Date - 16/09/2021

① 1

** Importance of safe water supply system.
*

∋ Water supply system:-

Introduction:- No life can exist without water as it is the elixir of life. Air, water & Food are the essential items for any living being.

Historical developement:-

Since old days, there has been search for pure water. Some of the earliest civilizations flourished along rivers bank. Archaeological excavation reveals that as early as 2500 BC, the people of Harappa, Mohanjodaro and arround Indus river basin had well organized water supply systems. Rig veda makes a mention of digging of wells. Similarly, Indian epics like Ramayana & Mahabharatha make mention of digging of wells. and used wells as principal source of water supply. As the need for water increased and tools were developed, wells were made deeper.

However, these wells caused water supply problems in times of drought. Hence, cisterns were constructed for collecting rain water while reservoirs were constructed to store water from streams & rivers during mansoon period.

⇒ Essentials of any water supply scheme:-

→ The most important aspect of any water supply scheme is the choice of source of supply. The source should be permanent, reliable and should provide water with minimum impurities.
Lake, streams, springs are surface sources whereas wells, infiltration galleries are ground sources.

→ After the selection of source of water, the next step is to construct suitable intake works to collect and carry water to treatment plants for treatments.

→ The treatment of water depends on the source of supply, and the amount and nature of impurity present in it.

→ Water is carried through pipes from source to treatment plant, and then from treatment plants to distribution system.

→ Distribution system consists of large arterial mains, distribution mains, minor distributors and appurtenances, including valves, meters and hydrants.

→ Treated water is stored in clean water reservoir from where it is distributed to the consumers through distribution system of pipes.

→ In low level area water will flow directly under gravity but for high level area, elevated tank and pumps will have to be installed.

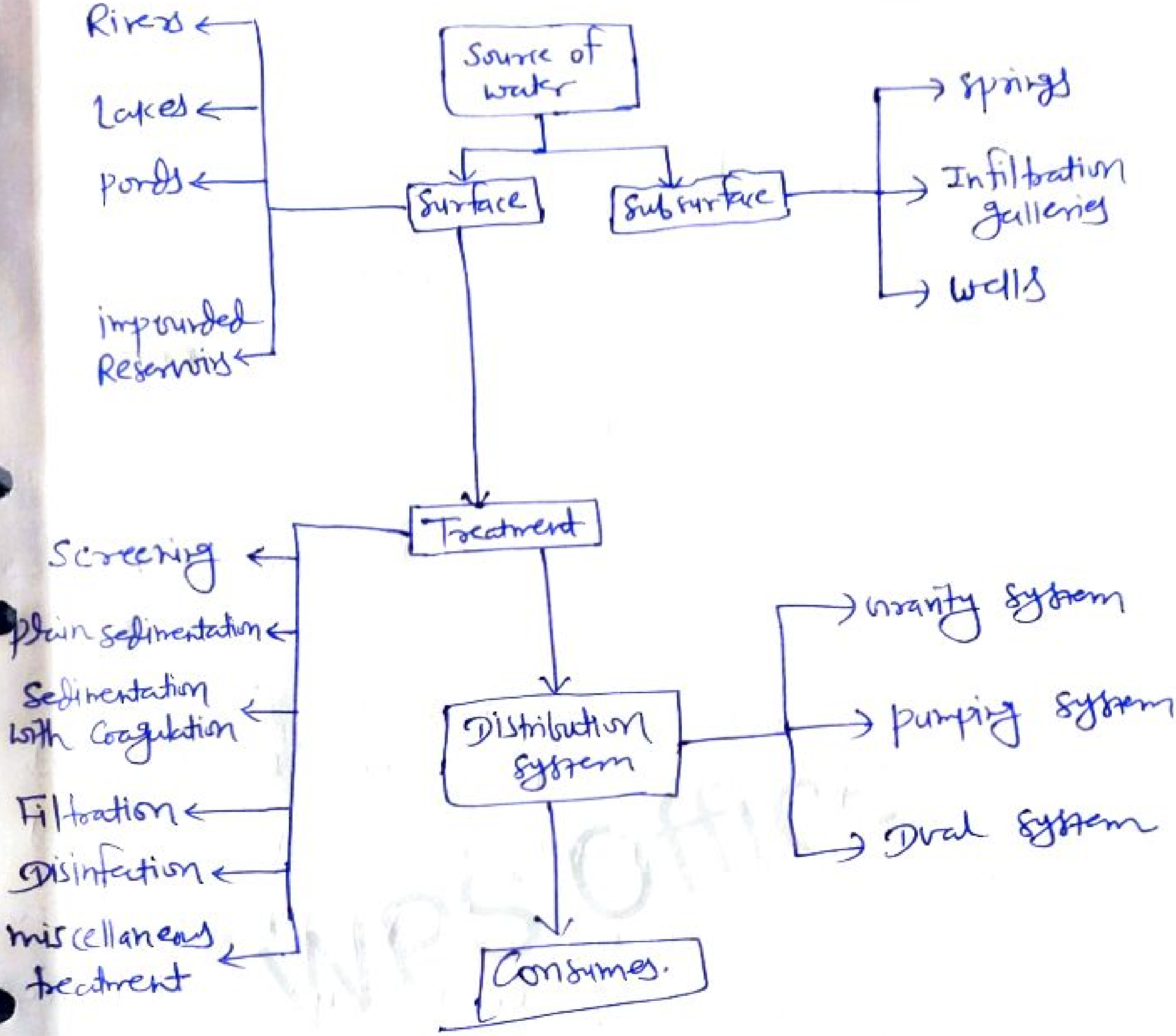


Fig:- outline of water supply system.

⇒ **Preliminary investigations for water supply scheme:-**

the following point should be looked into while considering any water supply system.

1) Sources of water supply:-
2) population.
3). Financial aspects
4) Quantity of water

5) Quality of water
6) Sanitary survey
7) Topography
8). Town developement trend.

⇒ Importance of safe water supply system:-

→ water constitutes one of the important physical ~~[illegible]~~ environments of man and has a direct bearing on the helth and hygiene of mankind.

→ The contamination of water leads to numerous health hazards.

→ Water is a good carrier of disease germs. If water is not made safe against disease germs, it may become responsible for so many diseases and epidemics. Diseases such as typhoid, cholera, dysentery, etc are the direct cause of defective water supply that's why safe water supply system is necessary.

→ If water contains excessive amounts of minerals or poisonous dissolved ~~[illegible]~~ substances, it will again cause so many difficulties to the public.
Therefore, water which is used by the public should be wholesome and must be free from disease producing bacteria.

** Domestic water requirements of urban and rural areas.

In order to arrive at a reasonable water requirements for any particulars town, the demand of water for various purposes is divided under the following five category

1) Domestic purposes
2) Civic or public purposes
3) Industrial purposes
4) Business or trade purposes
5) Loss and waste.

1) Domestic purposes:

The quantity of water required for domestic purposes can be sub divided as follows.

i) Drinking:- A human body contains about 70%. of water. the consumption of water by a person depends on various things. But on the average and under normal condition it is about 2 litres per day.

ii) Cooking:- Some quantity of water will also be required for cooking. the quantity of water required for this purpose will depends upon the stage of advancement of family in particular and in society in general.

iii) Bathing:- The quantity of water required for bathing purpose will mainly depends on the habits of ~~pe~~ people and types of climate.

For an Indian bath, this quantity may be assumed as about 30-40 litres per capita per day & for tub-bath, it may be taken as about 50 to 80 litres per capita per day.

iv) Washing hands, Face etc.

The quantity of water required for this purpose will depends on the habits of people and may roughly be taken as 5 to 10 litres capita per day.

v) Household Sanitary purposes:-

Under this division, the water is required for washing cloths, floors, utensils, etc. and it may be assumed to be about 50-60 litres per capita per day.

vi) Private gardening and Irrigations:-

In case of developed cities, these will be ~~practica~~ practically no demand of water for this purpose.

vii) Domestic animals & private vehicles:-

The amount of water required for the use of domestic animals and private vehicles is not of much concern to a water supply engineer.

2) Civic or public ~~pur~~ purposes:-

i) Road washing:- The road with heavy amount of dust are to be sprinkled with water to avoid inconvenience to the users. For this purpose average 5 litres per capita perday water required.

ii) Sanitation purposes:- Water required for cleaning public sanitary blocks, large market, etc. and for carrying liquid wastes from houses. It may be taken as 2 to 3 lpcd.

iii) Ornamental purpose:- In order to adorn the town with decorative features, fountains or lakes or ponds are sometimes provided. These objects required huge quantity of water for their performance

iv) Fire demand:- Usually, a fire occurs in factories and stores. The quantity of water required for fire fighting purpose should be easily available and always kept store in the storage reservoir.

Buston's formula:-

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

Freeman's formula

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

Kuichling's formula

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

National Board of fire underwriter's formula.

$$Q = 4637\sqrt{P}\left(1-0.01\sqrt{P}\right)$$

where Q = quantity of water in litres/minutes

P = population of town in thousands.

3) Industrial purposes:-

the quantity of water required for the industrial or commercial purposes can be sub-divided as follows

i) Factories:- the quantity of water required for the processes involved in factories will naturally depends on the nature of products, size of factory etc.

ii) power stations:- A huge quantity of water will be required for working of power station.

4) Business or trade purposes:

Some trade such as dairies, hotels, laundries, motor garages, restaurants, stables, etc require a large quantity of water.

5) Loss and waste:

The quantity of water required under this category is sometimes termed as unaccounted requirement. it includes careless use of water, leakage in mains, valves, other fittings etc.

*** Factors affecting water requirement :-

There are various factors which influence the water requirement. These factors are to be analysed carefully and properly before arriving at the rate of demand for particular locality.

1) Climatic Conditions: The requirement of water in summer is more than that in winter. So also is the case with hotter and cooler places.

2) Cost of water: The rate at which water is supplied to the consumers may also affect the rate of demand. The higher the cost, the lower will be the rate of demand and vice-versa.

3) Distribution pressure:-

→ The Consumption of water increase with the increase in the distribution pressure. This is due to increase in loss and waste of water at high pressure.

4) Habits of population:-

→ For high value premises, the Consumption rate of water will be more due to better standards of living of persons.

5) Industries:-

→ The presence of Industries in a city may also affect its rate demand.

6) Policy of metering:-

→ The quantity of water supplied to a building is recorded by a water meter and the consumer is then charged accordingly. The installation of meters reduces the rate of Consumption. But the fact of adopting policy of metering is a disputable one as seen from the following arguments which are advanced for and against it.

*** Sources of water supply :-

Source from which water is available for water supply schemes can conveniently be classified into the following two categories according to their proximity to the ground surface.

1) Surface water:

In this type of source, the surface runoff is available for water supply schemes.

Surface sources are as follows.

i) Lakes & Streams:-

A natural lakes represent a large body of water within land with impervious bed. Hence, it may be used as source of water supply scheme for nearby localities.

The catchment area of lakes and streams is very small and hence, the quantity of water available from them is also very low. Hence lakes & streams are not considered as principal source of water supply schemes for the large cities.

ii) Ponds:

A pond is man made body of standing water smaller than a lake. the quantity of water in pond is very low & it contains many impurites.

A pond cannot be adopted as a source of water supply and its water can only be used for washing of clothes or animals only.

iii) Rivers:.

Large river constitute the principal source of water supply scheme for many cities. Some river are perennial river while others are non-perennial. In perennial types of river water ~~flows~~ flows in all the seasons. In non-perennial types of river it drys in summer either wholly or partially and in mansoons, heavy floods visits them.

In such types of rivers, it is desirable to store the excess water of flood in mansoon by constructing dams across such rivers. this stored water may then be used in summer.

iv) Storage reservoirs.

An artificial lake formed by the construction of dam across valley is termed as a storage reservoir.

it essentially Consists of the following three parts.

→ A dam to hold water
→ A spillway to allow the excess water to flow.
→ A gate chamber containing necessary valves for regulating the flow of water.

At present, this is rather the chief source of water supply schemes for very big cities.

3. Underground Sources:-

In this type of source, the water that has percolated into the ground is brought on the surface. The difference between the terms infiltration & percolation should be noted. the entrance of rain water or melted snow into the ground is referred to as infiltration. the movement of water after entrance is called percolation. It is observed that the surface of earth consists of alternate courses of pervious layers and impervious strata.

the pervious layer are known as aquifers or water bearing strata. if aquifers consists sand and gravel strata, it gives good supply of drinking water.

Forms of Underground Sources:

i) Infiltration galleries:

An infiltration gallery is a horizontal or nearly horizontal tunnel which is constructed through water bearing strata.

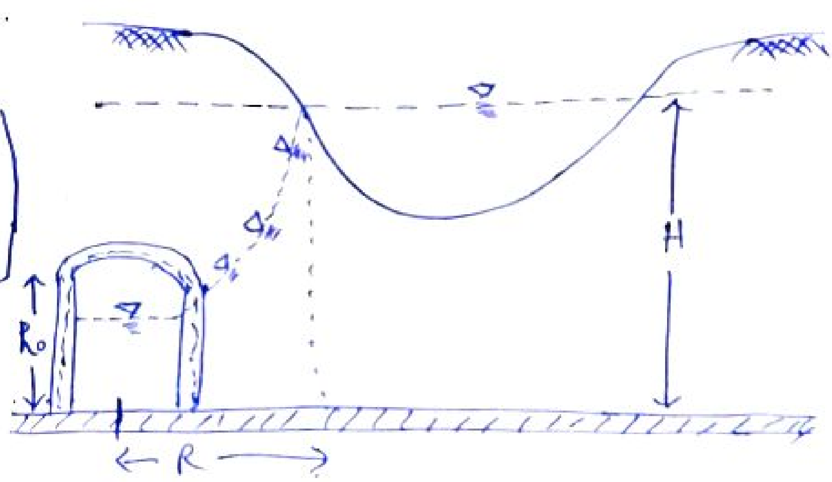
The gallery is usually constructed of bricks wall with slab roof. The gallery obtains its water from water bearing strata by various porous drain pipes.

The gallery is laid at a slope and the water collected in the gallery is led to a sump from where it is ~~pump~~ pumped & supply to treatment plant.

The infiltration galleries are useful as source of water supply when ground water is available in sufficient quantity just below the ground level. It is generally constructed 5 to 10 m from the ground level.

$$\boxed{Q = \frac{KL(H^2 - R_0^2)}{2R}}$$

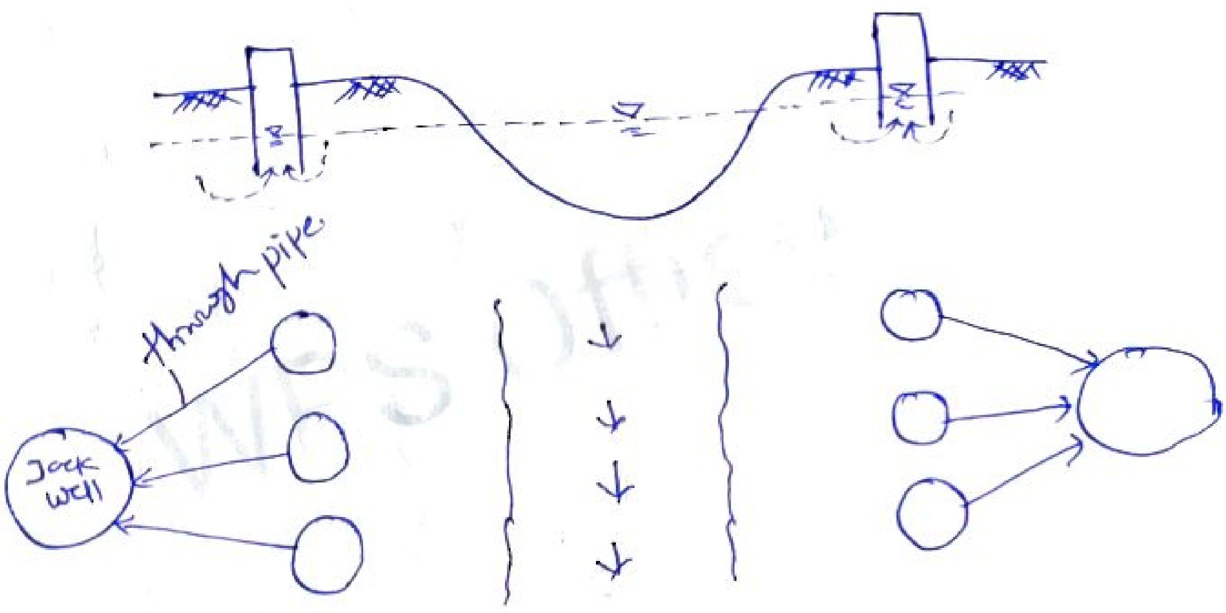
L = length of gallery



ii) Infiltration wells:

→ Infiltration well are shallow discontineous construction bored along the bank of the river through which water is utilize by seepage from bottom.

