the direc[tion] of flow of under-ground water.

- These underground tunnels used for tapping under ground water near rivers, lakes or streams are called a "Infi[ltration] Galleries.".

- Infiltration galleries may be constructed with masonary concrete with weep-holes of 5 cm × 10 cm.

- Infiltration galleries are surrounded on sides and top gravel or Pebble stones, to increase their intake capacity

(iii) Well:-

- When there is large quantity of ground water existin[g] over a wider area, it can be cheaply collected by laying Porous Pipes or Pipes with open joints in the full area at some distance.

- These longitudinal and cross-pipes will be given a slope such that they bring the water towards a Point, where a well is constructed to take out the water.

Classification of wells:-

(i) Dug well ...

(i) Dug well or Percolation well :—

- Sometimes these are also known as "Draw wells" or open wells".
- These are shallow wells which are usually confined to soft ground, sand and gravel.
- The diameter of these wells may be between 1m to 4 m. and depth may be upto 20 meters depending upon the requirements and geological structure of earth.
- These wells are suitable for small discharge of about 20cu.m/hr
- The walls of these wells may be constructed with precast R.C.C. blocks, bricks or stone masonary.
- The thickness of the steening ~~wall~~ of the well mainly depends on the depth of the well and varies from 50 c.m. to 75 cm
- Dug wells are very cheap in construction, therefore these are very popular in rural areas.

(ii) Driven well :—

- Like dug wells, driven wells pull water from the water-saturated zone above the bed-rock.
- Driven wells can be deeper than dug wells.
- They are typically 30-50 ft. deep, and are usually located in areas with thick sand and gravel deposits where the ground water table is within 15 ft of the ground surface.

(iii) Tube well :—

- The maximum discharge which is available from the ordinary open wells, is between 4 to 5 lit/sec.
- For obtaining more yield, now a days tube-wells are commonly used

- These wells essentially consist of blind pipes and strainer pipes, and their supply of water is from large no. of aquifers.

- The depth of the tube-well may vary from 50-500m and the maximum yield from the tube-well may be about 200 litres/sec.

- Types of tube-wells are :-
  - (a) Strainer type tube-wells
  - (b) Cavity type tube-wells
  - (c) Slotted type tube-wells
  - (d) Perforated type pipe tube-wells.

Aquifers and their types :-

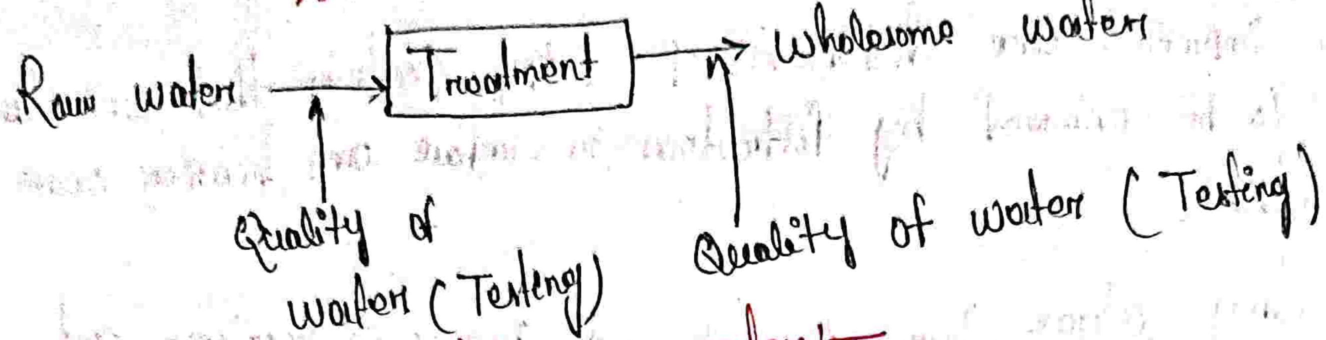
Aquifers :-

- A permeable stratum which is capable of yielding appreciable quantities of ground water under gravity is known as aquifer.

Aquiclude :-

When an aquifer is over laid by a confined bed of impervious materials, then this confined bed of over burden is called an "aquiclude".

- Aquifers are of 2-types :-
  - (i) Unconfined or Non-Artesian Aquifers.
  - (ii) Confined Aquifer or Artesian Aquifer.



Requirements of wholesome water:—

(i) It should be free from bacterias which may cause disease.

(ii) It should be colourless and sparkling which may be averted by the public.

(iii) It should be tasty, odour-free and cool.

(iv) It should not corrode pipes.

(v) It should be free from all objectionable matter.

(vi) It should have dissolved oxygen and free carbonic aci[d] So that it may remain fresh.

Quality of Water :—

1. To Know the extent of impurities present in water → based on this method and degree of treatment is decided.

2. To ensure the quality of treated water before suppl[y]

Impurities in Water :—

① Based on size of impurities :—

(i) Suspended impurities .... 10^{-1} mm to 10^{-3} mm [100 µm – 1 µ[m]
10^{-3} mm to 10^{-6} mm (1 µm – 10^{-3} µm

(ii) Collidal impurities..... 10^{-3} mm

10^{-6} mm to 10^{-8} mm [10^{-3} – 10^{-5} µm

(iii) Disloved impurities --- 10^{-6} mm

(i) Suspended impurities:-

- These impurities are dispersion of solid particles that are large enough to be removed by filtration on surface and heavier ones settle down.
- Ex:- clay, algae, fungi, organic and inorganic matters and mineral matter etc.
- The concentration of suspended matter in water is measured by its turbidity.

(ii) Colloidal impurities:-

- It is very finely divided dispersion of particles in water.
- These particles are so small that these cannot be removed by ordinary filters and are not visible to the naked eye.
- Most of the colour of the water is due to colloidal impurities.

(iii) Dissolved impurities:-

- Some impurities are dissolved in water when it moves over the rocks, soil etc.
- Solids, liquids and gases are dissolved in natural waters.
- These dissolved impurities may contain organic compounds, in-organic salts and gases etc.

2. Based on nature of impurities :-

(i) Organic impurities :-

If Present in water they Promote growth of micro-organisms.

(ii) Inorganic impurities :-

- They are of natural origin
- They are harmless, but that induced by humans are hazardous.

Ex :- Cadmium, Chromium, nickel, lead, zinc, mercury etc. are toxic.

3. State of matter :-

(i) Physical impurities
(ii) Chemical impurities
(iii) Biological impurities.

Physical water quality :-

- Physical water quality Parameters are those which respond to human senses.

① Temperature (10°C to 20°C)

(i) Warm temp. is ideal for microbial growth
(ii) Solubility of gases dependent of temp. Higher the temp. lower will be solubility.
(iii) Chemical reactions are temperature controlled.

② Colour :- (5 TCU to 20 TCU)

Apparent Colour → Suspended Solid

True Colour → dissolved substances

- Colour in water measured on Burgess Scale (Platinum scal and expressed in terms of True colour units (TCU) by using device known as "Tintometer".

1 TCU = 1 mg of Platinum as a Chloroplatinate ion mix...

- The colour of water is usually due to Presence of Organic matter in colloidal condition, but sometimes it is also due to mineral and dissolved organic and inorganic impurities.

- The Permissible colour for domestic water is 20 p.p.m on Platinum Cobalt Scale.

(iii) Turbidity:—

- It is caused due to Presence of Suspended and colloidal matter in the water.
- The character and amount of Turbidity depends on the type of soil over which the water has moved.
- Ground waters are generally less turbid than the surface water.
- Turbidity is measured by:—
  - (i) Devices working on the Principle of light Absorption
  - (ii) Device working on the Principle of light scattering

(iv) Tastes and odours:—

- Tastes and odours in water may be due to the Presence of dead or live micro-organisms; dissolved gases such as hydrogen sulphide, methane, carbon dioxide or oxygen combined with organic matter; mineral substances such as sodium chloride, iron compounds and ...

... also changes with temp. ...

- The odour of water also changes with temp. ... may be classified as fishy, mouldy, sweetish, vegetable, greasy etc.
- Odour in water is measured by a device known as "Osmoscope".
- Odour is expressed in terms of "TON" (Threshold odour Number).

Chemical Tests:-

(i) **Total Solids:-**

- These include the solids in suspension, colloidal and in dissolved form.
- The quantity of suspended solids is determined by filtering the sample of water through a fine filter, drying and weighing.
- The quantity of dissolved and colloidal solids is determined by Evaporating the filtered water and weighing the residue.

(ii) **Hardness:-**

- It is the properties of water which prevents the lathering of the soap.
- It is caused due to the presence of carbonates and sulphates of calcium and magnesium in the water.
- ... of chlorides and nitrates of ... the presence of ... the water.

(iii) Chlorides :—

- Sodium chlorides is the main substances in chlorides wat
- The natural water near the mines and sea have dissolve sodium chloride.
- The Presence of chlorides is dangerous and unfit for use.
- The chloride can be reduced by diluting the water.
- Chlorides above 250 P.P.m are not Permissible in water.
- The chloride can be determined by titrating the [water] with silver nitrate and potassium chromate.
- [In] this titration Process reddish colours will be formed [if] chlorides are Present.

Chlorine :—

- Dissolved free chlorine is never found in natural wat[er].
- It is Present in the treated water resulting from disinfection [by] chlorine.
- Chlorine remains as residual in treated water [for] the Sake of Safety against Pathogenic bacterias.
- The residual Chlorine should remain between 0.5 P.P.m [and] 2 P.P.m in the water so that it remains safe against [these] bacteria.

(v) Iron and Manganese :-

- These are generally ~~used~~ found in ground water.
- If these are present less than 0.3 p.p.m, it is not objectionable, but if exceeds 0.3 p.p.m, the water is not suitable for domestic, bleaching, dyeing and laundering purposes.
- The presence of iron and manganese in water makes ~~brownish~~ brownish red colour in it, leads to the growth of micro-organism and corrodes the water pipes.
- ~~The~~ Iron and manganese also cause test and odour in the water
- The quantity of iron and manganese is determined by colorimetic methods.

(vi) P.H :-

- Depending upon the nature of dissolved salts and minerals the water found in natural sources may be acidic or alkaline.
- The acidity or alkalinity is usually measured in P.P.m

$$\text{Conc. of } H^+ = \frac{10^{-14}}{\text{Conc. of } OH^-}$$

- A measure of how acidic or basic a substance or solution is.
- The P-H value of a water is generally determined by colorimetric method or Electrometric method.

(vii) Lead and Arsenic :-

- These are not usually found in natural waters. But sometimes lead is mixed up in water from lead pipes or from tanks lined with lead paint when water moves through them.

- These are poisonous and dangerous to the health of Public.

(viii) Dissolved Gases :-

- Usually it has been found that water contains various dissolved gases present in it.

- The following are some of the gases mostly found in the natural water.

(i) Oxygen (ii) Carbon-dioxide.

(ix) Nitrogen :-

- ~~Nit~~ The Presence of nitrogen in the water indicates the Presence of organic matter in the water.

- The nitrogen may be Present in the water in one or more of the following forms:-

(i) Nitrites (ii) Nitrates (iii) Free Ammonia (iv) ~~Albuminoid~~ Albuminoid nitrogen.

(x) Metals and Other Chemical Substances :-

- Water contains various types of minerals or metals such as iron, manganese, copper, lead, barium, cadmium, selenium, fluoride, arsenic etc.

Q:— $p^H = 4.1$

$-\log[H^+] = 4.1$

$[H^+] = 10^{-4.1} = 7.94 \times 10^{-5}$ mol/L

Biological Tests:—

In a biological test or bacteriological analysis, the following two tests are done:—

(i) Total count of bacteria:—

– In this method total no. of bacteria present in a millilitre of water is counted.

– The Sample of water is diluted, 1 ml of Sample water is diluted in 99 ml. of Sterilized water.

– Then 1 ml of diluted water is mixed with 10 millilitre of agar of gelatine.

– This mixture is then kept in incubator and colonies of bacteria are counted by means of micro-scope.

– Then the product of the number of colonies and the dilution factor will give the total number of bacteria per millilitre of undiluted water Sample.

(ii) Bactria Coli (B-Coli) Test:—

– There are two tests for B-Coli, First is Presumptive

(i) Presumptive

(ii) Confirmative.

– In the Presumptive test definite amount of diluted Sample of the water in Standard fermentation tubes containing lactose broth as culture medium is kept in ... 37

for 24- 48 hours.

- If some gas is Procedured in the formentation tube, it indica

the Presence of B-coli.

- In the confirmation test some sample from the Presumptive

is taken and placed in another formentation tube containing

"brilliant green lactose bile" as culture medium.

- It is again kept in incubator at 37°c for 48 ho

if there is formation of gas in the tube, it confirms

the Presence of B-coli and the water is unsafe for use.

Water born diseases:-

- Infectious diseases spread from infected person to another person through various routes.

- Water borne diseases spread through water contaminated with human or animal faces including food and utensils, which have been washed with the contaminated water and dirty hands.

- These diseases are also known as faeco - orally trans diseases.

Water gets contaminated under poor hygienic and in-sanitary conditions.

- The risk of water - borne diseases is higher in areas w

(i) Inadequate water supply

(ii) Poor quality of water and sewage pipelines

(iii) Poor sanitary conditions.

(iv) Poor system for the disposal of ...

Name of the disease	Organism causing the disease	Category
1. Cholera	Vibrio cholerae or Vibrio - Comma	Bacteria
2. Typhoid	Salmonella typhi	Bacteria
3. Paratyphoid	Salmonella Paratyphi	Bacteria
4. Dysentry	Shigella dysentera	Bacteria
5. Amobiasis	Entamoeba & Hystolyticae	Protozoa
6. Giardiasys	Giardia Lamblia	Protozoa
7. Jaundice	Infectious Hepatitis	Virus
8. Polio	Polio myelitis	Virus.

Quantity of Water

- while designing the water Supply Scheme for a town or city, it is necessary to determine the total quantity of water required for various Purposes by the city.

Types of demand

(i) Domestic water demand
(ii) Commercial and Industrial demand
(iii) Fire - demand
(iv) Demand for Public uses.
(v) Compensate losses demand.

Domestic water demand :-

- The total Consumption in this demand, generally amounts to 55 to 60% of the total water consumption the break up of 135 ltr /day /Person.

> Water demand is defined as the volume of water requested by users to satisfy their needs.

(iii) Commercial and Industrial Demand

- Commercial building and commercial centres include office building, warehouses, stores, hotels, shopping centres, health centres, schools, temples, cinema houses, railway and bus stations etc.
- The water requirements of commercial and public places may be upto 45 litres/day/capita.
- The quantity of water demand for industrial purpose is around 20% to 25% of the city.

(iv) Fire demand :-

- Generally, in a moderate fire breakout, three jet streams are simultaneously thrown from each hydrant; one on the burning property and one each on adjacent property on either side of the burning property.

The quantity of water required for fire fighting is generally calculated by using the following empirical formulae :-

(a) National Board of Fire Underwriters formula :-

$$Q = 4640\sqrt{P}\,(1 - 0.01\sqrt{P})$$

Q = Quantity of water required in ltr/min.

P = Population of the town in thousands.

(b) Freeman formula :-

$$Q = 1135.5\left(\frac{P}{10} + 10\right)$$

(c) Kuichling's Formula :-

$$Q = 3182\sqrt{P}$$

(d) Buston's formula:—

$$Q = 5663\sqrt{P}$$

4) Demand for Public-Use:—

- Quantity of water required for Public utility Purposes such as for washing and Sprinkling of roads cleansing of sewers, watering of Public Parks, gardens, Public fountains etc., comes under Public demand.
- To meet the water demand for Public use, Provision of 5% of the total consumption is made while designing the water works for a city.

5) Compensate Losses demand:—

- In some way, some quantity of water is lost due to unauthorised and illegal connections.
- while estimating the total requirement of water of a town, allowance for these losses and wastages should also be done.
- Generally allowance of 15% of the total quantity of water is made to compensate for losses, thefts and wastage of water.

Percapita demand:—

It is the annual average amount of daily water required by one person and includes the domestic use, industrial and commercial use, Public use, wastes, thefts etc.

$$\text{Percapita demand} = \frac{Q}{P \times 365} \text{ litres/day}$$

where Q = Total quantity of water required by a town per year in litres.

P = Population of the town.

Year	Population
1980	22,500 + 1×4833 = 27,333
1990	27333 + 1×4833 = 32,166
2000	32166 + 1×4833 = 36,999

2. Geometrical Increase method :-

- This method is based on the assumption that the Percentage increase in Population from decade to decade remains Con[stant].
- In this method the average Percentage of growth of la[st] few decades is determined, the Population forecasting is done on the basis that Percentage increase per decade will be the same.

$$P_n = P\left(1 + \frac{I_G}{100}\right)^n$$

P = Present Population.

I_G = Average Percentage growth.

n = Population at the end of 'n' decade.

Year	Population
1940	8,000
1950	12,000
1960	17,000
1970	22,[illegible]

Soln

Year	Population	Increase in Population	% increase in Population
1940	8,000		
		4000	$\frac{4000}{8,000} \times 100 = 50.0\%$
1950	12,000		
		5,000	$\frac{5000}{12000} \times 100 = 41.7\%$
1960	17,000		
		5,500	$\frac{5,500}{17000} \times 100 = 32.4\%$
1970	22,500		
Total		14,500	124%
Average per decade		4,833	41.37

The Population at the end of various decades shall be as follows:—

Year	expected Population.
1980	$22,500 + \frac{41.37}{100} \times 2250$ $= 31,808$
1990	$3,1808 \times \frac{41.37}{100} \times 31,808 = 44,967$
2000	$44,967 + \frac{41.37}{100} \times 44,967 = 63,570$

③ Incremental Increase method:—

— This method is improvement over the above two method.

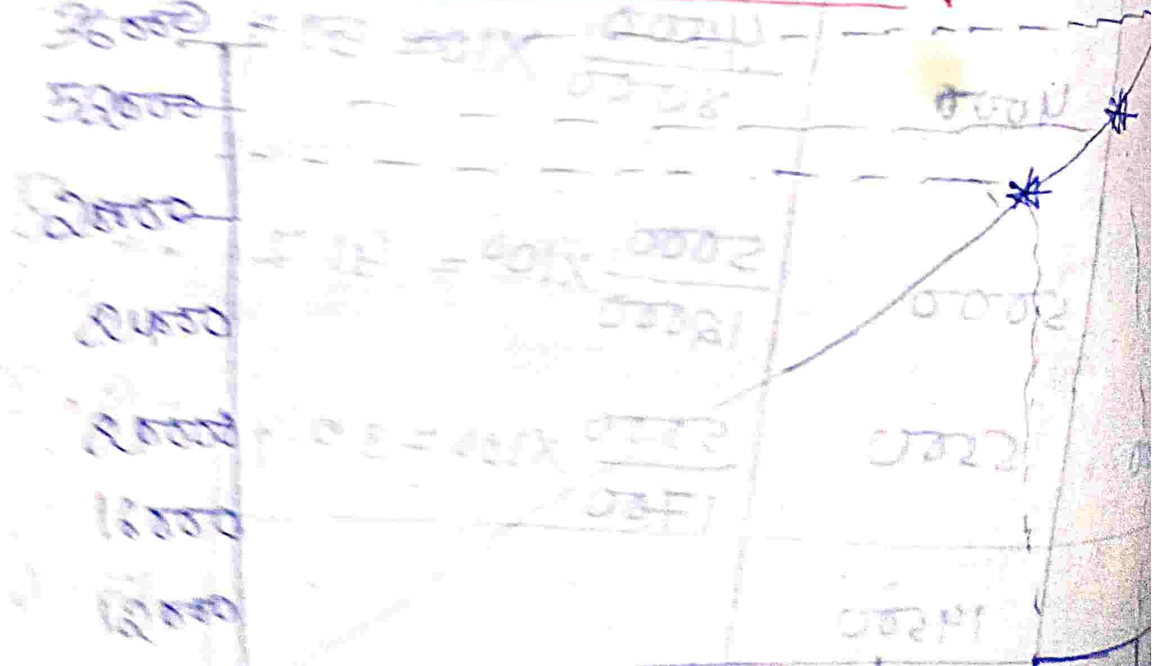
- The average increase in the Population is determined by the arithmetical method and to this is added the average of the net incremental total increase once for each future decade.

Curve is smoothly extended to forecast Population.

- The graph of Present City is Plotted and it will show the growth curve.

Year	Expected Population
1980	27,500
1990	32,000
2000	36,000.

6) Comparative Graphical method:-



- In this method, the cities having conditions and characteristics similar to the city whose future population is to be estimated are first of all selected.

7- The master plan method or zoning method:-

- The development of towns and cities is not allowed in haphazard way. The city is divided into various zones such as commercial centres, industrial area, residential area, the schools, colleges, parks etc.
- The future expansion of the cities is strictly regulated by various by laws of corporations and other local bodies according to the master plan.
- The master plans are prepared for the development of the cities for 25 - 30 years.

8 Logistic Curve method:-

- If the population of a town is plotted with respect to time, the curve so obtained under normal conditi[ons]
- The early growth of the city is shown by curve JK at an increasing rate of $\frac{dP}{dt} \propto P$.
- Growth rate between point K to M $\frac{dP}{dt}$ = constant.

- This transition

of inflexion, L.

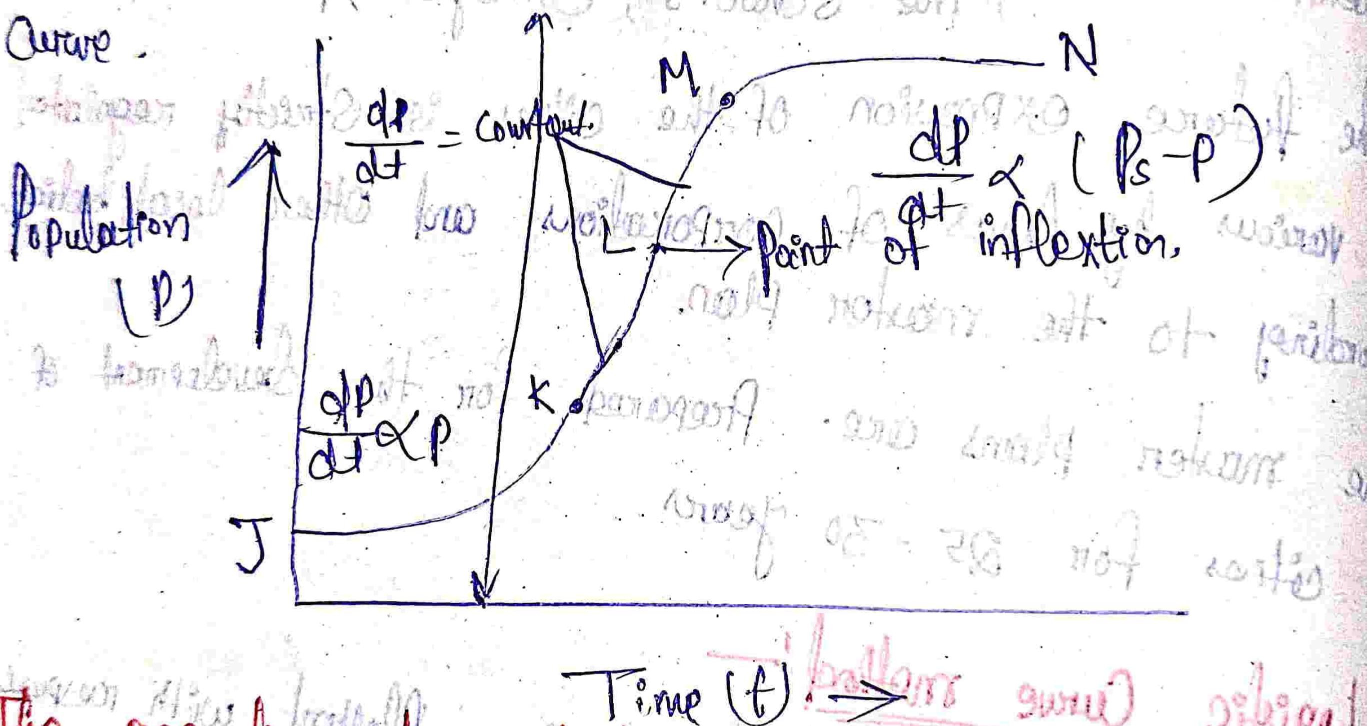
- Later on the growth from M to N follows the decrea

rate i.e. $\frac{dP}{dt} \propto (P_s - P)$

where P is the population of the to at point 'l' from the origin 'J'.

$P_s \Rightarrow$ The saturation value of the population

- The S-shaped curve JKLMN is called logistic curve.



The apportionment Method:—

- This is also known as the ratio method of forecasting future population.
- In this method the census population record is expressed as the percentage of the population of the whole country.
- This method is suitable for those towns and cities

whose development is likely to take place according to the national growth.

Factors affecting water demand :—

(i) Climate conditions.

(ii) Size of community

(iii) Living Standard of the People

(iv) Industrial and commercial activities

(V) Pressure in the distribution system

(Vi) System of Sanitation.

(Vii) Cost of water.

(i) Climate Conditions :—

— The quantity of water required in hotter and dry places is more due to use of air coolers, air conditioners, sprinkling of water in lawns, gardens, courtyards, washing of rooms, more washing of clothes and bathing etc.

— In Cold countries Sometimes the quantity of water required is less as compared with hotter climates.

(ii) Size of Community :—

— The Per capita water demand of the town will increase with the Size of the town, because more water will be required in street washing, running of Sewers, maintenance of parks and gardens.

(c) Living Standard of ...

- The Per capita demand of the town increase with the standard of living of the people.
- The people will start use of air conditioners, room coolers, maintenance of lawns, use of automatic disc washing and other appliances etc. with the rise in their standard of living.

(d) Industrial and commercial activities :-

- As the quantity of water required in certain industries is much more than the domestic demand, their presence in the town will enormously increase the per capita demand of the town.

(e) Pressure in the distribution system :-

- The rate of water consumption increases with the increase in the pressure of the building and even with the required pressure at the farthest point, the consumption of water will automatically increase.

(f) System of Sanitation :-

- The percapita demand of the towns having water carriage system will be more than the town where this system is not being used.

(g) Cost of water :-

- The cost of water directly affects its demand if the water cost is more, less quantity of water will be used by the people as compared when the

Pumping

Circumstances under which Pumping is Required:—

- The function of the Pump is to lift the water or any fluid at higher elevations or higher Pressure.
- In water works Pumps are required under the following circumstances:—

(i) At the sources of water to lift the raw water from rivers, streams, wells etc. and to Pump it to the treatment works.