→ Several such infiltration wells are connected to common well term as Jack well.
From there water is being pumped into the treatment plant.



iii) Springs:

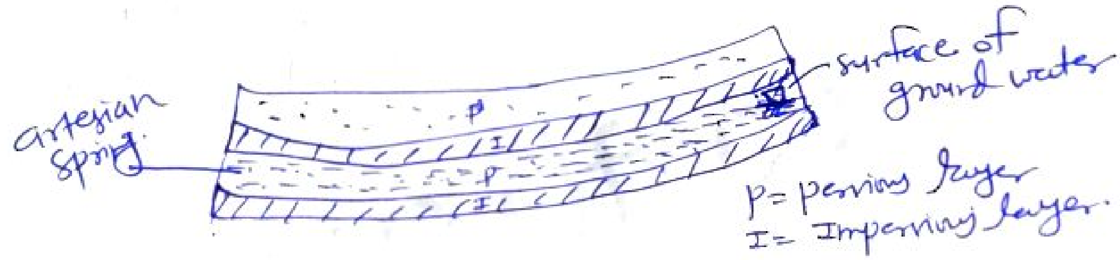
When ground water appears at the surface for any season, springs are formed.
They serve as a source of water supply for small towns, especially near hills or bases of hills.

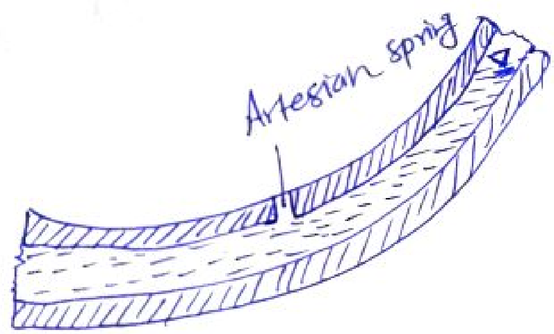
Following are the three types of spring:-

i) Artesian Springs

→ In this type of springs the ground water comes to the surface under pressure.

→ The artesian springs may also be formed due to presence of fissure or crack in the impervious layer. fissure or crack should be continue at the ground level.

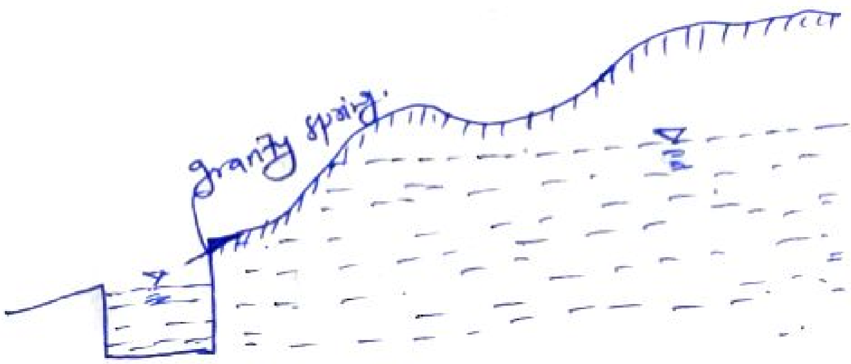




ii) Gravity Springs:-

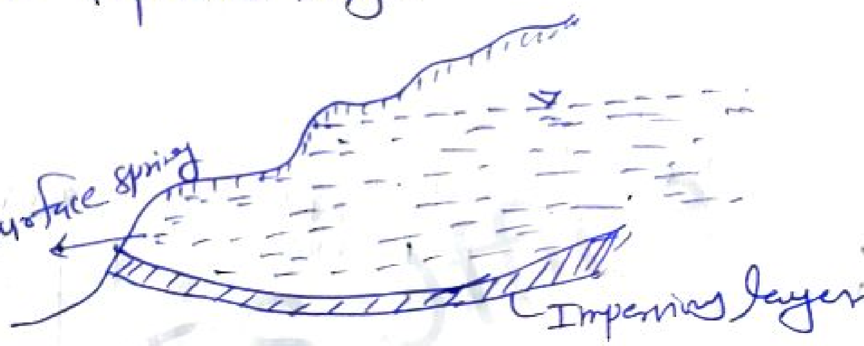
This type of springs develope due to overflowing of the water table.

The flow from a gravity spring is variable with the rise or fall of water table.



iii) Surface springs:

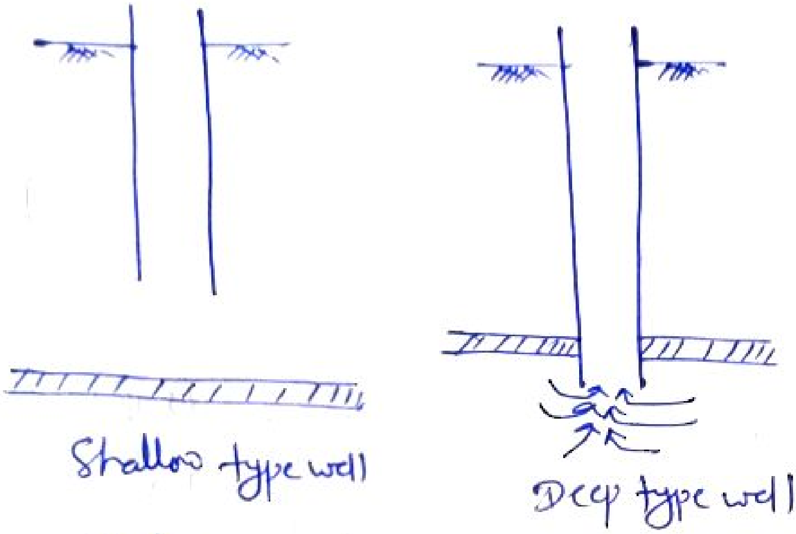
This type of spring is formed when subsoil water is exposed to the ground surface by the obstruction of an impervious layer



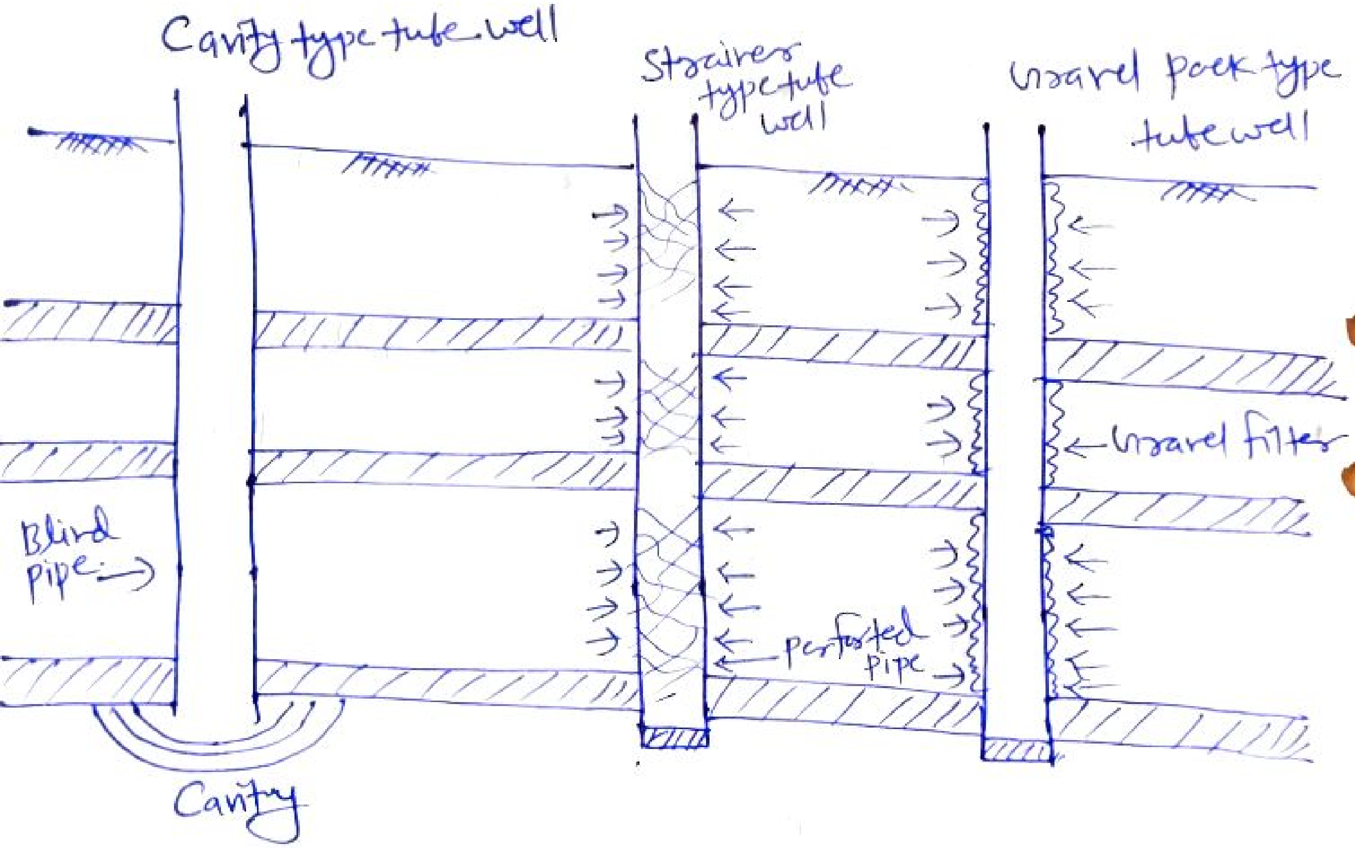
v). Wells:

A well is defined as an artificial hole or pit made in the ground for the purpose of tapping water.

- Wells
  - open
    - Shallow
    - Deep
  - Tube well
    - Cavity type
    - Screen type.



→ When water utilize from upper water bearing strata then it is called shallow type well



** Intakes for water supply:-

→ Intakes are the structures used for admitting water from the surface sources. (i.e, river, reservoir or lake) and conveying it further to the treatment plant.

→ Generally an intake is a masonary or concrete structure with an aim of providing relatively clean water.

* Site for location of intake structure:-

While selecting a site for location of intakes, the following points should be taken into account.

→ Intake work should provide purer water so that its treatment may be less exhaustive.

→ Heavy water currents should not strike the intake directly.

→ Intake should be located at such a situation where sufficient quantity of water remains available under all circumstances.

→ Site should be well connected by good type of roads.

→ During floods, the intake should not be submerged by the flooding waters.

→ The site should be selected in such a manner that there is ample scope for further expansion.

* Design of Intake:-

An Intake should be designed keeping in mind the following considerations.

→ Intake should be sufficiently heavy so that it may not start floating due to upthrust of water.

→ All the forces which are expected to work on intake should be carefully analysed and intake should designed to withstand all these forces.

→ The foundation of the intake should be taken sufficiently deep to avoid overturning.

→ Strainers in the form of the wire mesh should be provided on all the intakes to avoid large floating objects.

** Types of intake:-

1) Submerged intake:-

→ Submerged intake is the one which is constructed entirely under water.

→ These intakes are generally used to draw water from natural lakes & some rivers.

→ The water entering the intake conduit ~~fo~~ flows under gravity to the bank of the lake or river and collected in a sump well from where it is pumped to the treatment plant.

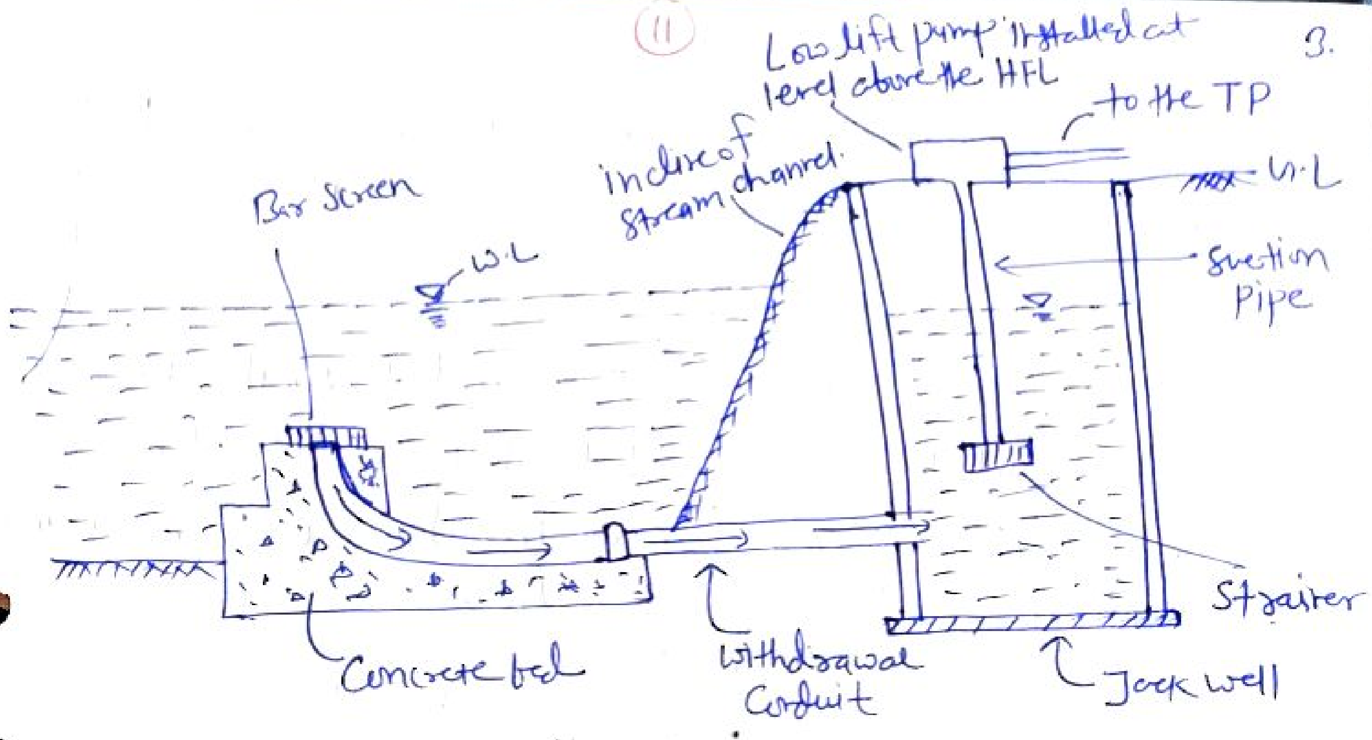
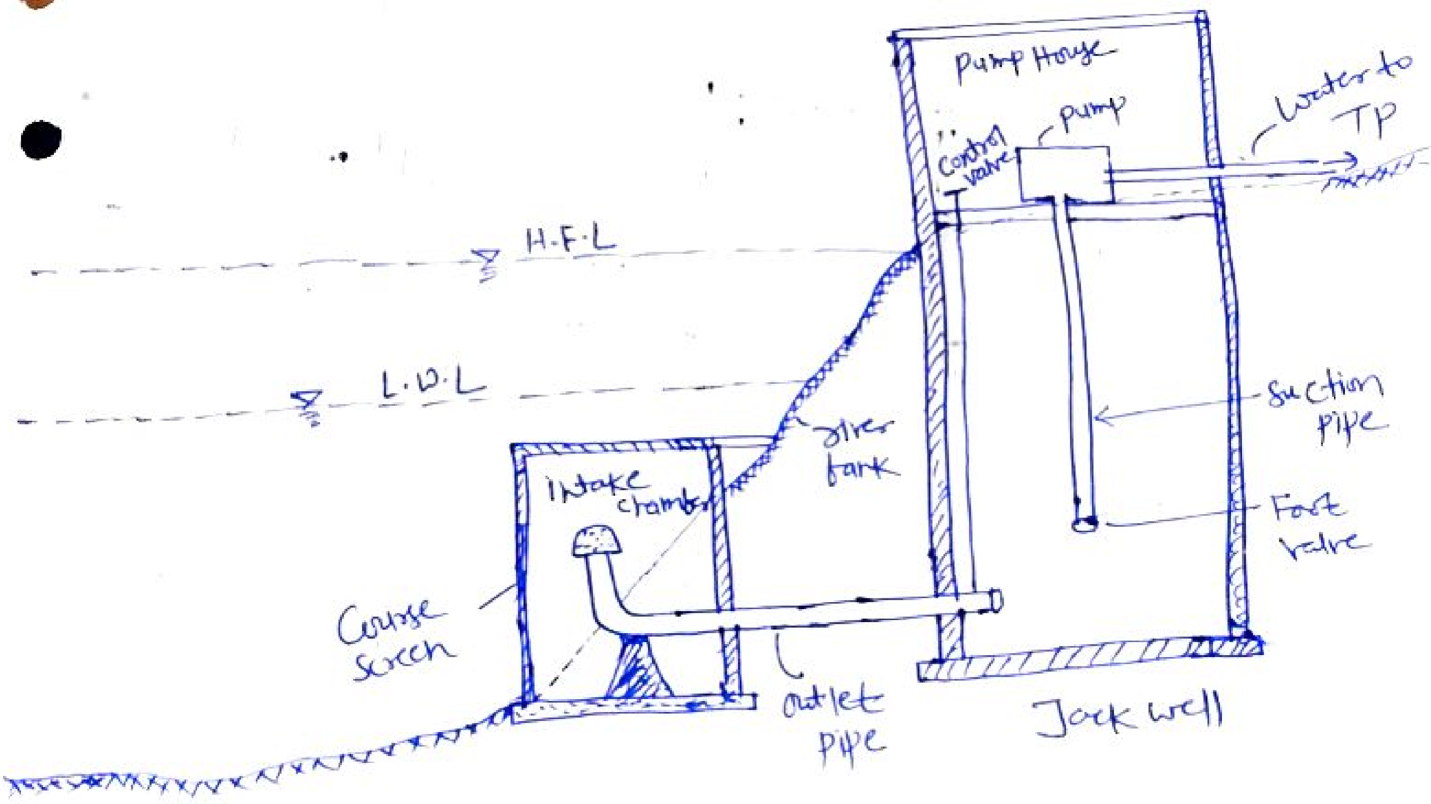