(ii) For the back washing of filters and increasing their efficieny.

(iii) For Pumping the chemical solution at treatment Plant.

(iv) For Pumping the treated water directly in the water mains for its distribution.

(v) For filling the elevated distribution reservoirs or overhead tanks.

Classification of Pumps:—

(a) Classification based on their Principle:—

(i) Displacement Pumps.

(ii) Centrifugal Pumps

(iii) Air lift Pumps

(iv) Impulse Pumps,

... casing of ... through suction

- The water enters in the cylinder through the valve.
- Now when the Piston moves inwards, it forces the inside water of cylinder outward through the delivery pipe.
- In this way the flow of water is not continuous but it is intermittent and gives vibration, shock and loss of energy.
- This condition can be partly overcome by using double acting pumps.

2) Double acting Pump :-

These Pumps have two sets of suction and delivery valve.

The discharge in these pumps depends on the number of revolutions per minute of the pump and the efficiency varies from 40% - 85%.

Rotary Pumps :-

- The revolving blades fit closely in the casing and push the water by their displacement.
- The blades revolve in a downward direction at the centre and the water is carried upward around the side of the casing.
- In this way the water is pushed through the discharge pipe and partial vacuum is created on the suction ~~pipe~~ side.
- The intensity of the vacuum mainly depends ~~on~~ on the tightness of the parts.
- Rotary pumps are not suitable for handling liquid containing suspended matter, because of the close fitting of the rotores in the casting.
- The efficiency of these pumps is between 50%-85%. .

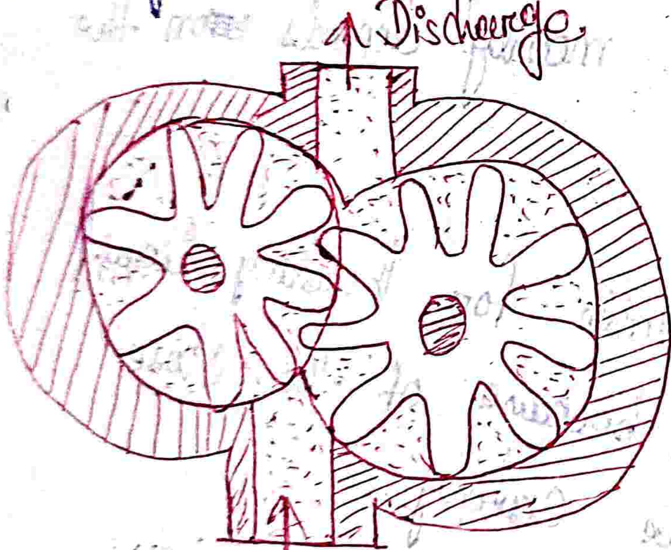
Advantages :-

- They do not require any priming as they are self-primed.
- The efficiency of these pumps is high at low to moderate heads upto discharge of 2000 lt/min.
- These pumps have no valves, are easy in construction and maintenance as compared with reciprocating pumps.

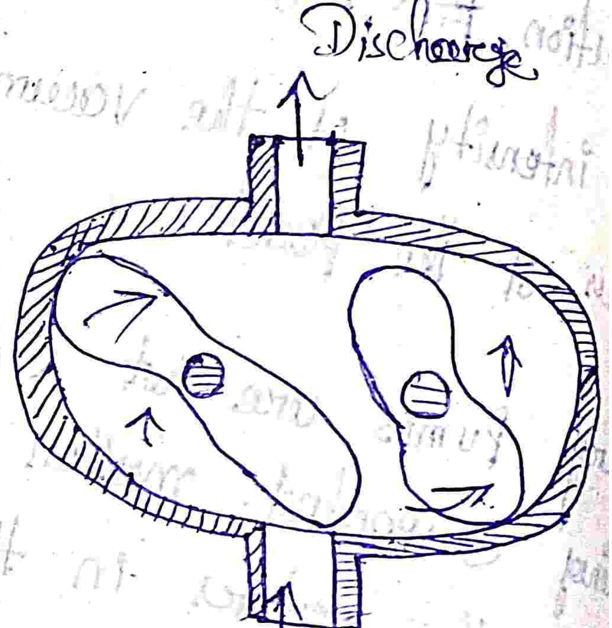
- These Pumps give steady and [illegible] flow w[illegible]
any Pulsations.
- These Pumps can be easily employed for the building water supply and for fire Protection.

Disadvantages of Rotary Pumps :—

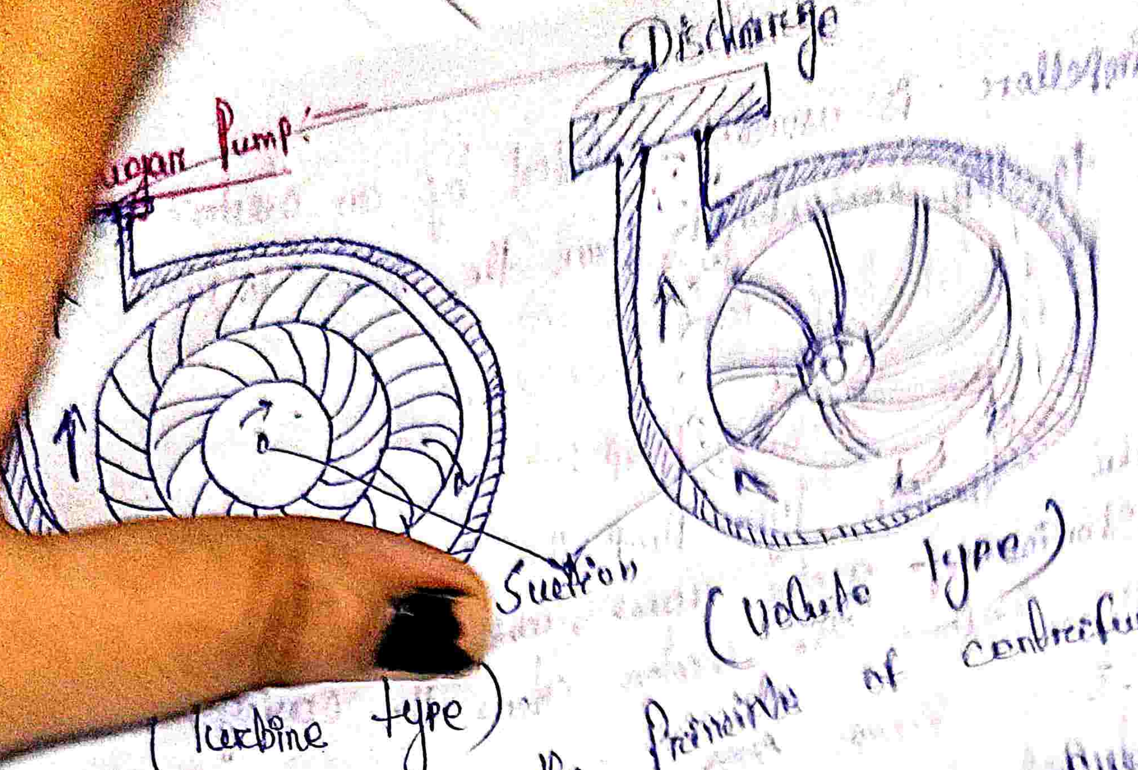
- The initial cost of these pumps is high.
- Their maintenance cost is high due to abrasion [illegible] their cams and gear.
- They can't Pump water containing suspended im[illegible]



(Rotary Pump with gear)



(Rotary pump with ca



- These pumps works on the principle of centrifugal force, therefore, named centrifugal pumps.
- The water which has entered inside the pumps is revolved at high speed by means of impeller and is thrown to the periphery by the centrifugal force.
- The water enters in the pump at the centre of the impeller called the eye usually at right angle to the plane of the impeller.
- There are two types of centrifugal pumps:—
  (i) Volute type centrifugal pump.
  (ii) Diffuser or Turbine type centrifugal pump.

(i) Volute type Centrifugal Pump:—

- In this pump the channel into which the water flows after leaving the impeller has a volute shape of such that the velocity of flow remains the same at all points in the channel.

- The impeller is usually rotated by an electric motor and due to the centrifugal force the water to raise in the delivery pipe at high rate.

(ii) Diffuser or Turbine Pump :-

- In the turbine type pump the impeller is surrounded the stationary guide vanes, which reduce the velocity of water before the water enters the casing.

- Thus, these pumps ~~are~~ convert the velocity head into pressure head in the casing itself.

- The casing surrounding the guide vanes is usually circular and concentric with the impeller.

- In this pump, the channel into which the water flows on leaving the impeller has the same cross-sectional area throughout.

- The velocity of the water which leaves the impeller blades is changed in direction and the velocity head is changed to pressure head by means of diffuser vanes.

- Centrifugal pumps using one impeller are known as single stage pumps.

- Pumps using two or more impellers are called as double or multistage pumps.

Advantages:—

(i) Due to compact design, they require very less space.

(ii) They can be fixed to high speed electric motor.

(iii) They have rotary motion due to which there is no noise.

(iv) They are cheap in cost.

(v) They have simple mechanism due to which they can be easily repaired.

(vi) They have very smooth operation.

(vii) They cannot be damaged due to high pressure.

Disadvantages:—

The rate of flow of water cannot be regulated.

- They cannot be operated without priming.
- For operation they have restricted suction.
- Any air leakage on suction side will affect the discharge of the pump.
- They have high efficiency only for low head and discharge.

Intakes

The main function of the intakes works is to collect the water from the surface source and then discharge water so collected, by means of pumps or directly, to the water treatment plant.

Design of Intakes:—

- Sufficient factor of safety should be taken so that intake work can resist external forces caused by heavy waves and currents, impact of floating and submerged bodies and ice pressure etc.

- Intake should have sufficient self-weight, so that it may float by the upthrust of water and washed away by the current. To prevent floating of intake structure massive masonary work should be done and broken stones should be filled in the bottom.

- If intake work is constructed in navigation channels it should be protected by clusters of piles all around from the blows of the moving ships and steamers.

- The foundations of intake should be taken sufficient deep so that they may not be undermined and current may overturn the structure.

- To avoids the entrance of large and medium objects and fishes, screen should be provided on the inlets, sides

- The inlets of intakes should be of sufficient size and allow required quantity of water to enter.

Types of Intakes :-

- Intakes are used to collect water for water works from various sources, the sources may be lakes, rivers, reservoirs or canals.
- Depending upon the source of water the intake is divided into 4 types :-
  - (i) Lake intake
  - (ii) Reservoir intake
  - (iii) River Intake
  - (iv) Canal Intake.

(i) Lake intake :-

- For obtaining water from lakes mostly submersible intakes are used.
- These intakes are constructed in the bed of the lake below the low water level so as to draw water in dry season also.
- It essentially consists of a pipe laid in the bed of the river.
- One end, which is in the middle of the lake is fitted with bell mouth opening covered with a mesh and ... timber or concrete crib.

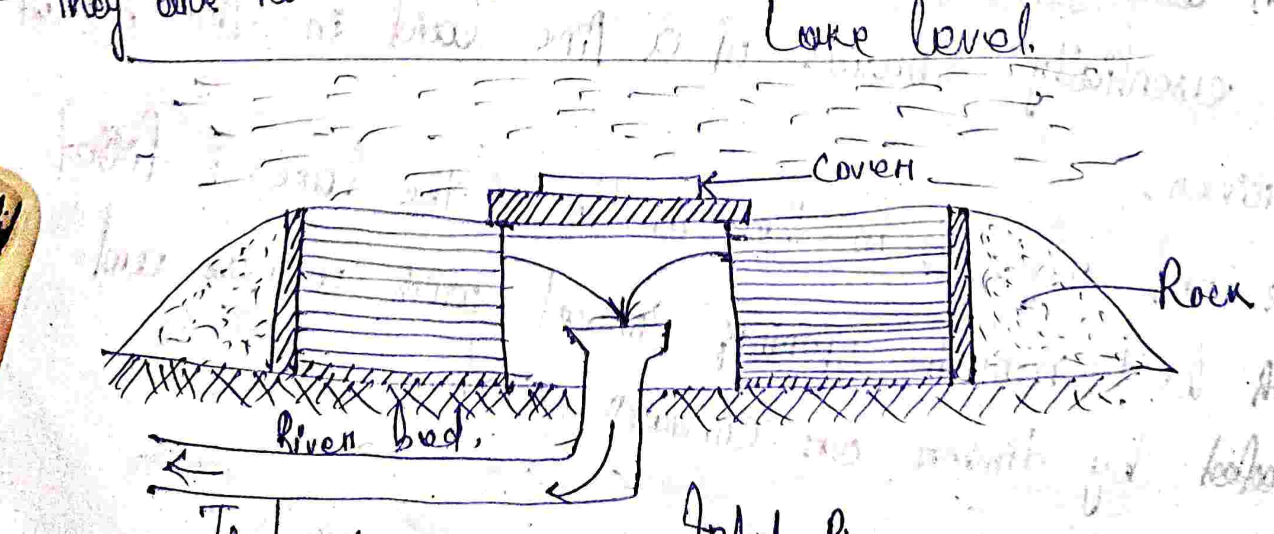
- The water enters in the pipe through the bell mouth opening and flows under gravity to the bank where it is collected in a sump-well and then pumped to the treatment plants for necessary treatment.