Fig:- Submerged intake.

2) River intake:-

→ A River intake is located to the upstream of the city so that pollution is minimized



3) Reservoir intake:-

→ When flow in the river is not guaranteed throughout the year a dam is constructed across it to store water in the reservoir.

→ The reservoir intake is practically similar to river intake, except that these are located near the upstream face of the dam where maximum depth of water is available.

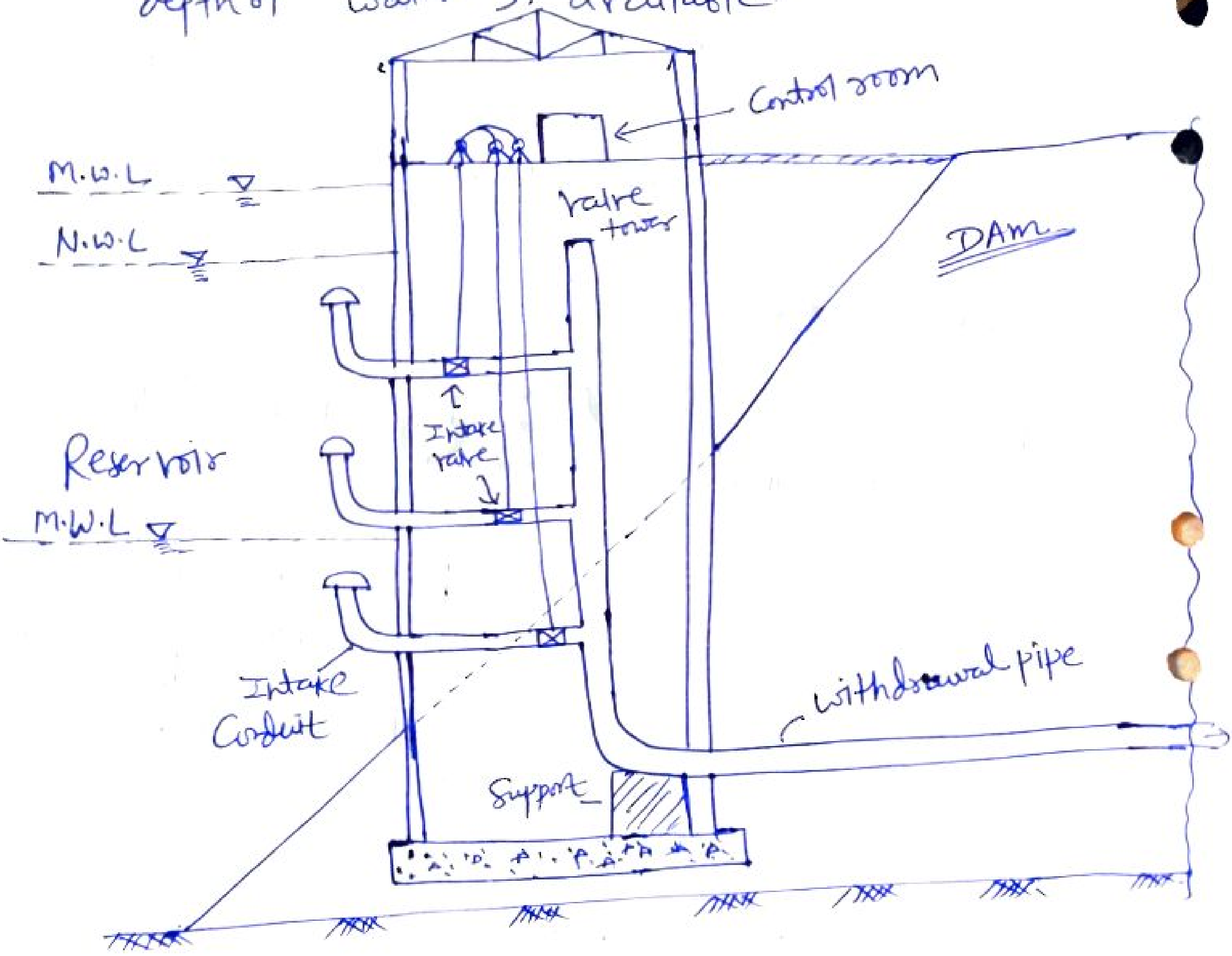


Fig:- Reservoir Intake.

4) Lake intake:-

→ Lake intakes are similar to reservoir intakes if the depth of the water near the banks is reasonable.

5). Canal intake:-

→ Some time, the source of water supply to a small town may be an irrigation canal passing near the town.

→ The canal intake essentially consist of concrete or masonry intake chamber of rectangular shape, admitting water through a course screen.

→ A fine screen is provided over the bell mouth entry of the outlet pipe.

→ The bell mouth entry is located below the expected low water level in the canal.

→ water may flow from outlet pipe under gravity if the T.P situated at a lower elevation. otherwise, the outlet pipe may serve as suction pipe, and the pump house may be located on or near the canal bank.

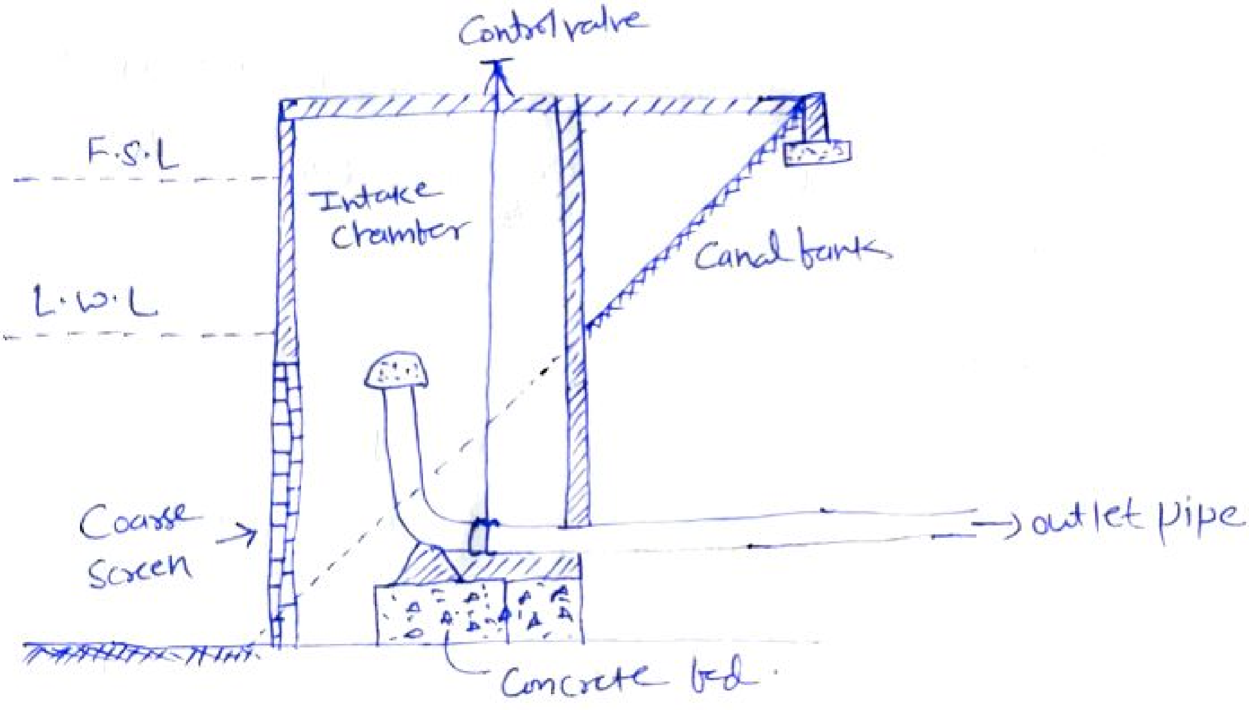


Fig:- Canal intakes system.

—x—

** Transportation of water:-

→ The term Conveyance/ Transportation refer to taking of water from source to purification plants & from treatment plant to Consumer.

→ Water supply system broadly involves transportation of water from the source to the area of Consumption, through free flow channels or Conduits or pressure mains. Depending upon topography

→ If the source is at higher level than the treatment plant, the water can flow under gravity automatically. Similarly after necessary purification of water, it has to be conveyed to the Consumers. Therefore, for Conveyance of water some sort of devices or structure is required.

1) open channels:-

→ In any water supply system raw water from source to Treatment plants may be carried in open channels.

→ Economical sections of open channels are generally Trapezoidal. The channels are to be properly lined to prevent seepage.

→ Initial Cost and maintenance Cost may be high 2.

→ open channel are not recommended for Conveyance of treated water, they may be adopted for Conveying raw water.

2) <u>Aqueducts:-</u>

→ The term aqueduct is usually restricted to closed conduits made up of masonary.

→ These can be used for conveyance of water from Source to treatment plant or for distribution also.

→ In ancient times, rectangular aqueducts were most Commonly used, but these days Circular or or horse-shoe shaped ones are more Common due to good hydraulic properties and resists earth pressure well.

3) <u>Tunnels:-</u>

Tunnels are also like aqueducts.

→ Tunnels are also like aqueducts.

→ Tunnels which are not under pressure are usually constructed in horse-shoe shape.

→ If they convey water under pressure, Circular Cross-section is best.

4). Pipes:-

→ Pipe is a circular closed conduit used to convey water from one point to another, under gravity or under pressure.

→ If pipe do not run full, they are called to flowing under gravity. but flow under gravity is possible only if the pipe is given a definite longitudinal slope.

i) Cast iron pipes:-

→ Cast iron pipes are used in majority of water conveyance mains because of centuries of satisfactory experience with it. Cast iron pipe is resistant to corrosion and accordingly long lived; its life may be over 100 years.

Advantage:-

→ Cast iron pipes are of moderate cost.
→ Their Jointing is easier
→ They are resistant to corrosion
→ They have long life.

Disadvantages:-

→ They are heavier and hence uneconomical when their diameter is more than 120 cm.
→ They can not be used for pressures greater than 7 kg/cm².
→ They are fragile.

ii) Wrought iron and galvanized iron pipe:-

→ wrought iron pipe are manufactured by rolling flat plates of the wrought iron to the proper diameter and welding the edges.

→ wrought iron pipe corrode quickly, and hence are used principally for installation within buildings.

→ These pipes are usually protected by coating them with a thin films of molten zink. Such coated pipes are known as galvanized iron pipes.

iii) Steel pipes:-

→ steel pipes of small diameter can be made from the solid, but larger sizes are made by riveting or welding together the edges of suitably curved plates.

→ steel pipes cannot be easily made to resist high external pressure.

iv) Cement Concrete pipes:-

→ cement concrete pipes may be either plain or reinforced, and are best made by the spinning process.

→ They may be either pre-cast, or may be cast in situ.

Advantages:-

→ They are more suitable to resist the external loads and loads due to backfill

→ The maintenance cost is low.

→ The inside surface of pipes can be made smooth, thus reducing the frictional losses.

→ The problem of corrosion is not here.

→ pipes can be cast at site and hence the transportation problems are reduced.

Disadvantages:-

→ Unreinforced pipes are liable to tensile cracks and they can not withstand high pressure.

→ The tendency of leakage is not ruled out as a result of its porosity and shrinkage cracks.

→ It is very difficult to repair them.

→ precast pipes are very heavy, and it is difficult to transport them.

—x—

** * Drinking water quality:-

→ The quality of water is determined by the impurities present in it. These impurities may be physical, chemical or bacteriological in nature

→ It is not possible to find pure water in nature. The rain water as it drops down to the surface of earth absorbs dust and gases from the atmosphere. It is further exposed to organic matter on the surface of earth and by the time, it reaches the source of water supply.

→ In order to ascertain the quality of water, it is subjected to various tests. These test can be divided into the following three categories.

1) physical quality parameters:-
2). Chemical quality parameters:-
3) biological quality parameters.

* Some precautions may kept in mind at the time of taking sample of water for test:-

i) The water should be collected in bottles having well fitted stoppers. bottels having holding capacity of about 2 litres of water are necessary for chemical analysis.

ii) Bottles should be throughly cleansed, filled thrice with water and thrice emptied before collecting the sample.

iii) When the sample of water to be collected from a pipe, the water tap should be turned on and water should be allowed to go waste for at least two minutes so as to prevent the entry of impurities of the pipe in sample water.

iv) For collecting the sample of water from lake, streams, spring or well the whole bottled with stopper closed should be immersed deep into the surface of water then only stopper of the bottle should be removed by means of a clean piece of string and bottle is filled. Thus the entry of floating material will be prevented in the bottle.

v) The bottle should be held as far away from its neck as possible. To prevent the contact of water with hand.

vi) After collecting the sample, the stopper of bottle should be well secured and the bottles containing samples of water should be labeled stating the source, date and time of collection.

1) physical water quality parameters:-

i) suspended solid:-

Source:- suspended solid in water comes from inorganic particles like silt, clay etc. and organic particles like plant fibres, algae, plankton etc.

Impact:- → make the water aesthetically displeasing.
→ It provides adsorption sites for chemical & biological reagents.
→ It leads to incrustation in pipe & reduce discharge carrying capacity.

Measurement:-
→ Measurement of suspended solid is done by gravimetric technique i.e SS are measured by weighing them.
→ Total solid (i.e SS + DS) are calculating by evaporating the sample at 104°C and measuring the residue.
→ suspended solid is obtained by filtration and heating the residue on filter at 104°C
→ $\boxed{\text{Dissolved solid (DS)} = \text{Total solid (TS)} - \text{suspended solid (SS)}}$

→ organic solid both in total and suspended form can be determined by firing the test sample and residue in muffle furnace at 600-650°C.