Advantages :—

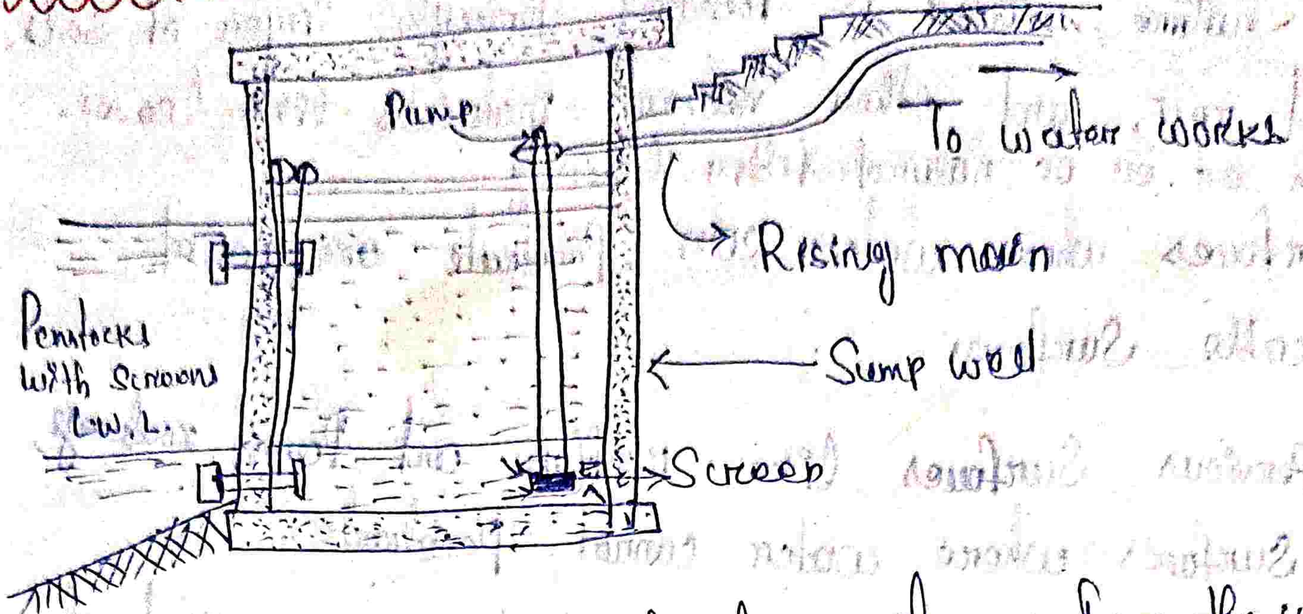
- No obstruction to the navigation.
- No danger from floating bodies
- No trouble due to ice.
- If one pipe is not sufficient two or more pipes may be laid to get the required quantity of water.
- These intakes are cheap in construction, therefore are widely used for small water supply schemes which collect their water from streams or lakes.

Disadvantages :—

- As these intakes draw small quantity of water, these are not used on big water supply schemes on rivers or reservoirs.
- They are not easily approachable for maintenance work.



River Intake:—



- Water from the rivers is always drawn from the upstream side, because it is free from the contamination caused by the disposal of sewage in it.
- The above fig. shows a typical intake used to draw water from the rivers.
- It is circular masonary tower of 4 – 7 metres in diameter constructed along the bank of the river at such place from where required quantity of water can be obtained even in the dry period.
- The water enters in the lower portion of the intake known as sump-well from penstocks.
- The penstocks are fitted with screens to check the entry of floating solids and are placed on the downstream side so that water from ~~the sump-well~~ ~~of the~~ free from most of the suspended solids may only enter the jack-well.

Natural Purification of water Source:-

- In nature, water is filtered through layer of s
Sand, rock, and other natural materials like leav
which act as a natural filter, trapping

- Surfaces where water can Penetrate are called Permeable Surfaces.

- Impervious Surfaces, like rooftops and Paved roadw are surfaces where water cannot Penetrate.

- Nature Purifies water through a Process called nat filtration.

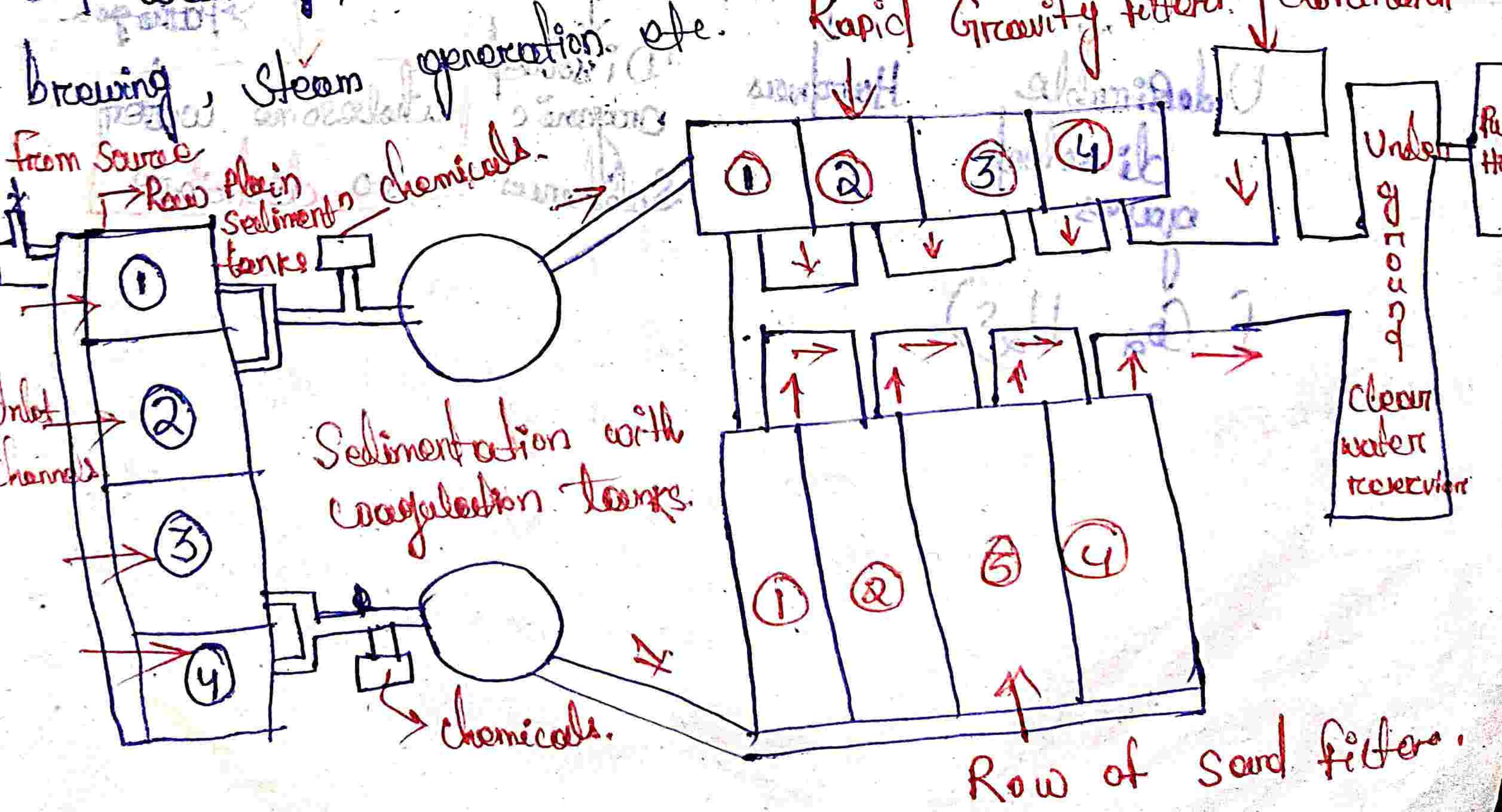
- In nature water is filtered through layers of soils Sand, rock and other natural materials which act as a natural filter, trapping and removing Pollutants, Contaminates Contaminants, and debris from the water.

- Sunlight is considered to be one of the mos natural ways to Purify water.

Module – III

Objectives of Water Treatments:—

- The main object of the treatment Process is to remove the impurities of raw water and bring the quality of water to the required standards.
- To remove the dissolved gases, murkiness and colour of water.
- To remove the unpleasant and objectionable tastes and odours from the water.
- To kill all the Pathogenic germs, which are harmful to the human health.
- To make water fit for domestic use as cooking and washing, and various industrial Purposes as dyeing, brewing, Steam generation etc.



Water Treatment

- Surface water Treatment
- Ground water Treatment

(i) Surface water Treatment :-

Raw water → Plain Sedimentation → Coagulation → Filtration → Disinfection → wholesome water to distribution.

- Plain Sedimentation ↓ Suspended Particles
- Coagulation ↓ colloidal Substances
- Filtration ↑ Dissolved organic Solids
- Disinfection → Pathogens

(ii) Ground water Treatments :-

Ground water → Aeration → Softening → filtration → Disinfection → wholesome water to distribute

- Aeration: ↓ O_2 in; ↓ Undesirable dissolved gases (CO_2, H_2S)
- Softening ↓ Hardness
- filtration ↓ Dissolved organic Substances
- Disinfection → Pathogens

Sedimentation

- If the water contains suspended impurities of large si[ze], it is very economical to remove them by Preliminary Sedimentation.

- Sedimentation is the Process of removing suspended matter may settle down in the bottom due to force of gravity.

Advantages :-

- It lightens the load on the subsequent Process.
- The operation of subsequent Purification Process can be controlled in a better way, because plain sedimentation delivers less variable quality of water.
- The cost of cleaning the chemical coagulation basins is reduced.
- No chemicals is lost with sludge discharged from the plain settling basin.
- Less quantity of chemicals are required in the subseque[nt] treatment Process.

Principle of Sedimentation :-

- Any Particle which does not alter its size, shape and weight while raising or settling in any fluid is called discrete Particles.

1) Alluminium Sulphate :- $[Al_2(SO_4)_3 \cdot 18H_2O]$

- It is also called simply as alum.
- Alum which is available in market, is dirty grey Solid in the form of lumps containing about 17% aluminium Sulphate.

This is a chemical coagulant which is widely used in water treatment plants.

Alum reacts in water in the Presence of alkalinity; if natural alkalinity is not Present sufficient lime is added.

- The dose of alum should be 0.03 – 0.13 gm/ltr. depending upon the ~~turbidity~~ of water.
- The amount of alum required for coagulation mainly depends on the turbidity and colour of water.
- The Average dose is about 19 mg/litre.
- Filter alum is very effective coagulant and is now-a-days extensively used throughout the world.
- The main ~~objective~~ difficulty in using alum was to remove the water from floc and its disposal.

- This is an alkaline compound.
- The best grade is contains → $Al_2O_3 = 55\%$ (Aluminium oxide)
  → $Na_2O_3 - 4.5\%$ (Sodium carbonate)
  → $Na(OH) = 6.3\%$ (Sodium Hydroxide)
- This can be used for treatment very easily in the water having no alkalinity.
- It reacts very quickly and forms the Precipitate of aluminium hydroxide.
- $CaAl_2O_4$ is the required floc, which causes Sedimentation.
- Sodium aluminate does not increase the non-carbonate hardness and it can be easily mixed with lime and Soda ash solution.
- It has the further advantage of removing corrosive qualities of the water, But it is costly due to which it is not widely employed in the water works Practice.

(C) Ferric Coagulants:-

- Generally ferric chloride ($FeCl_3$), Ferric Sulphate ($Fe_2(SO_4)$) or the mixture of both is used for coagulation Purpose.

(d) Chlorinated Copperas:-

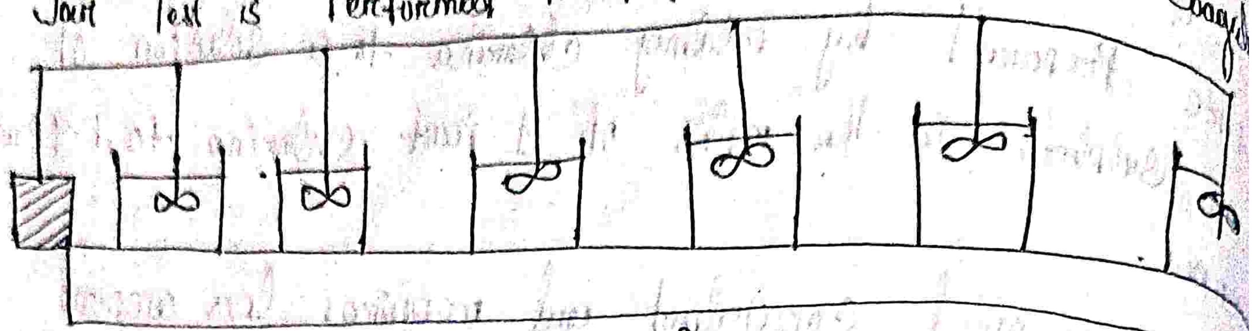
- It is a mixture of ferric chloride and ferrous sulphate prepared by adding chlorine to a solution of ferrous sulphate in the ratio of 1 part chlorine to 7.9 part copperas.
- It is very good coagulant and requires less amount of alkalinity in the water for floc formation.
- The produced floc is tough and easily settles due to which only small residue goes in the filters.
- This coagulant removes colours very well.

e) Ferrous Sulphate and Lime:-

- $Fe(OH)_3$ is the floc, which causes sedimentation.
- Feric coagulants are good oxidising agents due to which these also remove hydrogen sulphate, tastes and odours from the water.
- These coagulants are generally used in the treatment of sewage.
- Ferrous sulphate is commonly used in coagulation.
- It is cheaper than alum, and gives good results above PH-value of 8.5.