→ At this temperature organic solids will be vapourised leaving behind inorganic solid.

→ organic solid $\xrightarrow[@600°C]{}$ CO_2 + water + gas.

Limits:

Acceptable limit (TS) — 500 mg/L

Cause of rejection (TS) — 2000 mg/L.

ii) Turbidity:-

Turbidity is the measure of extent to which light is either absorbed or scattered by suspended material in water however it is not a direct quantitative measure of suspended solid.

Impact:

→ Disinfection of turbid water is difficult.

→ In natural water bodies, turbidity interferes with light penetration and hence with the photosynthetic reactions (which gives oxygen to the water).

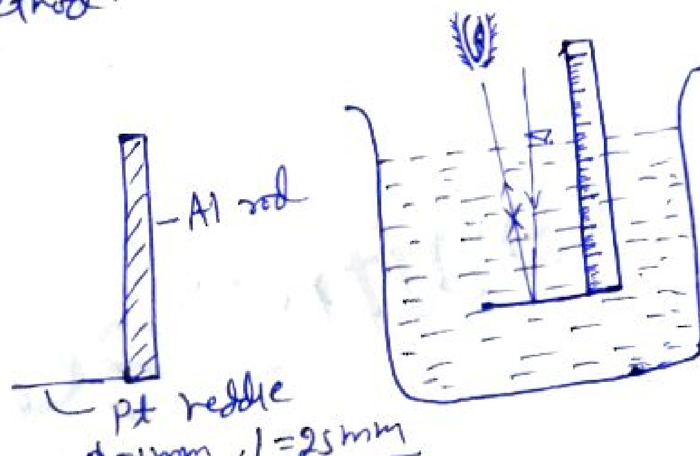
Measurement:

Measurement of turbidity is done using the following

a) Turbidity rod method
b). Jackson's Turbiditimeter
c). Baylis turbidimeter
d) Nephlometer.

a) Turbidity rod method:

→ It is field method.



→ Rod with pt niddle is inserted inside water and the depth at which platinum needle just become invisible is noted.

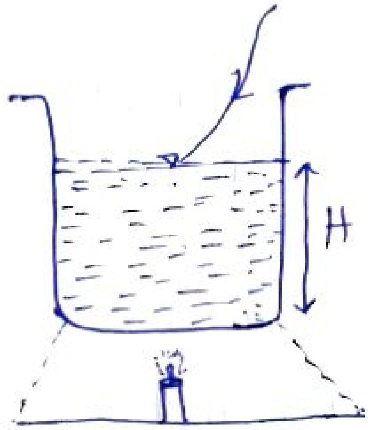
→ Depth is calibrated to give turbidity in standard unit.

→ Turbidity which one mg of finely divided silica powder produce in one litre of distilled water is taken as standard unit and expressed as ppm, mg/lit, STU (silica turbidity unit).

b) Jackson's Turbidimeter:-

→ It is laboratory method:-

→ The turbidity is measured from graduated glass tube



→ The level of water increased till the image of flame to be seen. This depth is noted and calibrated with turbidity.

→ It is used when turbidity is greater than 25 ppm

→ Unit expressed as JTU.

c). Baylish turbidimeter/ Nephlometer:-

→ Baylis turbiditimeter & Nephlometer are based on Color matching techniques.

→ In this case even a small turbidity of one unit or less can be measured.

→ Hence these are most widely used for domestic water supply

→ In Baylish turbidimeter light intensity is measured in the direction of incident light only where as in Nephlometer light intensity is measured a right angle to the incident ray.

→ Hence STU is based on absorption principle & NTU is based on scattering principle.
└ at right angle.

→ In Nephlometer formazine a chemical is used as base in place of SiO_2 and turbidity unit is also sometimes called FTU.
→ $C_{17}H_{13}N_3SO_3$ — carbon polymer.

Limits:

Acceptable limit — 1 NTU
Cause of rejection — 10 NTU.

iii) Colour:-

Source: → Colour is caused be suspended and dissolved matter in water referred as apparent colour.

→ After suspended matter causing colour is removed by ~~...~~ centrifugation, the colour obtained is called true colour.

Impacts:-

→ Coloured water is not used for dying purpose.

→ organic compounds causing colour may exert Cl (chlorine) demand and hence reduce the effectiveness of disinfection by chlorine.

Measurement

→ Measurement of Colour is done by Colour matching technique (Tintometer)

→ Result is expressed in TCU (True Colour Unit) Where 1 TCU is equal to Colour produce by 1 mg per liter of platinum in the form of Chloroplatinum ion.

→ The Colour testing is done within 72 hours of Collection as otherwise biological or physical properties may change.

Limits:-

Acceptable limit – 5 TCU
Cause of rejection – 25 TCU

IV) Teste and odour :-

Source:-

→ Test and odour are Caused by dissolved gases like hydrogen sulphide, methane, organic matter or from inorganic matter.

→ Sulphur imparts rotten egg like teste and odour.

Impacts:-

→ The teste and odour Causing Compounds may be Carcinogenic.

Measurement:

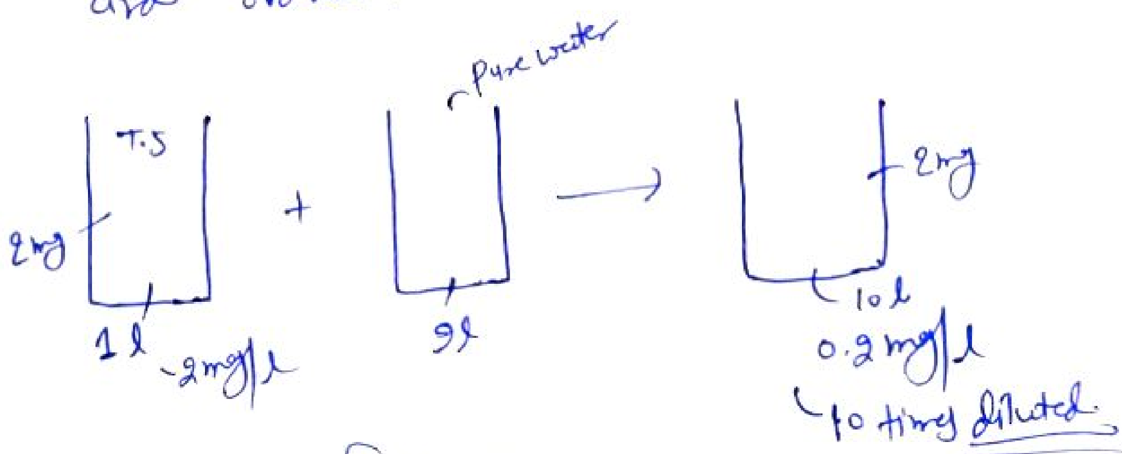
→ odour is generally measured by an instrument known as osmoscope by diluting the water sample up to an extent it is hardly detectable.

→ Intensity of taste and odour is expressed by Threshold odour Number (TON)

→ It represents the dilution ratio at which odour is hardly detectable.

→ TON = (A+B)/A , where A is the volume of odoury water in ml and B is the volume of odour free water required to produce a mixture in which odour is hardly detectable

→ TON testing is done in cold water because increased in temperature may change the taste and ordour.



$$\text{Dilution} = \frac{\text{final volume}}{\text{Initial vol}^m \text{ of test sample}}$$

e.g.:-

test sample	+ pure water	= Diluted sample	
40	160	200	[NA
30	170	200	greater than
5	195	200	200].

$$TON = \text{Dilution ratio} = \frac{\text{final volume of diluted sample}}{\text{Initial volume of tense sample}}$$

~~Te~~ limits:-

Acceptable limit – 1 TON
Cause of rejection – 3 TON

V) Temperature:-

→ Temperature affects the chemical & biological reactions.

→ An increase in 10°C almost doubles the biological activity

→ For water supply, the temp should be between 10-25°C.

=X=

** Chemical quality parameters of drinking water:-

i) Alkanity:-

→ The alkalinity is the capacity of a given sample to neutralize a standard solution of acid.

→ The ~~alkality~~ alkalinity is due to the presence of bicarbonate (HCO_3), carbonate (CO_3) or hydroxide (OH)

→ Most common constituents of alkalinity are

$\{CO_3^{2-}, HCO_3^-, OH^-\}$

L9610974.

→ Alkalinity caused by CO_3^{2-} is called carbonate alkalinity, alkalinity caused by HCO_3^- is called bicarbonate alkalinity and alkalinity caused by OH^- is called caustic alkalinity.

→ Minor constituents of alkalinity are:-

$HSiO_3^-$, $H_2BO_3^-$, HPO_4^{2-}, HS^-, NH_3^0, $H_2PO_4^-$

→ $CO_2 + H_2O \rightarrow H_2CO_3$

$$\left.\begin{array}{l} H_2CO_3 \longleftrightarrow HCO_3^- \\ HCO_3^- \longleftrightarrow CO_3^{2-} \end{array}\right\} \text{Reversable Reaction}$$

$CO_3^{2-} + H_2O \rightarrow HCO_3^- + OH^-$

→ $Ca^{2+} + CO_3^{2-} \rightarrow CaCO_3 \downarrow$

$OH^- + Mg^{2+} \rightarrow Mg(OH)_2 \downarrow$

$OH^- + Al^{3+} \rightarrow Al(OH)_3 \downarrow$

Measurement :

→ Alkalinity measurements are done by titrating the water with an acid and determining the hydrogen eqivalent of alkalinity and it is expressed in terms of mg/L as $CaCO_3$

→ Conversion of CO_3^{2-} to HCO_3^- is essentially complete at PH = 8.3 but resultant HCO_3^- also requires same amount of acid for neutralization.

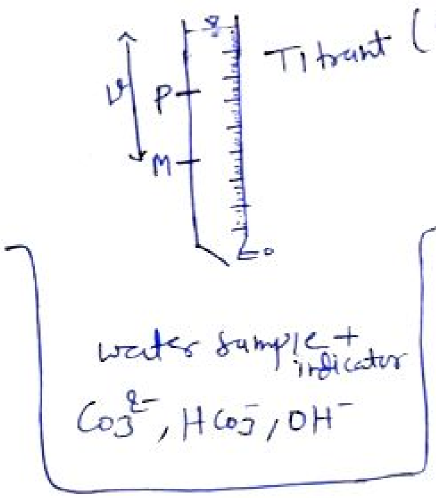
→ Hence half of CO_3^{2-} is thought of to have been neutralized upto PH = 8.3.

→ Neutralization of OH^- is also complete upto PH = 8.3

→ Hence $(OH^- + \frac{1}{2}CO_3^{2-})$, alkalinity is completely neutralized upto PH = 8.3

→ At PH = 4.5 all the bicarbonates will have been neutralized

→ Hence total alkalinity $(OH^- + CO_3^{2-} + HCO_3^-)$ is neutralized at PH = 4.5



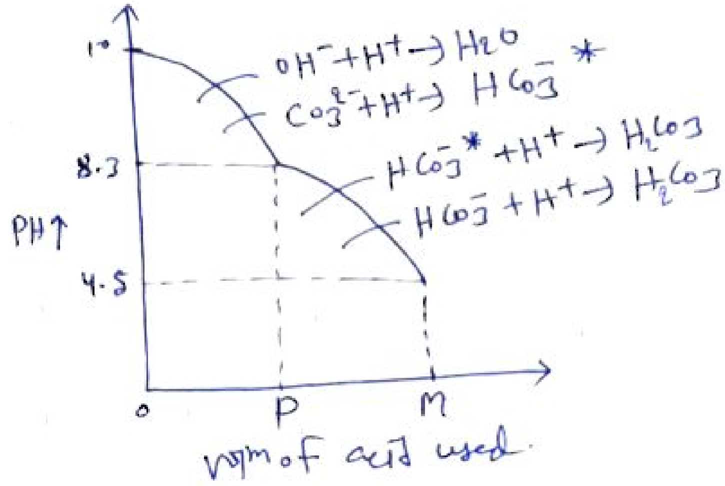
PH range (8.6 to 10.3)

1) phenopthaline - pink turns colourless

2) methyl orange

orange turns to yellow.

PH range (2.8 – 4.4)



- → If $P=0, M \neq 0 \Rightarrow$ only HCO_3^- alk is present
- → if $P=M \Rightarrow$ OH^- alk is present
- → if $P=M/2 \Rightarrow$ { only CO_3^{2-} alk is present
  - $[OH^-]=[HCO_3^-]$ – alk present
  - $[OH^-]=[HCO_3^-]$, CO_3^{2-} alk present.

Limits:

Acceptable limit = 200 mg/L

Cause of rejection = 600 mg/L.

Notes:

$\boxed{\text{Molarity} = \frac{\text{no of moles}}{\text{lit}}}$ [M] , $\boxed{\text{No of moles} = \frac{\text{given wt}}{\text{molecular wt}}}$

$\boxed{\text{Normality} = \frac{\text{no of gram equi}}{\text{lit}}}$ [N] , $\boxed{\text{no of gram equivalent} = \frac{\text{given wt}}{\text{equivalent wt}}}$

$\boxed{\text{equivalent wt} = \frac{\text{Molecular wt}}{\text{valency}}}$ $\boxed{N_1V_1 = N_2V_2}$

→ In 1 lit of water 500 gm of $CaCO_3$ is present means.

$\boxed{10\ N\ CaCO_3}$ $\boxed{5\ M\ CaCO_3}$

Q) A 20 lit Sample of water has 420 grams of Carbonate ion, 244 grams of bicarbonate ion and 68 gram of OH^- ion. repst the Concn of all these alkaline species as $CaCO_3$ in mg/l.

Soln

$CO_3^{2-} \rightarrow 420$ gm , gm. equi $= \frac{420}{30} = 14 = 14$ gm equi of $CaCO_3$

$HCO_3^- \rightarrow 244$ gm , gm. equi $= \frac{244}{61} = 4$ $= 4$ gm equi of $CaCO_3$

$OH^- \rightarrow 68$ gm , gm. equi $= \frac{68}{17} = 4$ $= 4$ gm eqn of $CaCO_3$.

total alkalinity as $CaCO_3$

$= 14+4+4 = 22$

Concn $= \frac{22 \text{ gm eqn}}{20 \text{ lit}} = \frac{22 \times 10^3}{20} \times 50 = 55 \times 10^3$ mg/l

$\Downarrow$

Concn $= \frac{\text{given wt}}{\text{volume}} = \frac{\text{No. of gm eqn} \times \text{equivalent wt}}{\text{vol}^m}$

[Note:- 1 gm equivalent of anything is equal to 1 gm equivalent of any other thing.] .

ii) PH :-

→ The acidity or alkalinity of water is measured in terms of its PH value or H-ion Concentration.

→ The acidic water causes tuberculation & the alkaline water causes incrustation.

→ It is scale which is used to indicate the acidity or basicity of water in the range of 0-14.

→ $PH = -\log[H^+]$ where $[H^+]$ = moles/litre.

→ $POH = -\log[OH^-]$ where $[OH^-]$ = moles/litre.

→ $PH + pOH = 14$

→ PH value of water is measured by Electrometric method.

→ In this method potentiometer is used to measure the electrical pressure exerted by positively charged H-ions.

→ PH range of supply water is 6.5 to 8.5.
└ Case of rejection < 6.5 or > 9.2

iii) <u>Hardness:-</u>

→ It is defined as ability of the water to destroy the surfactant property of soap.

→ It is the soap destroying capacity or property due to the presence of Bicarbonates, sulphates and chlorides of calcium and magnesium.

→ It may also be referred as concentration of multivalent cation in the solution.
Like Ca^{2+}, Mg^{2+}, Al^{3+}, Sr^{2+}, Fe^{2+}, Mn^{2+} etc.

→ It is divided into two parts.

a) <u>Carbonate hardness:-</u> Hardness due to CO_3^{2-} and HCO_3^- of multivalent cation is referred as carbonate hardness.