1 Jar Test :-

- Jar Test is Performed to find optimum dose of Coagulant



* Chemical conditioning (Coagulation)

Rapid mixing :- 1 to 3 min at 100 to 120 rpm (Uniform

- Physical Conditioning (Orthokinetic flocculation)

- Perikinetic flocculation :- Particles move and attract on their own.

Slow mixing :- 20 to 40 min at 1 to 3 rpm.

Water Softening

- The removal or reduction of hardness from the water is known as water softening.
- The main advantage of water softening is reduction in the consumption of soap.

Necessity of water Softening :-

- The raw water specially from the ground sources may contain large quantity of bicarbonates, sulphates, carbonates and chlorides of calcium and magnesium as dissolved impurities.

- These dissolved impurities of salts usually make the water hard.

- The hard water causes the following difficulties due to which its removal from the water becomes essential.

(i) More quantity of soap is consumed at home and in laundries for washing of clothes.

(ii) The fabric of clothes gets spoiled while washing it to remove precipitate formed by soap in hard water.

(iii) In industries hard-water forms scales in the boilers, due to which more fuel is wasted and boiler metals are overheated causing danger to the boiler plant.

(iv) Hard water creates serious troubles in the manufacturing process of textile, finishing, paper-making, dyeing, Rayon industry, ice-making etc..

(v) Hard-waters choke and clog plumbings due to precipitation of salts in them.

Removal of Temporary Hardness :-

If the water contains temporary hardness, it can be removed by :- (a) By Boiling

(b) By addition of lime water.

(a) By Boiling :-

- When water is boiled having temporary hardness, the following chemical reactions take places.

$$Mg(HCO_3)_2 \xrightarrow{\text{Boiling}} MgCO_3 \downarrow + CO_2 \uparrow + H_2O$$

(Magnesium Bi-carbonate) Magnesium carbonate

$$Ca(HCO_3)_2 \xrightarrow[\text{bi-carbonate}]{\text{Boiling}} CaCO_3 \downarrow + CO_2 \uparrow + H_2O$$

(Calcium hydrogen Carbonate) → Calcium carbonate

- The calcium and ~~Mang~~ Magnesium carbonates are insoluble in water and are removed by sedimentation tank.
- But this is very costly process and it is not possible to use it in water works.

- (b) Addition of lime water:—

- If the water of lime is added in the water containing temporary hardness, it can be removed by adding the lime water.

- The following chemical reactions take place, when the water of lime is added in the water.

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

Calcium hydroxide, magn...

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

Calcium carbonate

- The calcium carbonate and magnesium hydroxide are insoluble in water and get precipitated ~~can~~ and can be removed by sedimentation tank.

- This method is used in softening water which contains only temporary hardness.

Removal of [illegible]

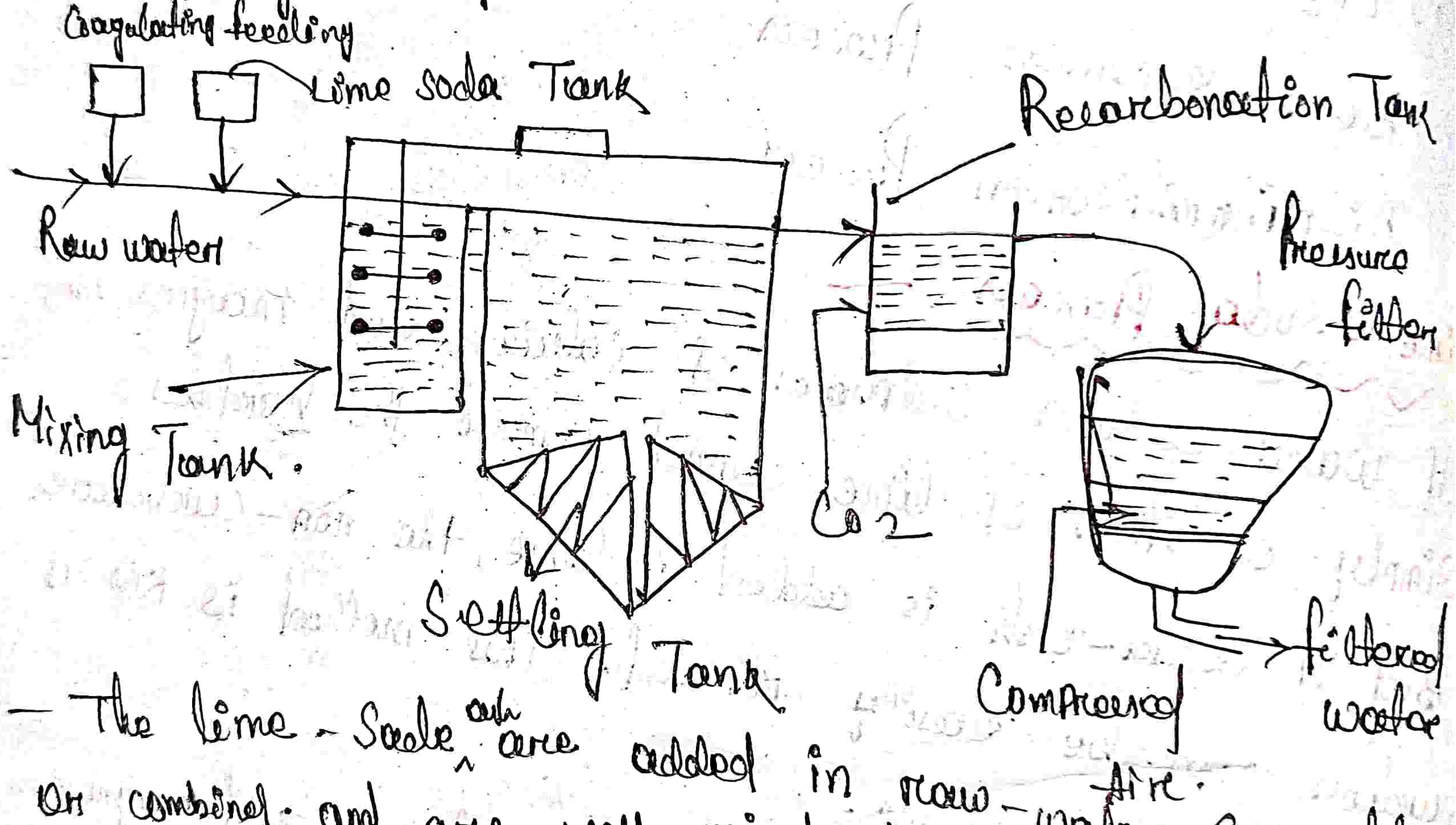
- Removal of Permanent [illegible]
and requires special [illegible]
removal.
- The methods employed for [illegible]
hardness from the water are [illegible]
methods.
(i) Lime - soda Process
(ii) Base - exchange Process
(iii) Di-mineralisation Process.

Lime - soda Process :-

- If water contains sulphates of calcium and magnesium,
simply addition of lime cannot remove the hardness.
- But if soda-ash is added in lime, the non - carbonate
hardness can be easily removal. This method is known
as lime - soda process.
- Lime react with bicarbonates of calcium and magnese[illegible]
to form carbonates and water. calcium carbonate is
insoluble and settles in the form of Precipitate.
[illegible] carbonates react with additional lime and
[illegible] hydroxide which is

- Magnesium and calcium sulphates and chlorides react with soda-ash and lime and form insoluble precipitates. ~~as is shown fro~~

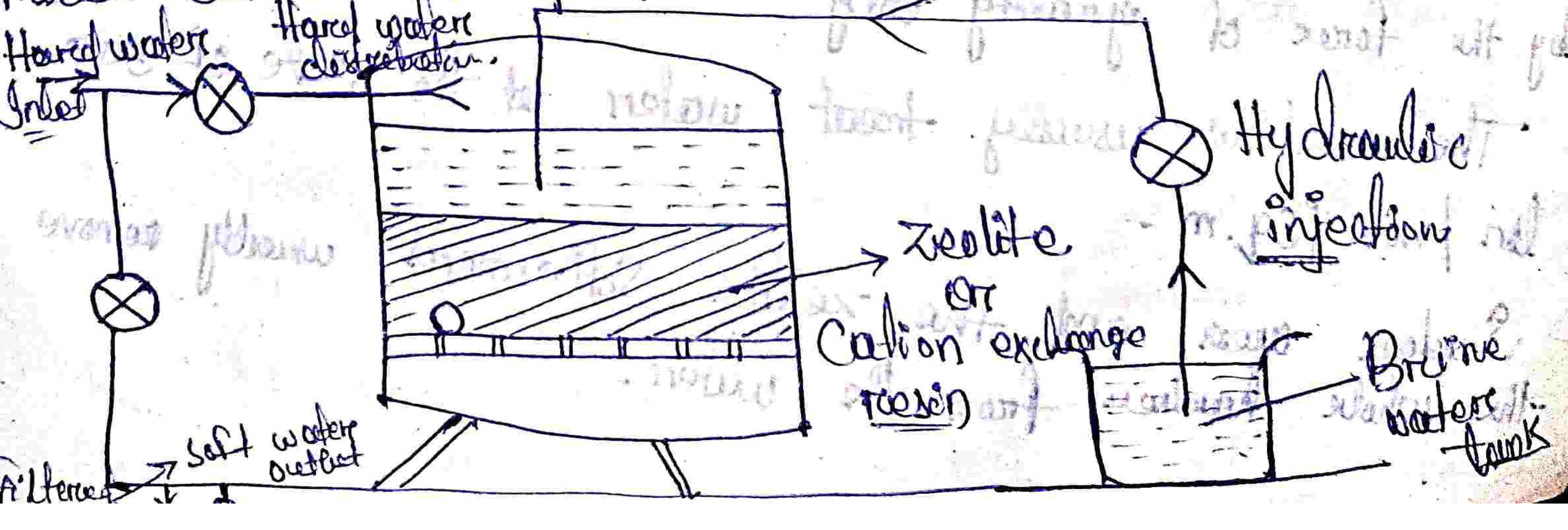
- while removing hardness by this method, lime is added in the begining and is allowed to form precipitates which are removed.
- The hardness which is not removed by lime alone is removed by adding soda-ash.



- The lime - soda ash are added in raw water separately or combined and are well - mixed together.
- The water is then allow to pass through the flocculator and sedimentation tanks.
- The feedings, mixing and good results the detention period is kept between 3- 4 hours.

(2) Base Exchange Process :—

- This Process is also known as zeolite or cation exchange Process.
- The Process depends on the ability of certain insoluble substances to exchange cation with other substances dissolved in water.
- The hard-water is passed through a bed of zeolite sand (Complex silicates of aluminium and sodium), while passing through in the Ca and Mg cation get replaced by sodium from the exchanger and the water becomes soft.
- The sodium from the zeolite sand goes on getting exhausted and after some time it can not remove the hardness of the water.
- But the reactions are reversible and the zeolite can be recharged by passing through it in a solution of common salt.
- ~~The Permutit Process or zeolite or base exchange Process can be easily follows~~



- The above figure shows the essentials of a zeolite softener.
- It resembles a pressure filter in appearance.
- In this unit zeolite is provided in place of filtering media of sand and gravel.
- The hard water is allowed to enter from the top and is evenly distributed over the bed of zeolite.
- After passing through the zeolite the treated water is collected at the bottom.
- When sufficient quantity of water has been treated and the calcium and magnesium has replaced the sodium of the zeolite.
- It is regenerated by passing ~~through the zeolite the~~ a solution of 10% common salt through it.
- The excess brine solution retained by the zeolite after the treatment is removed again by washing it with good water.
- Zeolite softener plants may be worked either with compressed air as in case of pressure filters or simply by the force of gravity only.
- The zeolites usually ~~treat~~ water at the rate of 300 ltr/min/sq.m.
- Surface area and the zeolite softeners usually remove the whole hardness from the

Advantages :—

- Zeolite Softener is a very compact and efficient unit, having less skill in maintenance as well as operation.
- No sludge is formed in this Process as in case of lime soda Process, therefore, there is no Problem of sludge disposal.
- This Process also removes Iron and manganese from water.
- The water having various degrees of hardness can be easily treated.
- No Problem of incrustation of Pipes arises with this Process as in case of lime-soda method.

Disadvantages :—

- This Process gives Sodium bicarbonate as residual, which causes Priming and foaming in industrial or boiler feed water, which is objectionable at such places.
- Water containing high turbidity cannot be efficiently treated with this, because suspended impurities will get deposited on the zeolite and create Problem for its working.