→ it is also referred as temporary hardness and it can be easily removed by simple boiling or by addition of lime. (CaO) $Ca(OH)_2$
└ quick lime └ Hydrated lime

b). <u>Non-Carbonate hardness:-</u>

→ Hardness due to SO_4^{2-}, Cl^- and NO_3^- of multivalent cation is referred as non-carbonate hardness.

→ It may be referred as permanent hardness as it cannot be removed by simple boiling or by addition of lime.

$$\begin{cases} Ca(HCO_3)_2 \xrightarrow{\Delta} CaCO_3\downarrow \\ Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3\downarrow \\ MgCO_3 + Ca(OH)_2 \longrightarrow Mg(OH)_2\downarrow + CaCO_3\downarrow \\ Mg(HCO_3)_2 + Ca(OH)_2 \rightarrow Mg(OH)_2\downarrow + Ca(HCO_3)_2 \end{cases}$$

$$Ca(HCO_3)_2 \xrightarrow{Ca(OH)_2} 2CaCO_3\downarrow$$

Alkalinity and Hardness:-

→ CO_3^{2-} and HCO_3^- ions in water are usually given by Ca^{2+}, Mg^{2+}, Na^+ ion.

$\boxed{Ca^{2+}, Mg^{2+} \quad CO_3^{2-}, HCO_3^-}$, Na^+, OH^-

→ If Na alkalinity [Na_2CO_3, $NaHCO_3$] is absent

$$\begin{cases} Alk = \text{Carbonate hardness} \\ \text{Total hardness} = \text{Carbonate hardness} + \text{Non CH} \\ T.H > \text{Alkalinity} \end{cases}$$

T.H > Alk

Alk = C.H

Alk > C.H

T.H > C.H

T.H = C.H

T.H > Alk

→ $CaCO_3 \downarrow$ - No hardness, no alkalinity.

→ Ca^{2+}, CO_3^- when present in ionic form then gives hardness and alkalinity.

→ Na alkalinity is absent only if when Non-Carbonate hardness is present if Non-carbonate hardness is absent then only Na-alkalinity present. because

$$\underbrace{Ca^{2+}/Mg^{2+} + \begin{cases} Cl^- \\ SO_4^{2-} \\ NO_3^- \end{cases}}_{\text{Non-Carbonate hardness}} + \underbrace{Na^+ \begin{cases} CO_3^{2-} \\ HCO_3^- \end{cases}}_{\text{Na-alkalinity}} \rightarrow \underbrace{Ca^{2+}/Mg^{2+} \begin{cases} CO_3^{2-} \\ HCO_3^- \end{cases}}_{\text{Carbonate hardness}} + \underbrace{Na^+ \begin{cases} Cl^- \\ SO_4^{2-} \\ NO_3^- \end{cases}}_{\text{Salt}}$$

$$\left.\begin{matrix} Alk > T.H \\ T.H = C.H \end{matrix}\right\}$$

→ $\boxed{(\text{Total hardness, Alkalinity})_{min} = \text{Carbonate hardness}}$

Q) A water contains the following dissolved ions:

$[Na^+] = 56$ mg/l ; $[Ca^{2+}] = 40$ mg/L , $[Mg^{2+}] = 30$ mg/L ;

$[Al^{3+}] = 3$ mg/l ; $[HCO_3^-] = 190$ mg/l ; $[Cl^-] = 165$ mg/l

water pH is 7.

Atomic weight: Ca-40, Mg-24, Al-27, H-1, C-12, O-16, Na-23, Cl-35.5

then find

→ The total hardness of the sample in mg/l as $CaCO_3$

→ The non-carbonate hardness of the sample in mg/l as $CaCO_3$.

Soln:-

i) For total Hardness. (Calculation done for 1 lit)

$$\text{total hardness} = \left[\frac{40}{20\times10^3} + \frac{30}{12\times10^3} + \frac{3}{9\times10^3}\right]\times 50\times10^3$$

equivalent wt

$= 241.67$ mg/l as $CaCO_3$

ii) For Non-Carbonate Hardness.

Total Hardness = C.H + N.C.H

$$\text{Alkalinity} = \frac{190}{61\times10^3}\times 50\times10^3 = 155.7 \text{ mg/l}$$

Carbonate Hardness = (Total Hardness, Alkalinity)$_{min}$

∴ Carbonate Hardness = 155.7 mg/l

∴ Noncarbonate Hardness = 241.67 − 155.7

= 86 mg/l as $CaCO_3$.

→ Acceptable limit − 200 mg/L
Causes of rejection − 600 mg/L.

iv) Chloride Content:-

→ Chlorides in water are derived mostly from natural minerals deposits, agricultural and irrigation discharge.

→ Presence of chloride in high quantity indicates pollution of water due to sewage or industrial waste.

→ Chlorides are estimated by Mohr's method in which raw water is titrated with standard $AgNO_3$ solution using K_2CrO_4 as indicator.

→ At end point when all Cl^- ion consumed with $AgNO_3$ than next drop of $AgNO_3$ reacts with K_2CrO_4 and it gives redish brown colour precipitate which easily visible in white color sample.

$$AgNO_3 + K_2CrO_4 \rightarrow Ag_2CrO_4 \downarrow \text{ (Redish brown)}$$

Acceptable - 200 mg/l, cause of rejection 1000 mg/l

v) <u>Nitrogen Content :-</u>

→ presence of Nitrogen in water indicates presence of organic matter.

→ It occurs in the form of

- <u>Free Ammonia:</u> → Indicates recent pollution
  → Due to organic matter
  → its decompose by microorganism.
  → Desirable limit 0.15 mg/l

- <u>organic Ammonia:-</u>
  → Indicates quantity of Nitrogen before decomposition has started.
  → Its bond is complex that's why less organic matter present here.

- <u>Nitrite:-</u> (NO_2^-) Indicates partially decomposed condition

- Nitrate:- Indicates old pollution i.e fully oxidised.

→ Free amonia should not be present more than 0.15 mg/L and it can be measured by simply boiling the water and measuring the liberated ammonia by distillation process.

→ organic ammonia should not be more than 0.3mg/l and it measured by boiling a sample of already boiled water plus strong alkaline solution like $KMnO_4$ and measuring the ammonia so liberated.

→ Free ammonia + organic ammonia = Kjeldahl Nitrogen ammonia.

→ Nitrite is highly dangerous, hence its permissible limit is zero.

→ Nitrate is not harmfull as it is fully oxidised. But too much of Nitrates affects infants because it cause ~~the~~ blue baby disease or mathemoglobinemia.

→ Concentration of Nitrate should not be more than 45 mg/l

vi) Dissolved gas:-

→ oxygen has high solubility in water and solubility of Nitrogen in water is very less so in water oxygen present as a major gas.

→ If NH_3, CO_2, CH_4 & H_2S gas present in water means organic matter present in water.

→ H_2S imparts bad taste and odour.

→ O_2 level less than saturation level indicates oxygen deficiency.

→ oxygen in water is determined using Winkler's test.

i) if D.O is absent:

water sample + $MnSO_4$ + NaOH + KI → $Mn(OH)_2 \downarrow$ (white).

ii) If D.O is present:-

water sample + $MnSO_4$ + NaOH + KI → $MnO_2 \downarrow$ (Red).

—x—

** Biological quality parameters:-

\# **Pathogens:-** [virus, Bacteria, ~~Helminthes~~ Helminths, Fungi, protozoa].

\# **Coliforms:-** [E- Coli, B- coli].

Test is always done for Coliforms because this test has less time taken and less Dangerous.

1) Most probable No. test:-

→ It is multiple tube fermentation test

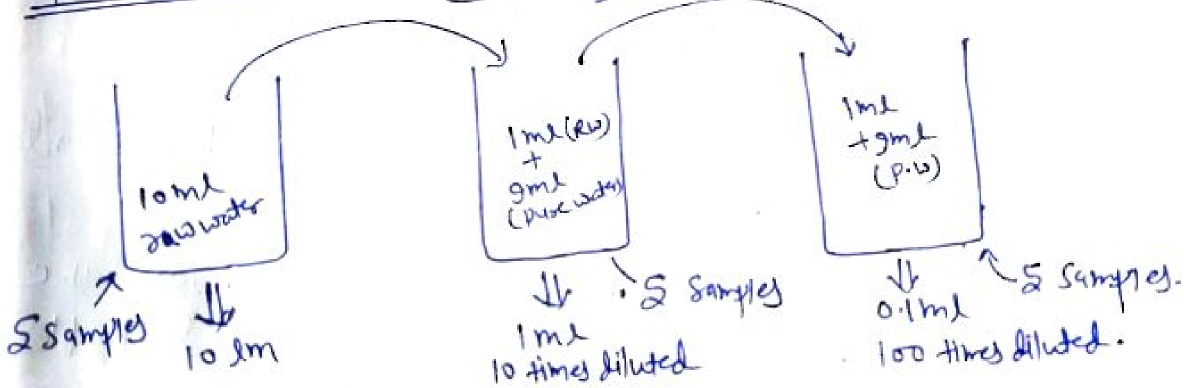
→ water sample of different dilution ratio are mixed with lactose and Incubated at 37°C for 48 hrs.

→ After Incubation presence of Coliforms is tested by noting gases and acid in the sample.

→ Then referring to the standard table $\frac{MPN}{100\ ml}$ is noted.

→ MPN represents the microbial density which is most likely to be present in the water sample.

procedure:- [In lab]



→ Each sample have different dilution ratio. Here three types of dilution ratio taken in lab 10ml, 1ml and 0.1ml.

→ Kept in Incubator [T = 35–37°C , t = 48 hrs].

→ Here 6 result is possible for Each type of diluated sample.
0, 1, 2, 3, 4, 5.

→ So three types of diluated Sample is present that's why Here total possibility of test result is $(6)^3 = 216$.

→ For Example from 216 result some result is Considering Here.

10ml	1ml	0.1ml	$\frac{MPN}{100ml}$ of pathogen
5	5	5	A
5	3	4	B
5	4	3	C
5	2	1	D
0	2	2	E

[Now In field].

→ let us our result is 5, 2, 1, then,

For
i) 10 ml, 1ml, 0.1ml ⟶ D
ii) 100ml, 10ml, 1 ml ⟶ 10 D
iii) 1 ml, 0.1ml, 0.01ml ⟶ D/10

→ If No° of diluted test Sample is more than Standard diluted Sample.

i) prepare the possible no° of set of Sample of same difference of dilution ratio as standard table.

→ Than report the MPN crossponding to the set which have all set present E-Coli. 3.

→ If No. of set is more than one than report crossponding to the set in which dilution ratio is maximum.

→ If No any set available which all sample have Coliforms than we choose that set which 2nd no. of sample have Coliforms. and if this types of set is more than one than select that set which have least dilution ratio.

Experiment

Sample size	Ex1	Ex2	Ex3	Ex4	Ex5
5 — 100ml	5	5	5	5	0
5 — 10 ml	5	5	5	2	2
5 — 1 ml	5	5	3	1	2
5 — 0.1 ml	5	4	4	0	0
5 — 0.01 ml	5	3	0	0	0

ii) Membrane filter technique:-

→ water sample is passed on a sterile membrane filter.

→ Membrane is then put in contact with nutrients (m-endo medium) that permits the growth of only coliform colony. After incubation for 20 hours number of visible colonies are counted and related to the pathogens.

—×—

** Indian Standards for drinking water :- (IS 10500:1991)

S.No	Substance/characteristic	Desirable limit	permissible limit or Cause of rejection.
1.	Colour	5 TCU	25 TCU
2.	odour	unobjectionable	—
3.	Taste	Agreeable	—
4.	Turbidity	5 NTU	10 NTU
5.	PH value	6.5 to 8.5	10
6.	Total Hardness (as $CaCO_3$ in mg/l)	200 mg/l	600 mg/l
7.	Iron	0.3 mg/l	1 mg/l
8.	Chlorides.	250 mg/l	1000 mg/l
9.	Residual, free chlorine.	0.2 mg/l	—
10.	Fluoride.	1 mg/l	1.5 mg/l
11.	Dissolved solid	500 mg/l	2000 mg/l
12.	Calcium	75 mg/l	200 mg/l
13.	manganese	0.10 mg/l	0.3 mg/l
14.	Copper	0.05 mg/l	1.5 mg/l
15.	Magnesium	30 mg/l	100 mg/l

16.	Sulfate	200 mg/l	400 mg/l
17.	Nitrate	45 mg/l	No Relaxation
18.	phenolic Compound	0.001 mg/l	0.002 mg/l
19.	mercury	0.001 mg/l	No relaxation
20.	Cadmium	0.01 mg/l	"
21.	Selenium	0.01 mg/l	"
22.	Arsenic	0.01 mg/l	"
23.	Cyanide	0.05 mg/l	"
24.	Lead	0.05 mg/l	" ~~mg/l~~
25.	Zinc	5 mg/l	15 mg/l
26.	Anionic detergents	0.2 mg/l	1 mg/l
27.	chromium	0.05 mg/l	No relaxation
28.	mineral oil	0.01 mg/l	0.03 mg/l
29.	Pesticides	Absent	Absent
30.	Radioactive material	Absent	Absent
31.	Alkalinity	200 mg/l	600 mg/l
32.	Aluminium	0.03 mg/l	0.2 mg/l
33.	Boron.	1 mg/l	5 mg/l

Treatment of water:-

→ Treatment of water is based open both quality of raw water and quality of treated water.

→ Treatment of water can be done by any of the following methods.

Screening	Disinfection
Aeration	Softning
Coagulation	De-Salination.
Flloculation	De-Ferrisation
Sedimentation	De-Fluoridation
Filtration	Fluoridation.

1). Screening:-

→ It is process of removal of heavy suspended particles from the water like plants, animals, stones etc.

→ It is adopted for the treatment of surface water.

→ Screening is done with the help of the unit screen which are classified into two types.

i). Coarse screen/Bar screen/Trash rack:-

→ The screens are in the forms of the bars of dia 10-25 mm having spacing of 20 to 100 mm c/c in between them.

→ The screen is always placed at an inclination of 3 to 6 vertical to 1 horizontal. as it helps in.

a) effective cleaning of screens by racking mechanism.

b). Increasing the efficiency of screen process.

c). When water passes through the screen loss in head takes place. magnitude of which is given by

$$\boxed{h_c = \frac{K}{2g}\left(V^2 - u^2\right)}$$

Where $\frac{K}{2g} = 0.0729$

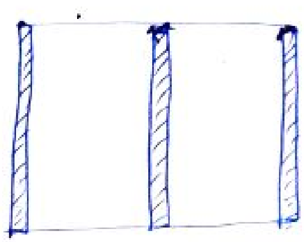
K = Constant, depends upon material of screen.
V = Velocity through the screen.
u = velocity approach.
g = accn due to gravity.

ii) Fine Screen:-

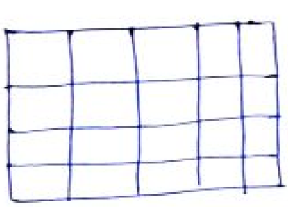
→ The screen are in the form of wire or mesh of size 10 mm.

→ Under normal treatment Condition fine screens are avoided as they can fequently chocked, required frequent cleaning which is turns increases its operational Cost.

→ Hence It is recomended to use Coarse Screen instead of fine screen.



Coarse screen



Fine Screen.

2) Aeration:-

→ It is process in which water is brought in intimate contact with air, so as to allow to absorption of oxygen in it.

→ In order to carry out the oxidation of following dissolved solid from the water.

i) It remove dissolved gases like H_2S, CO_2 from the water.

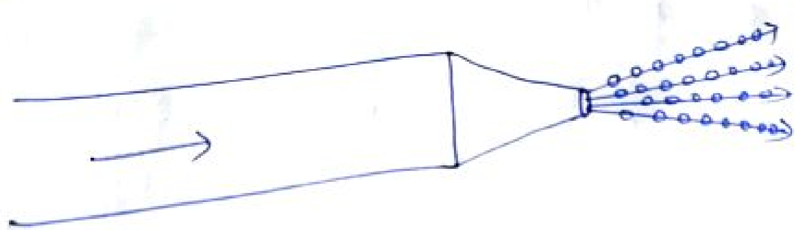
ii). It removes dissolve organic matter from the water.

iii). It removes volatile liquid like phenol and humic acid from the water.