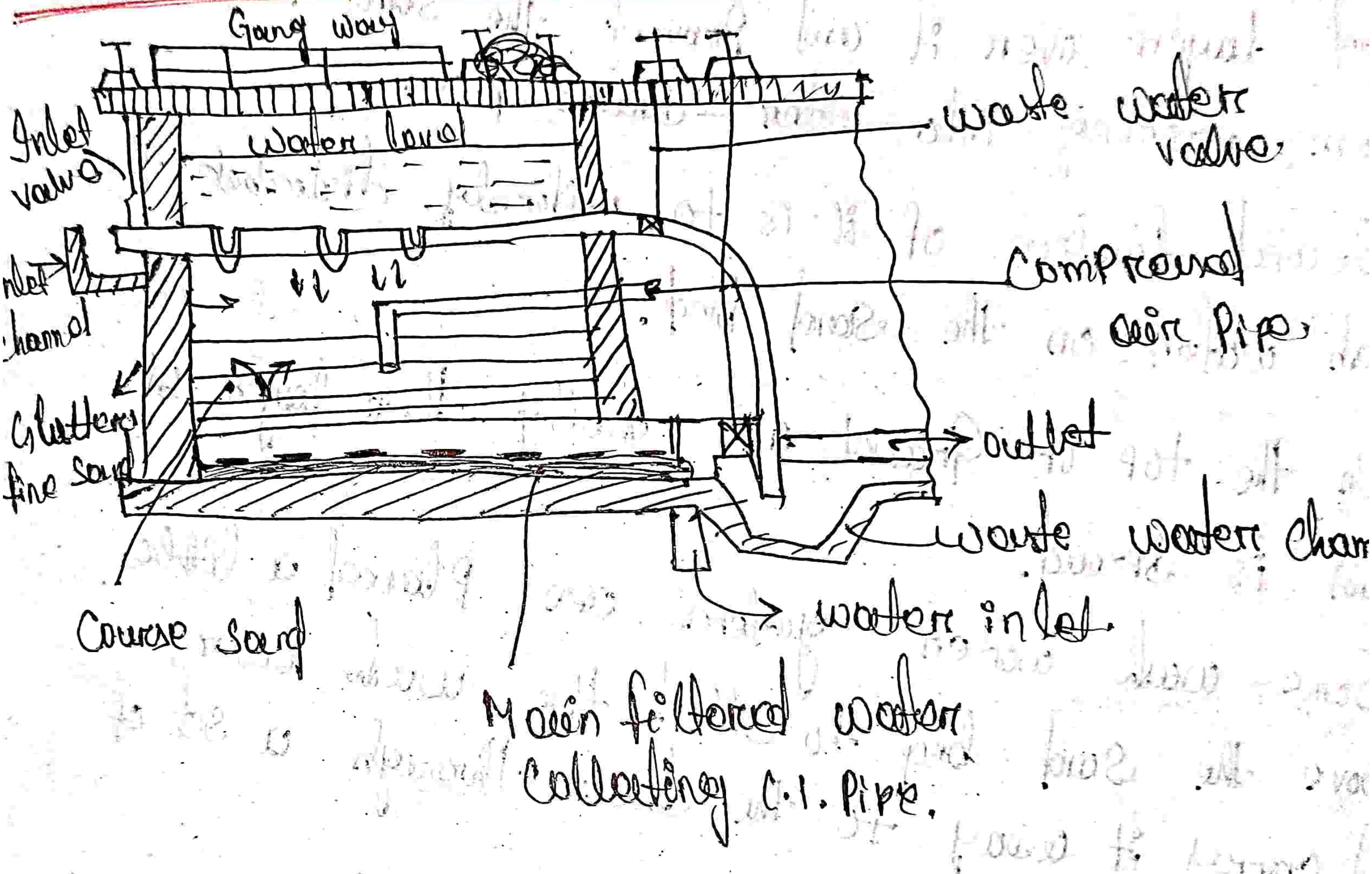
③ Dimineralisation Process :—

- The requirements of boiler feed water are that it should be free from all types of impurities.
- Such quality water can be obtained by diminerealisation Process which is known as de-ionised water.
- In this method first the minerals are removed by Passing the water through a bed of anion exchanges

- The slow sand filters can remove turbidity to the extent of about 50 ppm.
- For water having greater turbidity than 60 ppm, it is necessary to give Preliminary treatment.

Rapid Sand Filter :-

Construction of Rapid Sand filter :-



- The Above fig. clearly shows the constructional details of a rapid sand filter.
- It is essentially consists of an open watertight basi of masonary or concrete.
- On slopy floor of concrete, underdrainage system, Consisting of one central longitudinal conduit with lateral pipes connecting from all sides is laid.

- All Pipes of under-drainage system is embedded in 60 cm - 70 cm thick Graded gravel.
- The size of Gravel Varies from 2.5 cm at the bottom to 0.5 cm at the top.
- The size of Gravel depends on the rate of filtration.
- The size of Gravel depends on the rate of filtration, larger is the gravel size more the rate of filtration.
- The main function of Gravel layer is to support the Sand layer over it and Prevent the Sand Particles from entering into under-drain Pipes.
- Second function of it is to uniformly distribute the wash water on the Sand bed.
- On the top of Gravel an equally thick layer of Sand is Spread.
- Some wash water gutters are placed a little above the Sand bed to collect the wash water, and carry it away to the drain through a set of Pipes.
- The above fig. Shows the Section through a Rapid gravity filter.
- It essentially Consist of an open watertight rectangular tank, Constructed with masonary or concrete.
- The depth of the tank varies from 2.5 - 3.5 m.
- The Surface of each filter is kept between 10 m², 80 m²

- According to Morrell and Wallace to get ... the no. of rapid gravity filter units is :—

$$N = 1.22\sqrt{Q}$$

where N = No. of units
Q = The Quantity of water in million litre/day

- The filter media consists of coarse sand layers of effective size varying from 0.35 mm to 0.55 mm, having uniformity co-efficient $\frac{D_{60}}{D_{10}}$ ranging from 1.2 to 1.8.
- The base material consists of gravel in thickness of 60-90 cm.
- Usually five to six layers of 10-15 cm each are used.
- The size of the coarse gravel is about 40 mm and that of smallest is 3 mm.
- The gravel must be packed in uniform grading for proper and efficient function of the filter.

Operation of the filters:—

- The water from coagulation sedimentation tank enters the filter unit through inlet pipe and is uniformly distributed on the whole sand bed.
- Water after passing through the sand bed is collected through the underdrainage system in the filtered water well.

(i) It completely oxidizes the ammonia and other impurities of water.

(ii) The colour of water which is due to organic matters is also removed.

(iii) It completely destroys all the disease bacteria.

(iv) It removes taste and odour from the water.

(v) It prevents growth of weeds in water.

Super - chlorination:—

- Super - chlorination is defined as the administration of a dose considerably in excess of that necessary for the adequate bacterial purification of water.
- The adding of chlorine in excess is called "Super-chlorination".
- Super - chlorination gives a strong odour and taste of chlorine in the treated water, which can removed by dechlorination.

De - chlorination:—

- It is defined as the partial or complete reduction of residual chlorine in water by chemical or physical treatment.

In this method, Some chemicals are added for the reduce chlorine residual to a desired value.

(vi) By using Potassium Permanganate.

(vii) By treatment with Silver or electro-Katadyn Process.

Chlorine Demand :—

- Chlorine demand is defined as the difference between the amount of Chlorine added to water and the amount of chlorine remaining at the end of a specified contact Period.
- The chlorine demand for a sample of water depends on :—

(i) Nature and conc. of chlorine consuming Substances Present in water.

(ii) Time of Contact

(iii) PH- value of water

(iv) Temp. of water

(v) Variable Conditions in the Process of Chlorination.

(vi) And so many other factors.

Break - Point Chlorination :—

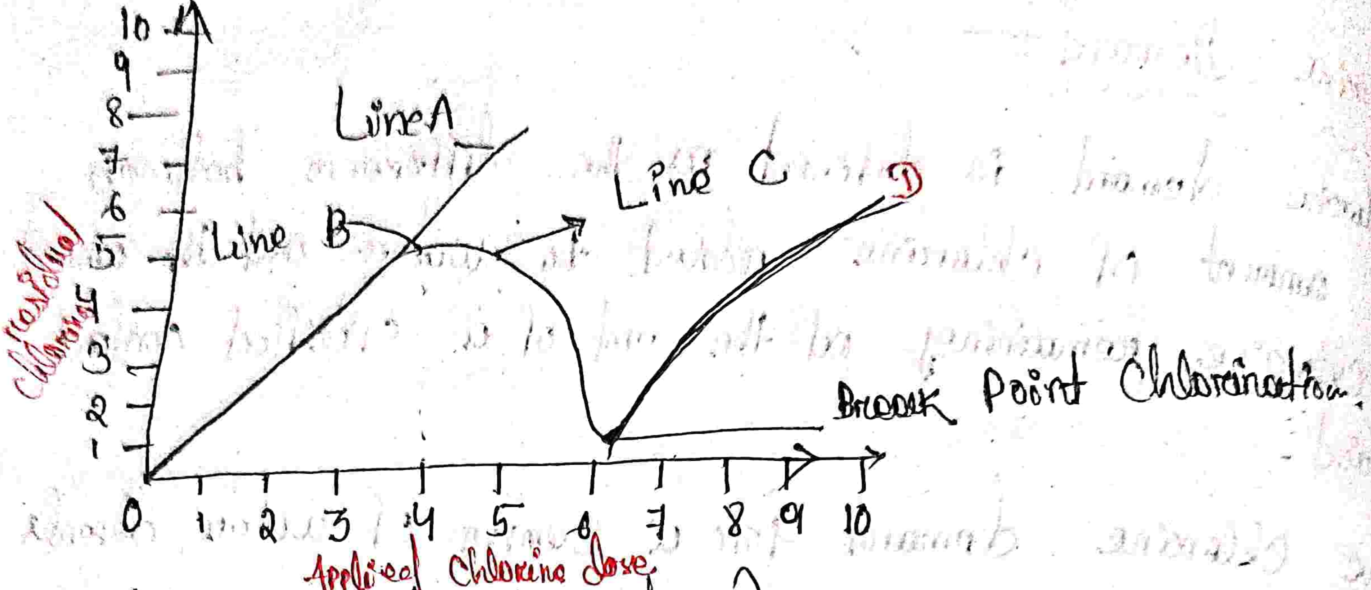
- When Chlorine is added to water it reacts with Organic and inorganic matter and forms common Com

- Some Portion of chlorine remains as res

~~which is not~~

- If the Chlorine dose is increased, the residual Chlorine also increase.

get oxidized and the substances which ~~new~~ are newly formed.



(Break – Point Chlorination)

- From the above fig. the curve it will be noticed that residual chlorine in the begining increases with the applied chlorine dose, but after point 'C' it suddenly drops upto point 'D' then increases.
- Portion 'OC' shows formation of chloramines and Portion CD shows their oxidation.
- Point 'D' at which residual chlorine again starts increasing is known as "Break – Point chlorination".
- After reaching this point if chlorine is added, it remains as free residual chlorine and curve becomes a straight line.
- The shape of the curve depends on the type of ammonia present in the water.

Module - IV

Generation and collection of waste water :—

- Wastewater comes from ordinary living process :— bathing, toilet flushing, laundry, dishwashing, etc.
- It comes from residential and domestic sources.
- Commercial waste-water comes from non-domestic sources, such as beauty salon, taxidermy, furniture refinishing, musical instrument cleaning or auto body repair shops.

- There are three types of waste-water or sewage :—
  (i) Domestic sewage
  (ii) Industrial sewage
  (iii) Storm sewage

(i) Domestic sewage :—

- Domestic sewage is slightly more than 99.9 % water by weight.
- The rest, less than 0.1 Percent, Contains a wide variety of dissolved and suspended impurities.

(ii) Industrial sewage :—

- Industrial waste-water usually contains specific and readily identifiable chemical compound, depending on the nature of the industrial process.

(iii) Storm sewage :—

- Storm sewage carries organic materials, suspended and dissolved solids, and other substances picked up as it travels over the ground.

- Sanitary sewage includes waste water from residences and industries.
- Sanitary sewage is also called as Dry weather flow
- Sanitary sewage is one system of sewers in and it flows only in dry season in separate system throughout the year and in dry season in Combined system.
- Combined system carries both the sanitary and storm sewage during monsoons.

Source of Sanitary Sewage :-

(i) Water supplied to the Public for domestic Purposes by the local authority.

(ii) Water supplied to the various industries for various industrial Process by the local authority.

(iii) Water drawn from wells by individual houses for their domestic Purposes.

iv) Water supplied by the local authority to various Public Places such as schools, cinemas, hotels, railway-Stations etc.

v) Water drawn from wells, lakes, Canals etc. by industries for their Purposes.

vi) Infiltration of ground water into sewers through leaky joints.

(vii) Unauthorised entrance of rain water in sewer lines.

Factors affecting sanitary [illegible]

(i) Rate of water supply

(ii) Population

(iii) Type of area served as residential, industrial or commercial.

(iv) Ground water infiltration.

Quantity of Storm Sewage

- When rain falls over the ground surface, a part of it percolates into the ground, a part is evaporated in the atmosphere and the remaining part overflows as storm or flood water.

- The quantity of storm water reaching the sewers or drains is very large as compared with sanitary sewage.

Factors affecting Storm sewage :-

(i) Area of the catchment area.

ii) Slope and shape of the catchment area.

iii) Nature of the soil and its degree of porosity.

iv) Obstructions in the flow of water as trees, fields, gardens etc.

v) Initial state of the catchment area with respect to wetness.

) Intensity and duration of rainfall.

) Atmospheric temperature, wind and humidity.

) Numbers and size of ditches present in the area.

Quantity of Storm-Water :—

- Generally there are two methods by which the quantity of storm-water is calculated :—
  (i) The Rational method.
  (ii) Empirical formulae method.