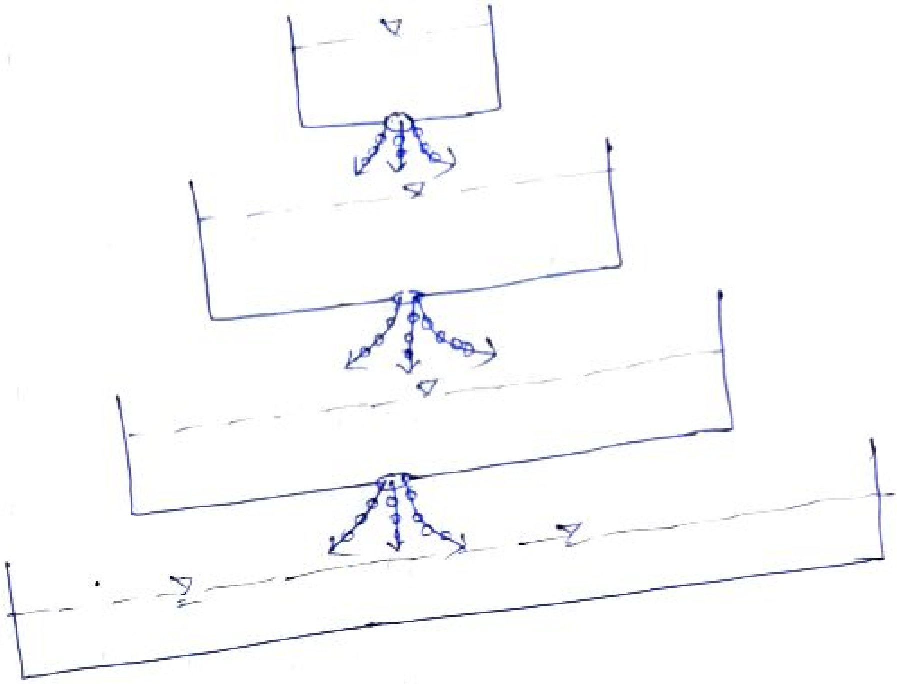
iv). It removes dissolve minerals like Fe and Mn from the water.

→ It is adopted for the treatment of water which is deavoided of oxygen eg:- ground water and water at the bottom of the lacks.

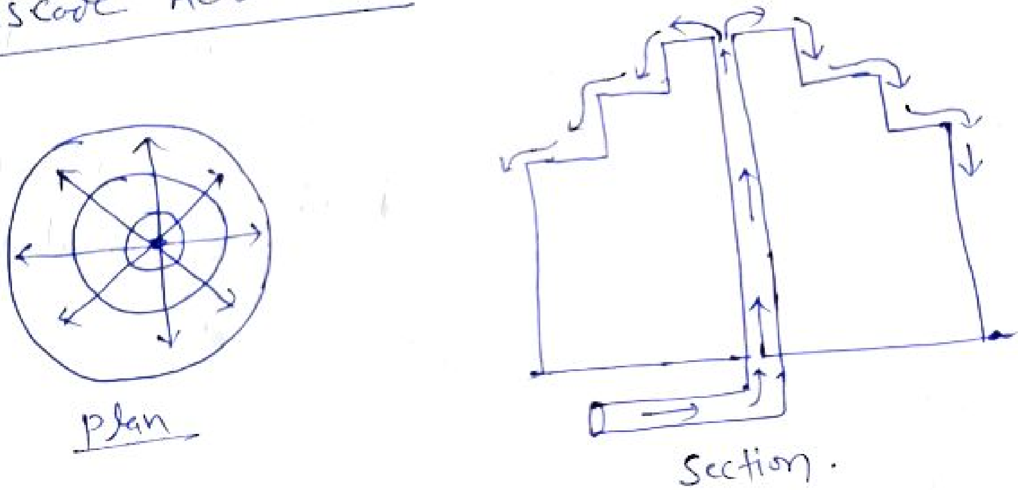
A). Sprey Nozzle method:-



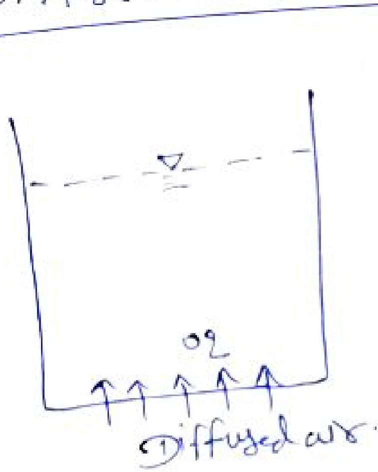
B) Tray tower method:



c). Cascade Aerator:-



d). Diffused Air method:-



$H_2S \xrightarrow{O_2} SO_4^{2-}$

$CO_2 \xrightarrow{O_2} CO_3^{2-}$

$Fe^{2+} \xrightarrow{O_2} Fe(OH)_3 \downarrow + 8H^+$

$Mn^{2+} \xrightarrow{O_2} MnO_2 \downarrow + 4H^+$

Increase turbidity & acidity.

** Sedimentation :-
*
3

→ It is process of removal of suspended particles from the water.

→ The entire theory of sedimentati[redacted]pon the single parameter Terms as specific gravity.

$$G = \frac{\text{wt. of Solid of given vol m [redacted]}}{\text{wt. of } \underbrace{\text{Std. fluid}}_{\text{water}} \text{ of same volume}}$$

$$G = \frac{W_s}{W_w} \times \frac{V_s}{V_s}$$

$$G = \frac{W_s}{V_s} \times \frac{V_s}{W_w}$$

specific gravity ⇒ $\boxed{G = \dfrac{\gamma_s}{\gamma_w}}$ $\gamma_w = 9.81 \ KN/m^3$ — specific wt of water.

→ During sedimentation all the factors which oppose the tendency of settlement are taken proper care off.

i) Velocity of flow (V_f) — $V_f(\downarrow) = \eta(\%)\uparrow$

ii) viscosity (μ)

iii) size of particle (d)

→ For laminar flow Condition

$$\boxed{V_s = \frac{(G-1)\rho g d^2}{18\mu}}$$

Kinematic viscosity — $\boxed{\nu = \dfrac{\mu}{\rho}}$ — μ dynamic viscosity, ρ density

ρ = density of water

μ = dynamic viscosity of water.

G = specific gravity of particles.

μ = Ns/m^2

ν = m^2/sec.

d = dia of particle.

→ Sedimentation is carried out in the tank called sedimentation tank which are broadly classified into two types.

i) [redacted]: Quiescent type.

ii) Contineous flow type.

[redacted]

i). Quiescent type:-

→ Also termed as fixed type or fill and draw type tank.

→ These are the type of tank in which flow of the water is completely stopped for 24 hours during which suspended particles get settled in the tank.

→ After settling suspended particle leading to the formation of the sludge in the bottom of the tank after which settled water is further drawn out from the tank for next treatment.

→ Detention time (td) of this tank is 24 hrs., cleaning time period 6 to 12 hrs.

ii) Contineous flow type tank:-

→ These are the types of tank in which flow of the water is insure to be contineous either in horizontal or in vertical plane in order to carry out the sedimentation.

* Coagulation added sedimentation:-

→ Efficiency of plain sedimentation is comparatively reduced if water consist of fine suspended particle.

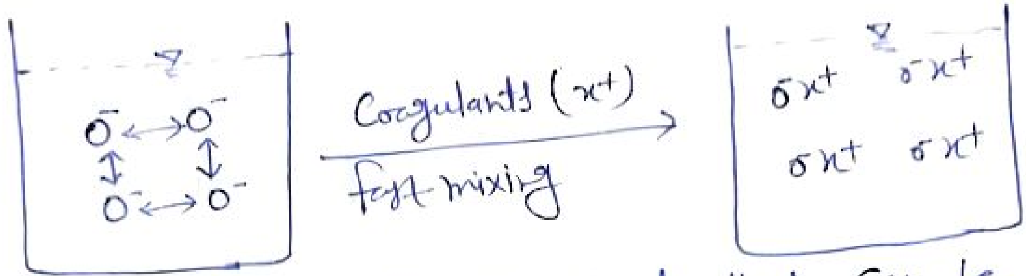
→ Hence in such case in order to increase the efficiency coagulation added sedimentation is adopted which is carried out in 3 stages:

i) Coagulation
ii) Fllocculation
iii) Sedimentation.

i) Coagulation:-

→ It is process in which certain chemicals termed as coagulants are added in water in order to neutralise the negative protective charge over the suspended particle and to form sticky precipitate resulting in the formation of bigger size particle which can get easily settled in sedimentation process.

→ In order to neutralize the charge over the suspended particles certain minimum energy termed as threshold energy is required to be provided which is induced by fast mixing in this process.



→ Different types of chemical that can be used as Coagulant.

a) Alum:- [$Al_2(SO_4)_3 \cdot 18H_2O$] - Hydrated Aluminium Sulphate

pH range 6.5 to 8.5

→ Alum when added in water reacts with alkalinity present in water and leads to the formation of sticky precipitate of [$Al(OH)_3$] which attracts fine suspended particles over its surface resulting in the formation of bigger size particle which can get easily settled.

→ If alkalinity is not present in water Naturally then it is introduce artificially either by adding lime or soda ash.

b) Copperas:- [$FeSO_4 \cdot 7H_2O$] - Hydrated Ferrous Sulphate.

→ Sticky precipitate of [$Fe(HCO_3)_2$] → pH range 8.5 and above

c) Chlorinated Copperas:- [$Fe_2(SO_4)_3 + FeCl_3$]

→ Chlorinated Copperas is formed by addition of cl in Copperas.

→ If ferric chloride is used independently as a Coagulent it works with the pH range 3.5 to 6.5 and above 8.5.

→ If ferric sulphate is used independently it works with PH range of 4 to 7 and above 9. hence chlorinated copperas work in a wide range of 3.5-7 and above 8.5.

d) Sodium aluminate [$NaAl_2O_4$].

→ It reacts with Ca & Mg present in the water and leads to the formation of sticky precipitate of Ca/Mg - Aluminate [Ca/Mg Al_2O_4]. Which attracts fine suspended particles over its surface leading to the formation of a bigger size particle which can get easily settled in following sedimentation process.

→ It does not required alkalinity to be present in the water. Also remove the hardness of water.

→ Working PH range 6-8.5.

ii) Flocculation:-

→ It is process in which neutrilize particles are brought in intimate contact with each other and with sticky precipitate resulting in formation of a bigger size particle which can get easily settled in the following sedimentation process.

2. Filtration:-

→ The process of filtration forms the most important stage in the purification of water

→ It usually consists in allowing water to pass through a thick layer of sand.

→ During the process of filtration, the following effects occur on water.

i) The suspended and colloidal impurities which are present in water in a finely divided state are removed to a great extent.

ii) The chemical characteristics of water are altered.

iii). The number of bacteria present in water is also considerably reduced.

→ The theory of filtration to explain why such effects take place is based on the following four actions.

1) Mechanical straining
2). Sedimentation
3) Biological metabolism
4). Electrolytic changes.

1). Mechanical Straining:

→ particle which are larger in size than the pores of filter are strained out.

→ The arrested impurities including coagulated flocks forms a mat on the top of sand layer, which has pore sizes smaller than that of the sand grain.

→ Hence even the particle smaller than the pores size of sand gets removed.

2) <u>Sedimentation</u> :-

→ Due to removal of turbulance from the water upto certain extent some particles settle down on the surface of sand grains making the filtered water free from suspended solids.

3) <u>Biological metabolism</u>:-

→ During first few days upper layer of sand grains gets coated with sticky deposits of partially decomposed organic matter together with iron, manganese, aluminium etc, which contains the algae, plankton etc that uses nitrogen and phosphorous as nutrient and grow, and due to photosynthetic reaction produces oxygen.

→ This oxygen is utilized to oxidize the organic matter which are in particulate form or dissolved form, thus stable harmless compound is formed.

→ This process takes place in the layer termed as SCHMUTZDECKE.

→ Due to scarcity of organic matter, bacteria by endogenous respiration also destroys each other and hence bacterial load is also reduced.

y) Electrolytic Charges:-

→ The sand grain in filter and impurities in water carry opposite charges, they because of their interaction the chemical characteristics of water changes and it becomes free from dissolved impurities.

Classification of filters:-

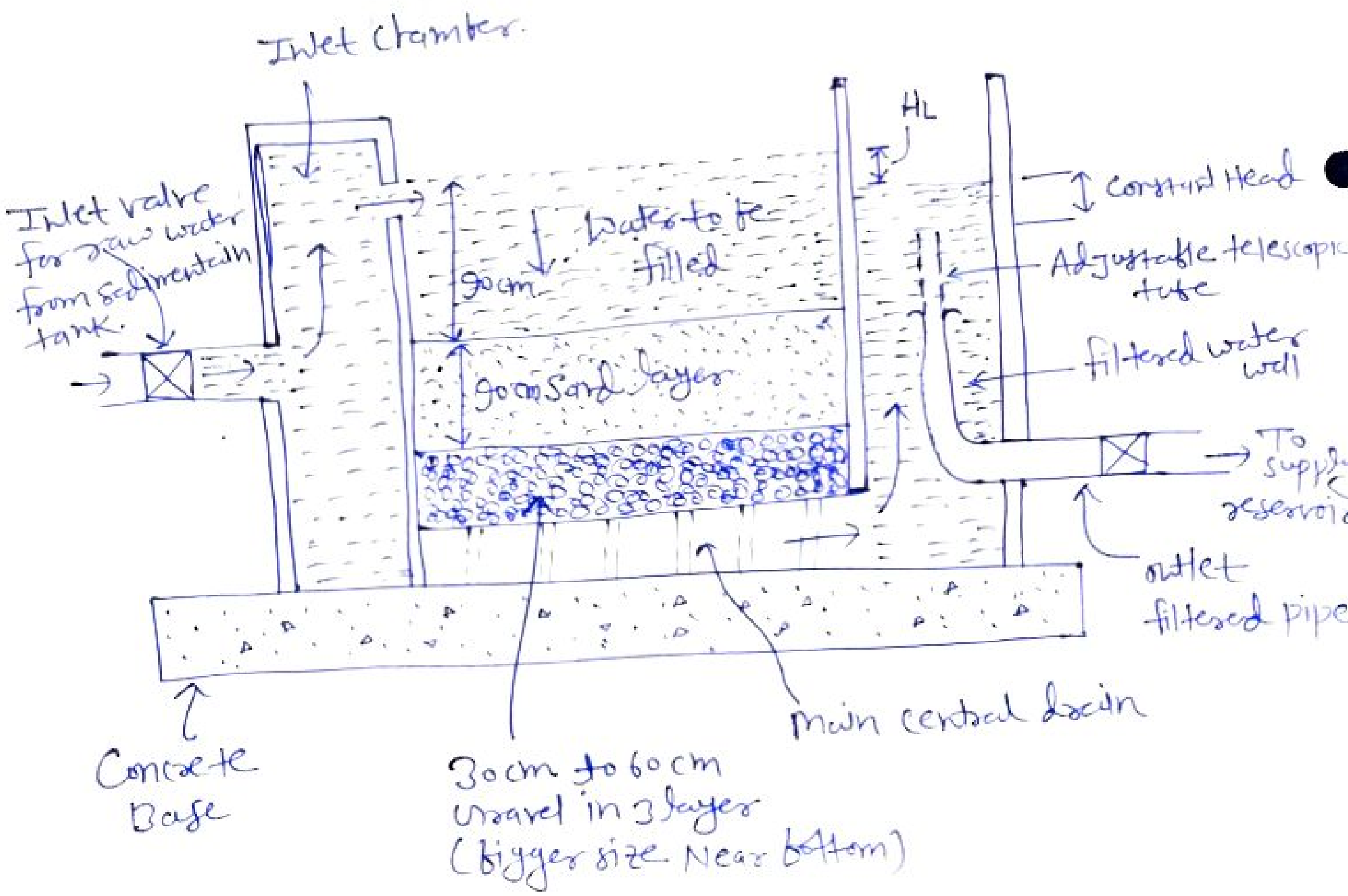
The filter are classified into following categories.