The rational method :—

- The storm water quantity is determined by the rational formula.

$$Q = \frac{C \cdot i \cdot A}{360}$$

where Q = Quantity of Storm-water in m^3/sec.
C = Co-efficient of runoff.
i = intensity of rainfall in mm/hour.
A = drainage area in hectares.

Empirical formulae method :—

For determining runoff from very large areas, generally empirical formulae are used.

(A) Burkli-Ziegler's formula

$$Q = \frac{C \cdot i \cdot A}{141.58} \sqrt[4]{\frac{S}{A}}$$

(B) Mc. Math's formula :—

$$Q = \frac{C \cdot i \cdot A}{148.35} \sqrt[4]{\frac{S}{A}}$$

c) Fuller's formula

$$Q = \frac{C \cdot M^{0.8}}{13.23}$$

(D) Fanning's Formula :-

$$Q = 12.8 M^{5/8}$$

(E) Talbot's Formula :-

$$Q = 22.4 M^{1/4}$$

where Q = runoff in cu.m/sec.

c = runoff co-efficient

i = intensity of rainfall in cm/hour

S = Slope of the area in metre per thousand metre.

A = drainage area in hectare

M = drainage area in square K.m.

Runoff co-efficient :-

- In rational method, the value of runoff co-efficient 'c' is required.
- The whole quantity of rain water that falls over ground does not reach the sewer lines or drains.
- A Portion of it Percolates in the ground, a Portion evaporates, a Portion is Stored in Ponds and ditches, and only the remaining Portion of rain water reaches the drains and Sewers.
- The runoff co-efficient is a fraction which is multiplied with the quantity of total rainfall, to determine the quantity of rain water which will reach the sewers.

$$\text{Runoff co-efficient } 'c' = \frac{A_1 \cdot C_1 + A_2 \cdot C_2 + \dots + A_n C_n}{A_1 + A_2 + \dots + A_n}$$

$$= \Sigma A \cdot C$$

and C_1, C_2, C_3 are their ... respectively.

Characteristics of Sewage :—

(i) Physical characteristics.

(ii) chemical characteristics.

(iii) Bio-logical characteristics.

(i) Physical Characteristics :—

(a) Colour :—

- Fresh domestic sewage has a soap solution colour.
- With the time of the colour of sewage begins to get black as the decompositions starts.
- The colour of the septic sewage is more or less black.
- The colour of the industrial sewage depends on the chemical process used in the industries.

(b) odour :—

- Fresh domestic sewage has slightly soapy or oil odour, but the stale sewage has offensive odour of hydrogen sulphide and other sulphur compounds.

Sewage is ...

(C) Temperature :-

- Generally the temp. of the sewage is ... than the water supply.
- If the temp. of the sewage is below the normal atmospheric temp., it will indicate the infiltration of ground of surface water, but in case of higher temperature it indicates the addition of industrial sewage.

(D) Turbidity :-

- The turbidity of the sewage directly depends on the quantity of solid matters present in it in suspension state.

(E) Solids :-

- The sewage contains more than 99.9 % of water and only 0.1 %. chemicals.
- These solids are present in sewage in suspended, dissolved and colloidal states.

Chemical Characteristics :-

- Normally fresh sewage is alkaline in nature but tends to acidity as it becomes stale.

- The organic compounds can be divided as containing nitrogen and free from nitrogen.

Biological Characteristics :—

(i) Bacteria :—

- There are two groups of bacteria, the higher and the lower bacteria.
- The largest bacteria is known as B – butse which is about 60 in. length and 5 in. diameter.
- The smallest bacteria is known as Dialister Pneu having 0.15 in diameter.
- The disease causing bacteria are known as Pathogens and come under the category of lower b
- The pathogens may cause typhoid fever, Parat fever, bacillary dysentery and cholera.

(ii) Algae :—

- The algae are unicellular plants containing chlorophyll and often additional pigments on which these have various names.
- Blue-green algae, Green algae, diatoms and yellow algae are various varieties of algae commonly used.

(iii) Fungi :-

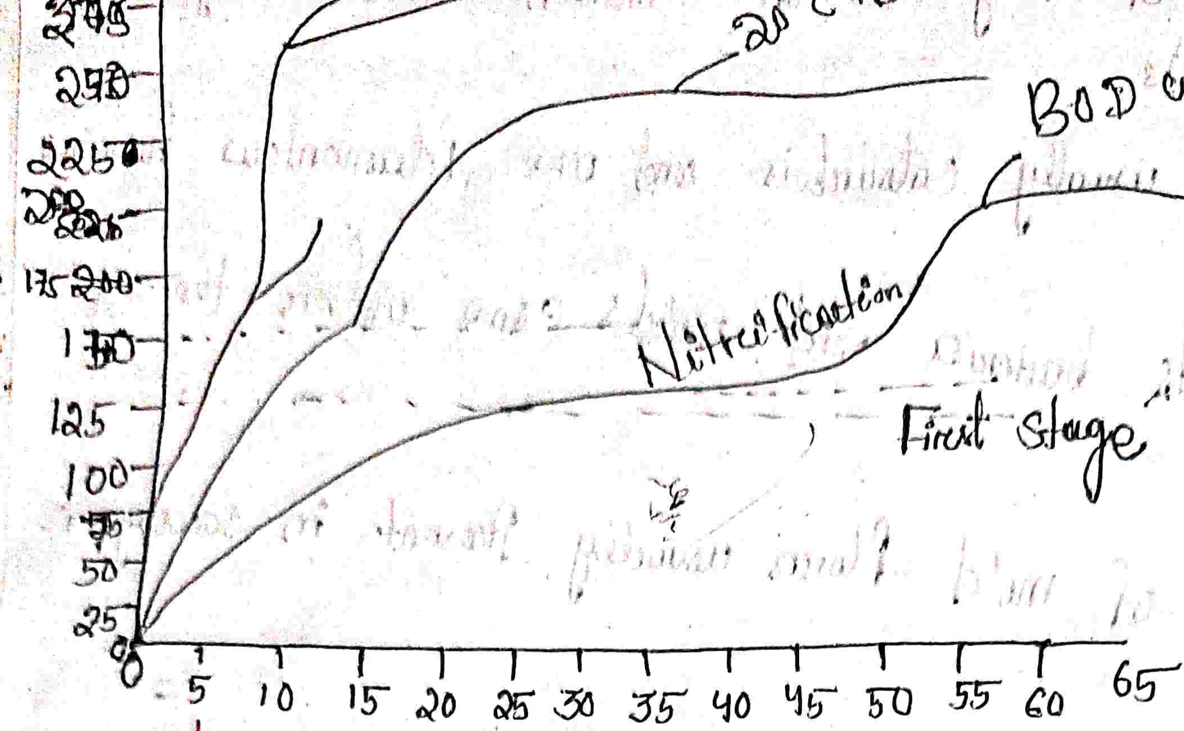
- The cells of fungi do not contain chlorophyll and pigments.
- These are usually colourless and are filamentous having branches.
- The yeasts, bacteria and molds come under the group of fungi.
- The size of mold flora usually present in sewage is large.

(iv) Protozoa :-

- These include all the unicellular animals.
- There are various protozoa such as amoeboid, flagellae and ciliate protozoa.
- Mostly all the protozoa are bacteria eaters and destroy the pathogens.

Biological oxygen Demand (B.O.D)

- Biochemical oxygen demand (B.O.D) represents the amount of oxygen consumed by bacteria and other micro-organisms as they decompose organic matter under aerobic conditions at a specified temperature.
- The BOD is an important parameter for assessing water quality.



BOD Rates:—

- The B.O.D rate at any ~~Point~~ moment depends upon the temperature and the demand remaining to be satisfied.

If 'B' be the B.O.D at any distance

$$\frac{dB}{dt} = K'B$$

or $\frac{dB}{B} = -K \cdot dt$

Integrating $\log_e B = -K't + C$ → (1)

If the initial B.O.D be B_1 and after time t, B_1 then

$\log_e B' = K't' + c$ (when t = t')

$C' = \log_e B_1' + K_1't'$ — (2)

Putting value of 'c' in eq^n (1)

$\log_e B = K't + \log_e B_1' + K_1't'$

Anyo $\left(\frac{B_1'}{B}\right) = k'(t-t')$

$B_1' = B.(e)^{k'(t-t')}$

$\Rightarrow B_1' = B.(10)^{k'(t-t')}$

B_1' - B.O.D at any time 't'. —— (3)

The demand exerted and the oxygen absorbed in time t'

$= (B_1 - B_1') = B - B.10^{k(t-t')} = B\left[1-10^{k(t-t')}\right]$ —— (4)

The value of k' in the above equation varies with the change in the temp. and is determined by the following formula.

$$K_T = K_{20}(1.047)^{(T-20)} \quad \text{—— (5)}$$

where K_T = value of k' at temperature T.

K_{20} = Value of k at 20°C (= 0.1 approx.)

- The value of the Initial B.O.D also changed with the change in the temperature and is determined by the formula :-

$$(B_i)_1 = (B_i)_{20}(0.02T + 0.6) \quad \text{—— (6)}$$

where $(B_i)_1$ = the value of B_i at T°C

$(B_i)_{20}$ = the value of B_i at 20°C.

Chemical oxygen Demand (COD)

- This test is a measure of the amount of Carbon in organic matter of Sewage.
- Chemical oxygen demand test determines the oxygen required for chemical oxidation of organic matter with the help of strong chemical oxidation.
- COD is defined as the amount of oxygen equivalent consumed in the chemical oxidation of organic matter by strong oxidation.

Primary, Secondary and Tertiary treatment of waste water

- There are three main stages of waste-water treatment process :—
  - (i) Primary Treatment
  - (ii) Secondary Treatment
  - (iii) Tertiary Treatment.

(i) Primary Treatment :—

- After Passing through Preliminary treatment, the water arrives at Primary treatment.
- The Purpose of Primary treatment is to Settle material by gravity, removing floatable objects and reducing the Pollution to ease

Secondary treatment.

- Primary treatment aims to reduce the Bio-chemical oxygen demand and Total Suspended solids in the wastewater.

- Primary treatment can remove 25-40% of the BOD and 50-70% of the TSS before the water goes to Secondary Treatment.

- The WRF uses circular clarifier in the Primary treatment Process, the solids settle to the bottom, the flotables collect and store in a tank, and then both are pumped to the anaerobic process.

- The remaining water then flows to secondary treatment for further treatment.

(ii) Secondary Treatment :-

- Secondary treatment involves the removal of biodegradable organic matter and suspended solids through the Processes of ~~aer~~ aeration and filtration.

- The aim is to achieve a certain degree of effluent quality in a sewage treatment plant suitable for the intended disposal or reuse option.

- These Processes are Performed by micro-organisms in a managed aerobic or anaerobic Process.

- Bacteria and Protozoa consume bio-degradable soluble organic contaminants while reproducing to form cells of biological solids.

- Secondary treatment is widely used in sewage treatment and is also applicable to many agricultural and industrial wastewaters.

Tertiary Treatment of waste water :-

- Tertiary treatment is the next waste-water treatment process after secondary treatment.

- This step removes stubborn contaminants that secondary treatment was not able to clean up.

- Waste-water effluent becomes even cleaner in this treatment process through the use of stronger and more advanced treatment systems.

- Tertiary treatment technologies can be the extensions of conventional secondary biological treatment to further stabilize oxygen demanding substances in the waste-water or to remove nitrogen and phosphorus.

- Tertiary treatment may also involve physical-chemical separation techniques such as carbon adsorption, flocculation, membranes for advanced filtration, ion-exchange, dechlorination and reverse osmosis.

Tertiary treatment processes are more commonly proprietary than secondary treatment.

Waste water Disposal Standard :—

- After conveying the sewage through sewers, the next step is its disposal.
- The sewage can be disposed off without treatment or after suitable treatment.
- Finally the sewage is disposed off either in natural water courses or on land.

Method of disposal

The methods of sewage disposal can be clarified as:

(A) The natural methods.
  (i) By dilution.
  (ii) Land Treatment.

(B) The Artificial methods :—
  (i) Primary treatment
  (ii) secondary treatment.

Module - V

Biological waste water treatment system:—

Principle:—

- Sewage can remain in aerobic or ~~ana~~ anaerobic condition depending on the availabity or non-availability of oxygen.
- In aerobic condition the bacteria consume oxygen and remain active, without causing any foul smell.
- In anaerobic condition foul smell is created, due to which only aerobic conditions are preferred.

Classification of sewage filters:—

At sewage treatment works, the biological treatment of sewage is done by sewage filters and activated sludge units.

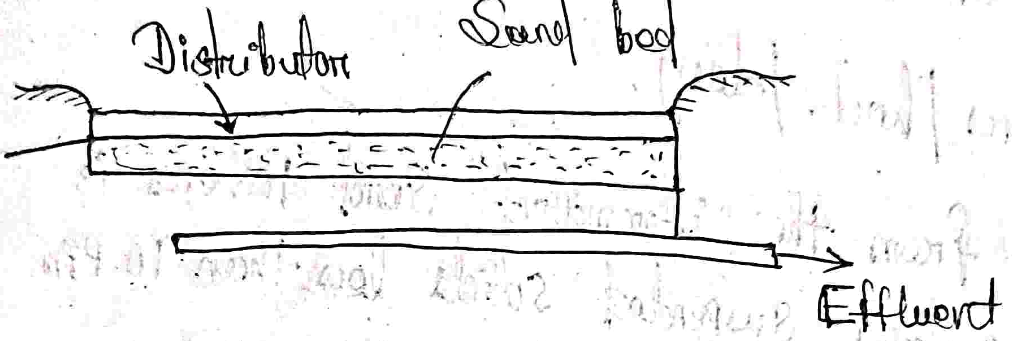
- The filters which are mostly used in sewage treatment can be classified as:—

(i) The intermittent sand filters

(ii) The contact Beds

(iii) The Trickling filters.

- These are the early development of Sewage treatment units.
- These are Similar in construction to the slow-Sand filter of water treatment.
- These require large area, due to which these are not commonly employed in modern Sewage treatment works.



- The fig. Shows an intermittent Sand filter.
- It consist of layer of Sands with an effective Size of 0.2 to 0.5 mm and of uniformity co-efficient 2.5.
- If the Soil itself is sandy, there is no need of Providing extra sand.
- But if the Soil is of other variety, Sands of the above Specifications are laid in a depth of about 100-120cm.
- Their drainage Pipes are surround with layers of Coarse Stone and gravel graded from coarse to fine, to keep and the sand out.
- The sewage is applied evenly on the Surface of the Sa bed by influent waste water troughs.
- The distribution through has side openings to

- To prevent the scouring and displacement of sand the distribution trough is kept on concrete apron or protective stone.
- While applying the sewage the flooding is done from 3 - 10 cm depth after an interval of 24 hours.
- The capacity of these filters is 0.8×10^6 - 1.1×10^6 litres / hect. / day.
- The effluent from the intermittent sand filters is very clear and contains suspended solids less than 10 ppm. which is well nitrified and stable.
- The effluent also has B.O.D less than 5 ppm and is free from odours.
- If the quantity of sewage is more 3-4 such beds can be constructed in parallel.
- For cleaning these filters, the sand from the top is scraped from time to time and are refilled with fresh clean sand.

Advantages :—

(i) Operation is simple, only mechanical equipment is required for dosing.

(ii) There is no trouble of odours and insects.

(iii) Small head is required.

of orient the

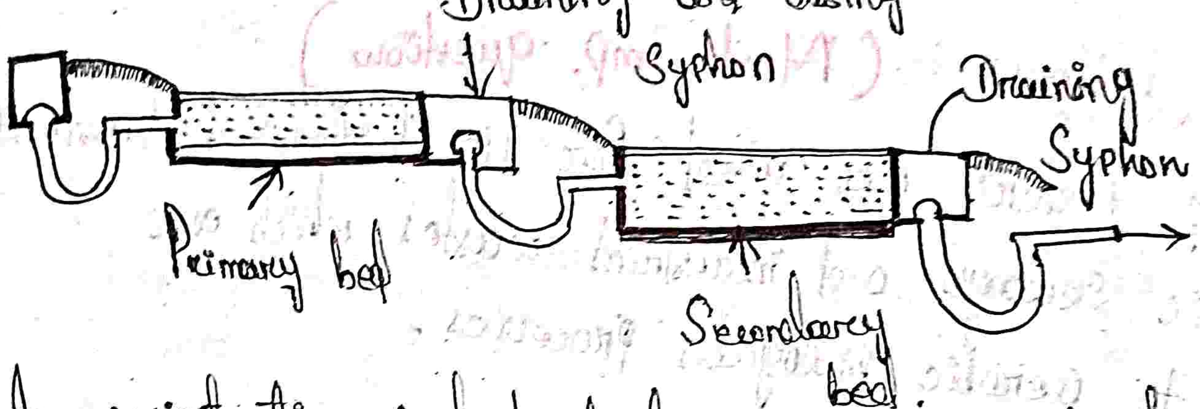
Disadvantages:—

(i) Their rate of loading is very small.

(ii) They require large area and much quantity of sand in their construction which makes them uneconomical.

(iii) They cannot treat large quantity of sewage, therefore cannot be employed at big plant.

Contact Beds:—



- In ancient time contact beds were very popular in the treatment of sewage, but now a days these are not commonly used.
- These are similar in construction to the intermittent sand filters, the only difference being in the filtering media.
- The filtering media consists of 2 - 2.5 c.m. size broken stone ballast or brick ballast.
- The depth of the filtering media is between 90-150cm.
- The sewage is uniformly applied over the whole surface of the filtering media, by means of distribution troughts and is collected at the bottom by means of a system

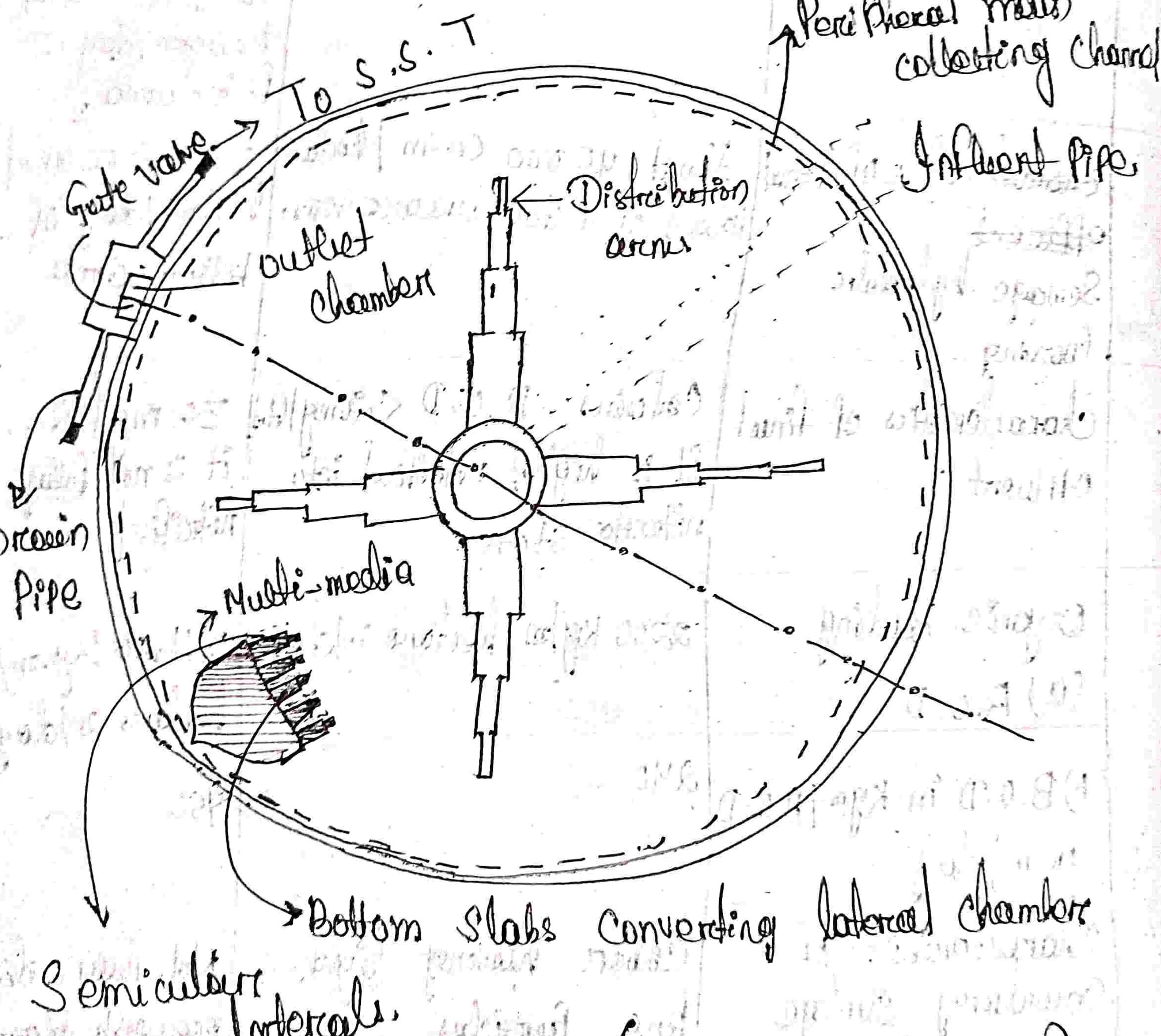
of underdrain pipes.

- The operation of the contact beds includes the following:—
  - (i) Filling
  - (ii) Contact
  - (iii) Emptying
  - (iv) Resting
- The complete cycle of operation takes 8–12 hours.

Trickling Filters:— (Most imp. question)

- Trickling filters are used for the biological treatment of domestic sewage and industrial wastes, which are amenable to aerobic biological process.
- These are used for the complete treatment or moderately strong wastes and as roughing filter for strong wastes prior to activated sludge units.
- The trickling filter is always preceded by primary sedimentation so that the settleable solids in the sewage may not clogg of the filter.
- In comparison to low rate filters in high rate filters, a part of the settled or filter effluent is recycled through the filter.

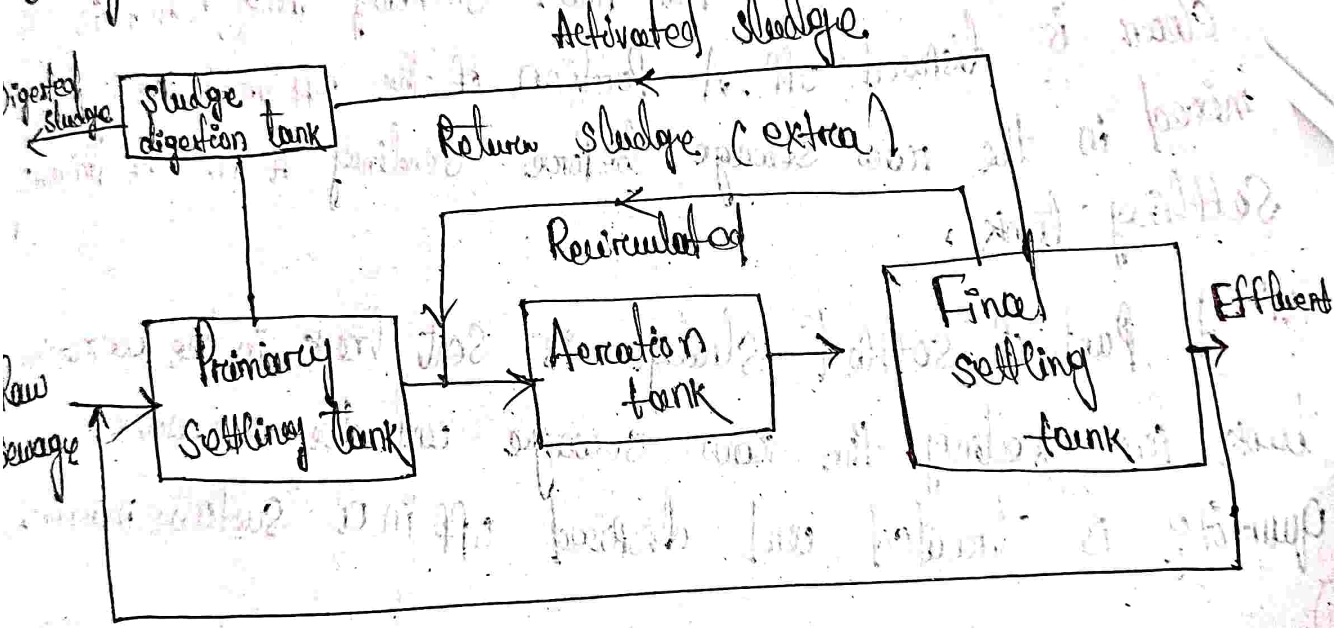
		the hydraulic load does exceed the limits	in all high rate filters.
8.	Depth of contact medium	1.8 to 2.4 m.	1.2 to 1.8 m
9.	Cost of operation	more	Small



~~Trickli~~ (Trickling filter)

Activated Sludge Process:-

- The floc is added in another fresh sewage caused its digestion. This floc is called the activated sludge.
- Activated sludge is very active and can treat the fresh sewage.
- The activated sludge Process is an aerobic, biological sewage treatment system.



Procedure:-

i) The raw sewage is given the Primary treatment in the Primary settling tank. The detention Period is kept short 1-1.5 The Primary settling tank removes less Percentage of settleable Solids. Due to less removal of Solids, the filter media does not clog.

ii) After Primary treatment, the raw Sewage is mixed up with the required quantity of activated sludge which is called aeration tank. The mixer difficulty in disposal.

(v) There is uncertainty of results under all conditions.

Types of Activated Sludge Process:—

(i) Tapered aeration

(ii) Step aeration

(iii) High rate treatment or modified aeration.

(iv) Two stage aeration

(v) Activated aeration

(vi) Reaeration

(vii) Contact Stabilisation

(ix) Extended Aeration method.

RBC (Rotating biological Contactor)

- A rotating biological contactor or RBC is a biological fixed film treatment process used in the secondary treatment of waste-water following primary treatment.

- The primary treatment process involves removal of grit, sand and coarse suspended material through a screening process, followed by settling of suspended solids.

- The RBC process allows the waste-water to come in contact with a biological film in order to remove

Pollutants in the waste-water before discharge of the treated wastewater to the environment.

- A RBC is a type of secondary treatment process.
- It consists of a series of closely spaced, parallel discs mounted on a rotating shaft which is supported just above the surface of the wastewater.

- Rotating biological contactors (RBCs) are capable of withstanding surges in organic load.