A). Slow sand filter

B). Rapid sand filter

c) pressure filter.

A). Slow sand filter:-



Purpose:

→ In case of slow sand filter, the water is allowed to pass slowly through a layer of sand placed above the base material and thus the purification process aims at simultaneously improving the biological, chemical and physical characteristics of water.

→ The slow sand filter is very well suited for rural area in developing countries because of its simple operation and maintenance procedure.

→ Rate of filtration of normal slow sand filter varies from 2400–4800 l/m^2-day.

→ Depth of water over sand medium is approx same as that of the sand medium depth.

→ Top 15 to 30 cm of the sand layer is of finer variety and remaining is of uniform size.

→ Freshly clean filter will have a Head loss 10–15 cm. When headloss increases telescopic tube is adjusted to maintain constant discharge.

→ When head loss becomes 0.7 to 0.8 times the depth of sand cleaning is done.

→ For cleaning the top 1.5 to 3 cm of sand is removed in each cleaning and the remaining surface is scrapped.

→ Filter is washed with good water and is loaded with raw water but effluent is not used.

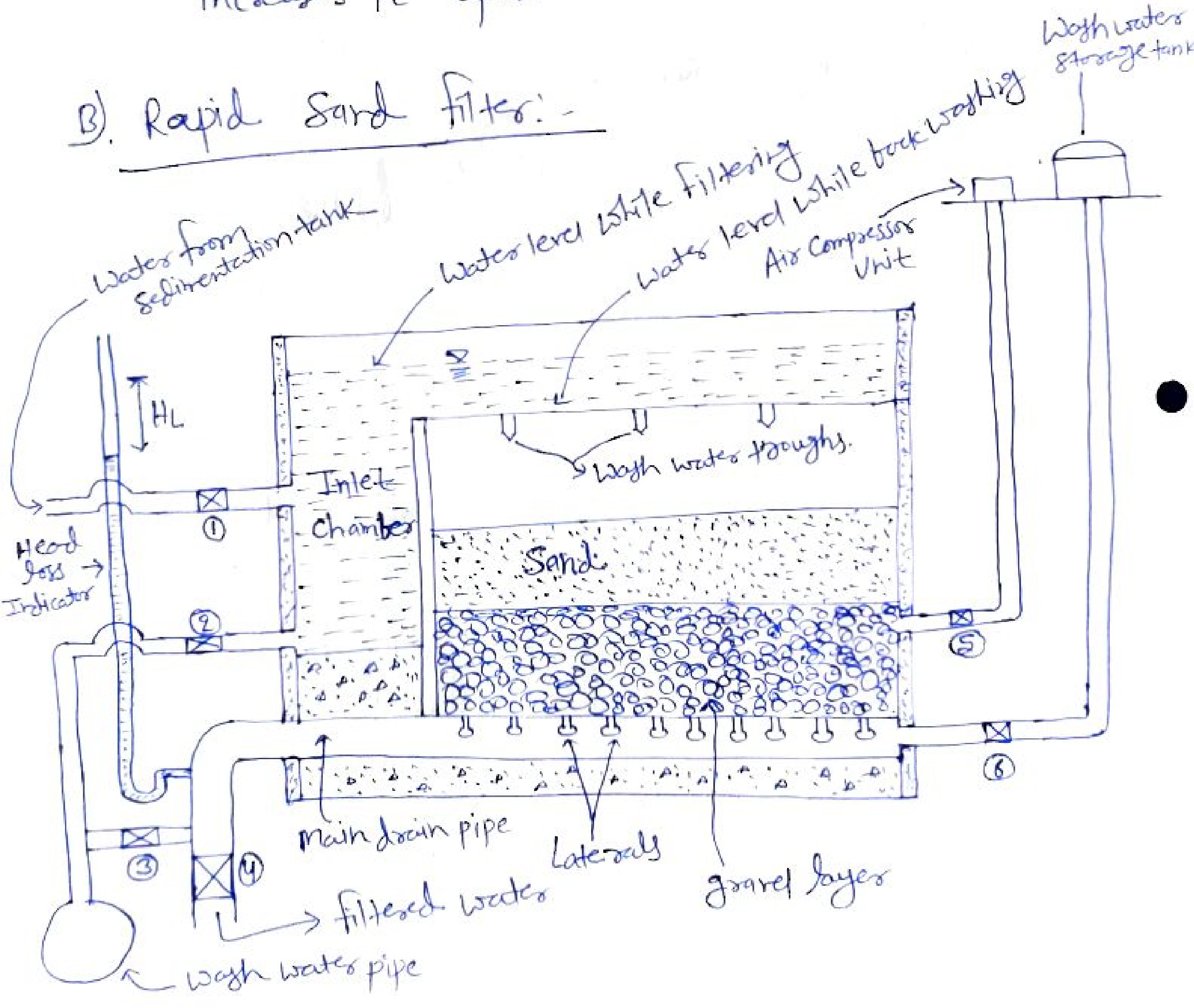
→ After 24 to 36 hr a film of arrested impurities forms and filter becomes ready for operation.

→ Frequency of cleaning is 1 to 3 months.

→ Efficiency of slow sand filter in bacteria removal is 98 to 99%.

→ This filter can not be used if turbidity of water is grater then 50 NTU, as it gets frequently choked requiring its frequent cleaning which increases it operational cost.

B). Rapid sand filter:-



→ operation of rapid Sand filter is same as that of Slow Sand filter.

→ At the time of operation valve 1 and 4 remains open and 2,3,5 & 6 remain closed.

→ In case of rapid Sand filter, size of Sand particles are large hence impurities can penetration deep inside the Sand layer thus surface washing alone will not be affective. In this case we go for back washing.

→ Back washing is necessary so that the bed of sand is expanded and impurities thus having better chance to come in contact with water because porosity of bed increases due to expansion.

→ For back washing valve 1 and 4 is closed 2 and 5 and 6 are opened thus wash water and air forces its way up through the filter thereby loosening up the sand and washing the accumulated solid in the sand. The dirty water goes in wash water through and is removed through valve 2.

→ once washing is complete valve 2,5,6 are closed and valve 1 & 3 are opened. This removes the remains of wash water and makes a dirty skin on the sand.

→ Finally valve 3 is closed and valve 4 is opened.

→ The entire process of back washing takes 15 to 30 min.

→ The washing period is normally 24 to 48 hrs.

→ The amount of water required 2 to 5% for back washing of total water filtered in a day.

→ The back washing velocity should not be more than the settling velocity of smallest size particle to be retained in filter.

→ Rate of filtration is 3000 to 6000 l/m^2-hr.

→ Efficiency of rapid sand filter with respect to bacteria removal = 80 to 90%.

c). Pressure filter:-

→ Flow of water through filter media is not under gravity but it under pressure.

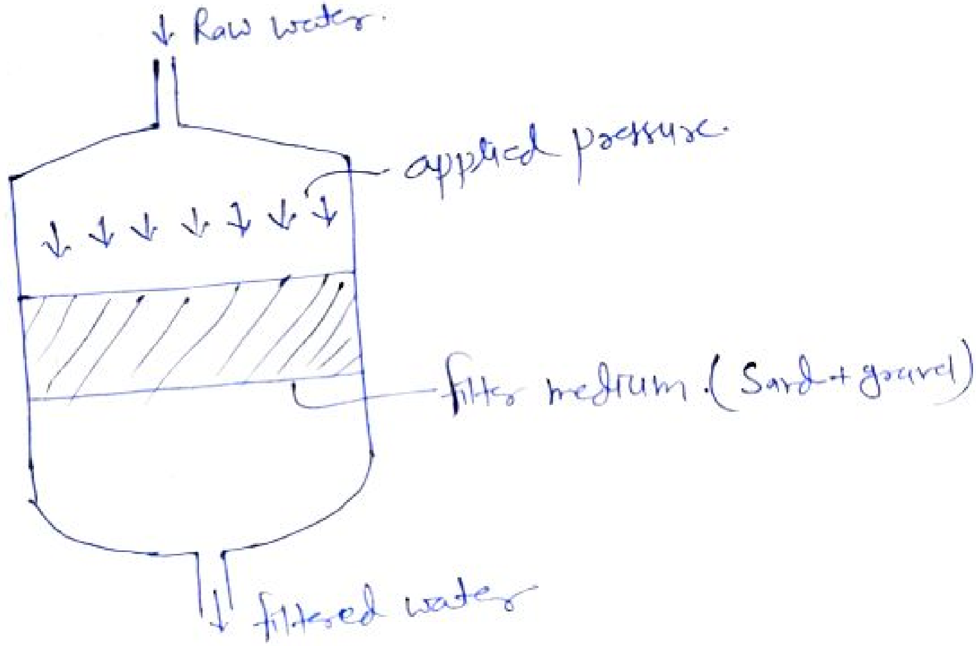
→ Dia of tank is 1.5 to 3m.

→ Height of tank - 3.5m.

→ It is operated like a rapid gravity filter except that the raw water is neither flocculated nor sedimented before it enters the filter.

→ Rate of filtration is 6000 to 15000 l/m^2-hr.

→ Used for clarifying softened water at industrial plant and in treating swimming pool water.



* Double filtration and Roughening filter:-

→ To increase the discharge through a slow sand filter without compromising on quality, we can use rapid sand filter in front of slow sand filter.

→ This rapid sand filter is called Roughening filter and process is called double filteration.

$$\rightarrow \text{R.S.F} \rightarrow \text{S.S.F} \rightarrow$$

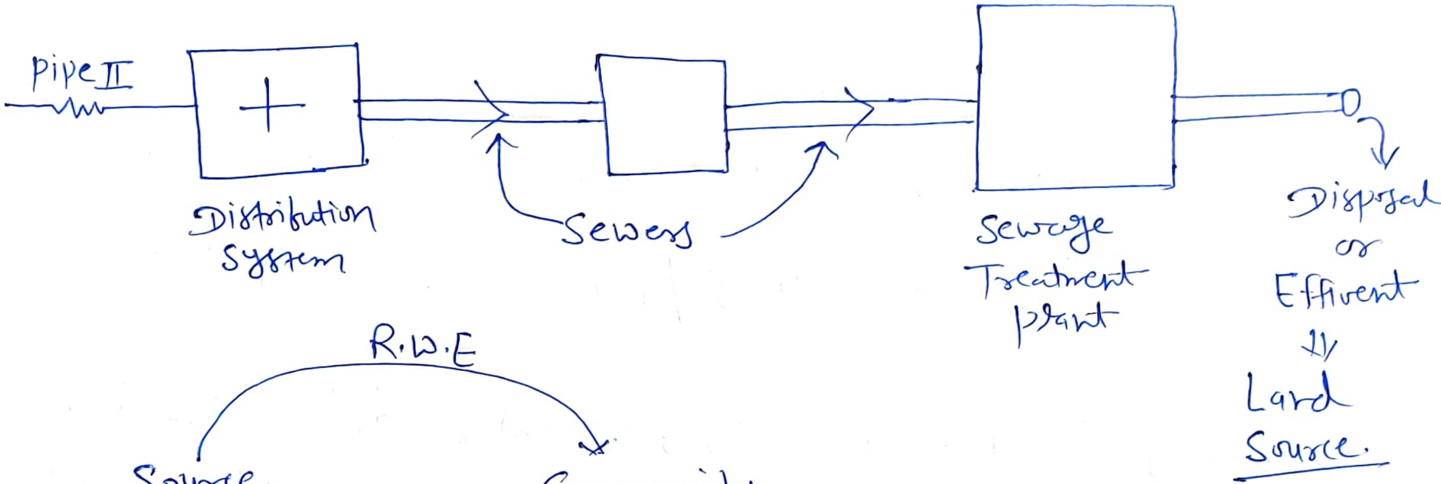
$$\boxed{\eta_{overall} = \eta_{I} + (1-\eta_{I})\cdot\eta_{II}}$$

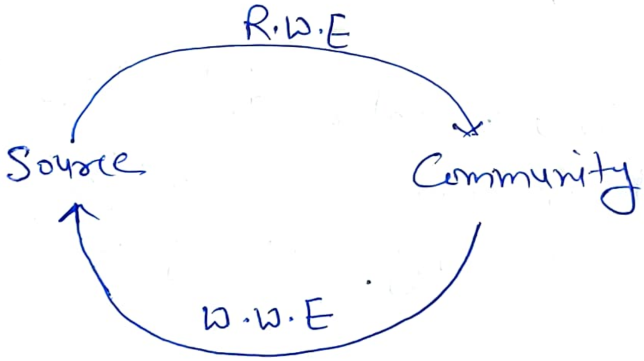
overall efficiency.

e.g.:- if $\eta_I = 60\%$ & $\eta_{II} = 70\%$, then find $\eta_{overall}$.

Soln:- $\eta_{overall} = 0.6 + (1-0.6)\times 0.7$
$= 0.88$
$= \underline{\underline{88\%}}$ Ans

*** Waste Water Engineering ***





*** Sewage/ waste water :-

→ mixture of water and liquid waste generated due to different activities in the Community is termed as sewage.

→ If this generated due to domestic activity it is termed as domestic sewage and if it is generated due to industrial activity it is termed as Industrial sewage.

→ If it is generated after heavy rainfall it is termed as drainage or run off.

Note :- Kitchen & bathroom waste taken together is termed as Sludge.

→ Domestic and industrial waste is together is termed as Sanitary sewage.

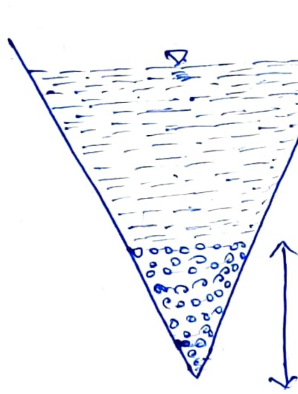
→ Drainage discharge is approximately 25-30 times more then Sanitary sewage discharge.

Sewage
- → Domestic
- → Industrial
  - (Domestic, Industrial) → Sanitary (organic)
- → Drainage / Runoff — Inorganic.

→ Sewage is more than 99.9 % water and less than 0.1 % Solid such that if 1000 kg of sewage sample is consider it consist of only 0.45 kg of total solids.

Total Solid
- 45% → organic
- 55% → Inorganic
- 50% → Dissolved
- 50% → Suspended
  - 25% → floating
  - 25% → settleable

<u>Note</u>:- If the sample of sewage is allowed to stand in Imhoff Cone for 2 hrs, an amount of Solid settled in it are termed as settleable Solid.



h, t = 2 hours.
height give Concn.

<u>Imhoff Cone</u>

** Sewers:-

→ Pipe or Conduits required to carry the sewage from one point to another point are termed as sewers.

* Sewarage System:-

→ The entire process of collecting, treating & Disposing the sewage is termed as sewarage system.

→ Depending upon the mode of collection of sewage these are classified into three Categories.

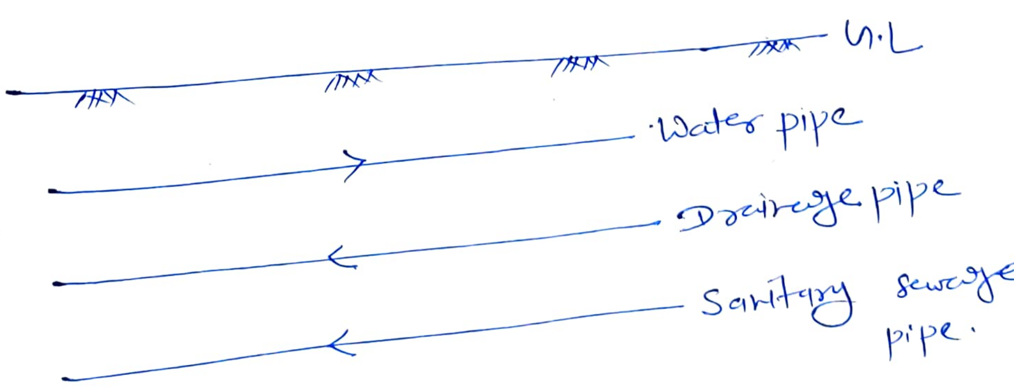
1). Seperate Sewarage system:-

→ In seperate sewarage system. different pipelines are used for water supply, Sanitary sewage and drainage.

→ In this system piping cost is high.

→ In this system Drainage runoff directly send to source.

→ If overflow takes place then it not creates any problem.



Seperate sewarage system.

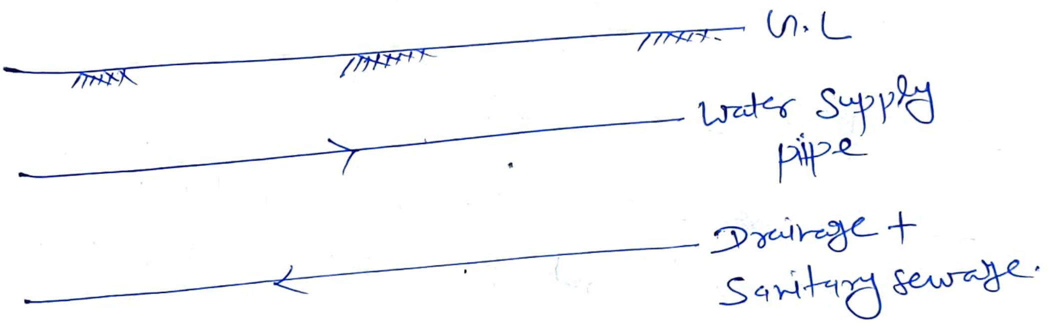
ii) Combined sewarage system:-

→ In Combined sewarage system only one pipe line is used for both Sanitary sewage and drainage.

→ Laying cost is very high.

→ In this type of system all drainage water send to treatment plant with Sanitary sewage.

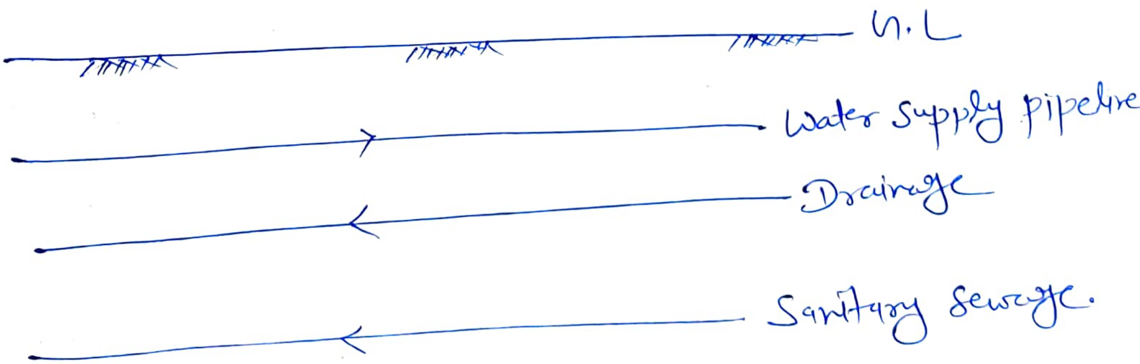
→ If overflow is takes place then it creates large number of problems.



iii) partially seperate sewarage system:-

→ In partially seperate sewarage system some part of drainage runoff mix with Sanitary sewage like roof drainage.

→ In this type of sewarage system three pipelines is used.



** * Quality of Waste Water:-

1) Physical Quality parameters.
[Same as Raw water].

2) Chemical quality parameters.

* Chemical quality parameters:-

1) Dissolve oxygen [D.O]:-

$D.O \simeq D.O_{sat}$ [In Raw water]

$D.O \simeq 0$ [In waste water].

$$\boxed{\text{Difficiency} = D.O_{sat} - D.O}$$

2) Chemical oxygen Demand [C.O.D]:-

→ It is the amount of oxygen required for the decomposition of both biodegradable and non-biodegradable organic matter present in a system.

→ It is determine by adding [$K_2Cr_2O_7 + H_2SO_4$] in the sample of the water to be tested and noting the amount of $K_2Cr_2O_7$ left after the decomposition of organic matter by titrating the water sample by ferrous ammonium sulphate [$(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$] using Ferroin indicator [Redox indicator].

Color change from pale blue to Red. When excess potassium dichromate converted into Cr^{3+} ion.

→ Water Sample + $[K_2Cr_2O_7 + H_2SO_4]$ $\xrightarrow[\text{Indicator}]{\text{Ferroin}}$ Blue Color Sample
{O.M & I.OM}

$\xrightarrow[\text{with F.A.S}]{\text{Titrate}}$ turn sample in Red/Brown Color.

→ $K_2Cr_2O_7$ is such a strong oxidising reagent, that in some cases it is also carries out the decomposition of inorganic matter along with organic matter resulting in higher O_2 demand in actual, which is termed as Dichromate demand.

3). Total organic Carbon:-

→ Total organic Carbon is just another way to express the concentration of the organic matter present in the system in terms of its Carbon content.

e.g.:- Q) 100mg/l of $C_6H_{12}O_6$ Contains How many grams/l of TOC.

Soln: $C_6H_{12}O_6$

1 mole of $C_6H_{12}O_6$ has 6 mole of 'C'.

⇒ 180gm " " " 72 gm " "

⇒ 100 gm " " " $\frac{72}{180} \times 100 = 40$ mg/l TOC.

4). Theoritical oxygen demand (Th.O.D):-

→ If the exact Concn and the type of organic matter is present in the system is known then the amount of oxygen demand for its decomposition can be computed theoritically and is termed as theoritical oxygen demand.

→ Generally C.O.D comes out the less than theoritical oxygen demand as complete decomposition of organic matter does not takes place during the test. But for all practical purpose C.O.D will be taken equal to th.O.D.

100 mg/l

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

1 mole $C_6H_{12}O_6$ require 6 mole of O_2

⇒ 180 gm " " 192 " "

∴ 100 mg/l " " $\frac{192}{180} \times 100 = 106.6$ mg/l (Th.O.D).

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

1 mole of CH_4 require 2 mole of O_2

⇒ 16 gm of " " 64 gm of O_2

⇒ 100 gm/l " " " $\frac{64}{16} \times 100 = 400$ mg/l (Th O D)

—x—

5) Bio-chemical oxygen demand [BOD]:-

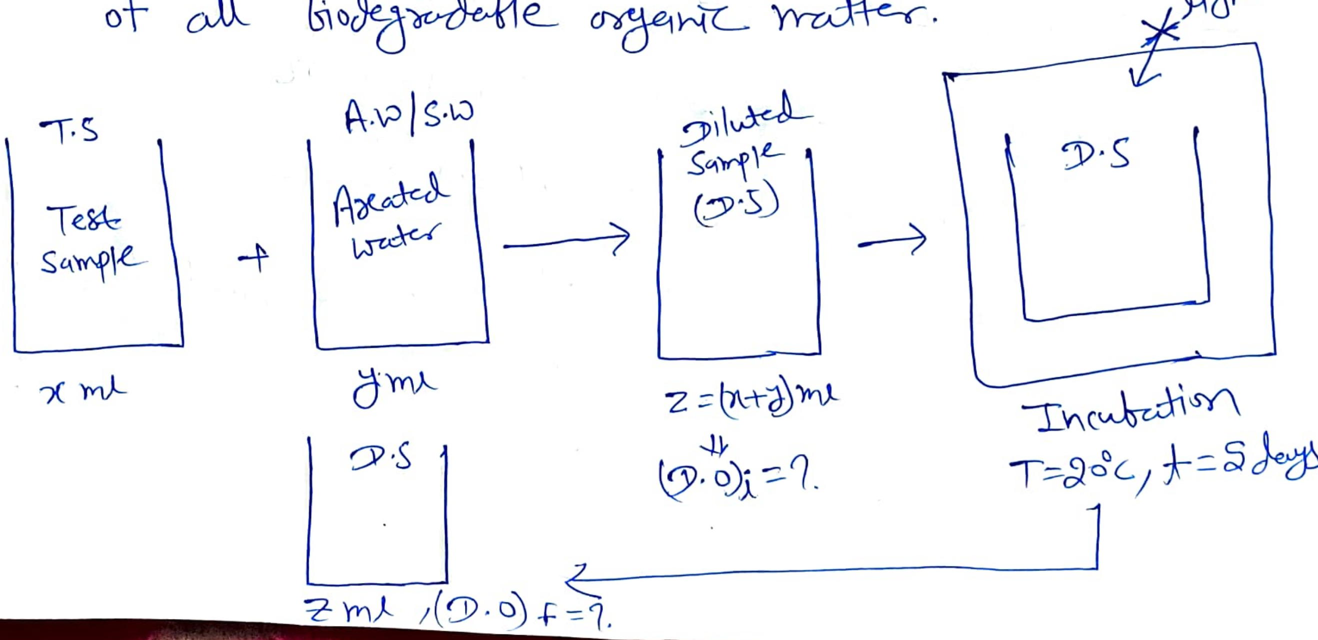
→ It is the amount of oxygen required for the decomposition of biodegradable organic matter present in the system.

→ BOD during 5 days at 20°C is taken as standard BOD and is approximately 68% of Ultimate BOD.

→ BOD is determine by diluting the known volume of the test sample with the known volm of aerated water sample and finding the D.O of the diluted sample before and after incubation for 5 days at 20°C.

→ Generally "300 ml" size bottles are used for the incubation and all the sources of the light must be excluded from the incubation in order to avoid photosynthesis during which O_2 is released which results in high D.O final and lower B.O.D than actual.

→ Ultimate B.O.D is amount of oxygen to decomposition of all biodegradable organic matter.



$$\boxed{(B.O.D)_{5,20^\circ C} = (D.O_i - D.O_f) \times \text{Dilution Ratio}}$$

$$D.F = \frac{\text{Find volume of D.S (300ml)}}{\text{Initial volm of T.S}}$$

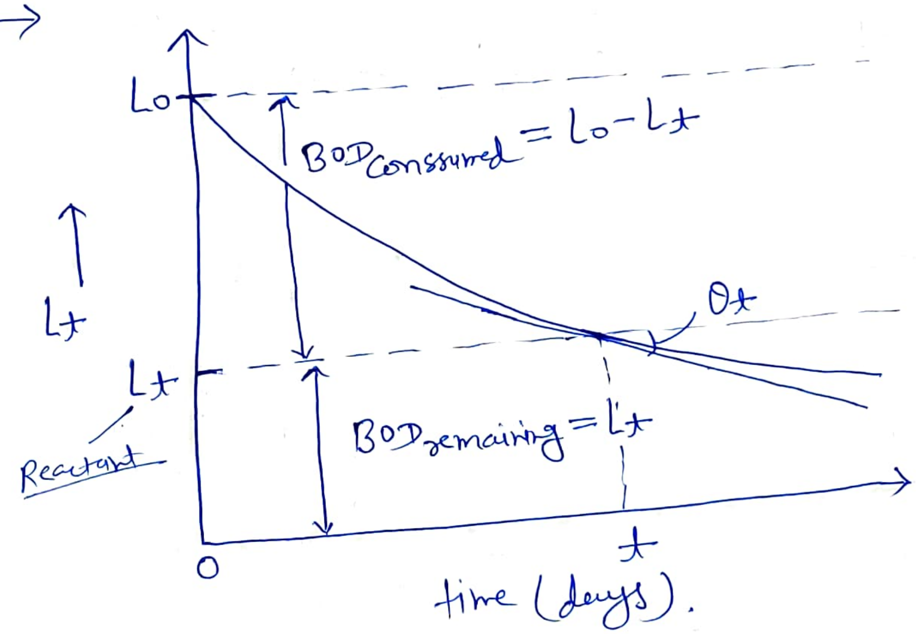
→ If we not dilute the sample than it will not gives result because initially O_2 present in waste water sample is zero or negligible so for the addition of Dissolve oxygen to the test sample we have to dilute it.

→ $(D.O)_f \Rightarrow 0$, then we have to again perform test with increased dilution ratio because if $(D.O)_F$ value becomes zero means no further oxygen is present in sample for reaction.

e.g:-

days:-	1	3	5	
		$(D.O)_f=0$	$(D.O)_f=0$	$10-0=10$ (x)
$D.O_i$:-	10			
$D.O_f$:-	20	$(D.O)_f=10$	$(D.O)_f=7$.	$10-7=13$ (✓)

→



According to first-order kinetics.

Rate of the reaction depends on the concentration of only one reactant, and is proportional to the amount of reactant

$$\therefore \frac{dL_t}{dt} \propto -L_t \quad \text{[According to I}^{st}\text{ order kinetics]}$$

$$\Rightarrow \frac{dL_t}{dt} = -K \cdot L_t$$

$$\Rightarrow \frac{dL_t}{L_t} = -K \cdot dt$$

$$\Rightarrow \int_{L_t=L_0}^{L_t=L_t} \frac{dL_t}{L_t} = -K \int_{t=0}^{t=t} dt$$

$$\Rightarrow \left| \ln L_t \right|_{L_0}^{L_t} = -K \left| t \right|_0^t$$

$$\Rightarrow \ln (L_t/L_0) = -Kt \Rightarrow \boxed{L_t = L_0 e^{-Kt}}$$

or

$$\Rightarrow 2.303 \log_{10} (L_t/L_0) = -Kt$$

$$\Rightarrow \log_{10} (L_t/L_0) = \frac{-K}{2.303} \cdot t \quad \left\{ \frac{K}{2.303} = 0.434K = K_D \right\}$$

$$\Rightarrow \log_{10} (L_t/L_0) = -K_D \cdot t$$

$$\Rightarrow \boxed{L_t = L_0 10^{-K_D \cdot t}}$$

Now

$$(BOD)_t = L_0 - L_t$$

$$= L_0 - L_0 e^{-Kt} \quad \text{or} \quad L_0 - L_0 10^{-K_D \cdot t}$$

$$\therefore \boxed{(BOD)_t = L_0 (1 - e^{-Kt}) \quad \text{or} \quad L_0 (1 - 10^{-K_D \cdot t})}$$

Where; L_0 = Ultimate BOD, K = de-oxidation const at base 'e'

t = time in days, K_D = de-oxidation const at base '10'

→ With the increase of temperature rate of decomposition also increases so that the value of de-oxidation const at temperature grater than 20°c can be computed as follows.

$$\boxed{(K_D)_{T°c} = (K_D)_{20°c} \cdot (K_T)^{T-20}}$$

$K_T = 1.047, \quad T \geq 20°$

→ For Ultimate BOD.

$$BOD_U = BOD_{\infty} = L_0\left(1 - 10^{-K_D \cdot \infty}\right)$$

$$\boxed{BOD_U = L_0}$$

→ $\boxed{Th.O.D \geq C.O.D \geq B.O.D \geq T.O.C}$

Q:- A portion of waste water sample was subjected to stand. BOD test (5 days, 20°c), yeilding a value of 180 mg/l. The reaction rate constant (to the base e) at 20°c was taken as 0.18 per day. The reaction rate constant at other temperature may be estimated by $K_T = K_{20}(1.047)^{T-20}$. Find out The temperature at which the other portion of the sample should tested to exert the same BOD in 2.5 days.

Soln:-

given $BOD_5|_{20°c} = 180$ mg/l

$$BOD_{2.5}|_{T°c} = BOD_5|_{20°c}$$

$$\Rightarrow \cancel{L_0}\left(1 - e^{-K_{T°c} \cdot t}\right) = \cancel{L_0}\left(1 - e^{-K_{20°c} \cdot 5}\right)$$

$$\Rightarrow K_{T°c} \cdot t = K_{20°c} \cdot 5$$

$$\Rightarrow K_{T°c} \times 2.5 = K_{20°c} \times 5$$

$\Rightarrow \cancel{K_{20^\circ C}}[1.047]^{T-20} \times \cancel{2.5} = \cancel{K_{20^\circ C}} \times \cancel{5}\ 2$

$\Rightarrow [1.047]^{T-20} = 2$

$\Rightarrow \boxed{T = 35^\circ C}$ Ans

Q. Following observations were ~~re~~ taken for 4% dilution of waste water sample.

DO of original sample is 0.6 mg/l

DO of aerated water used for dilution is 3 mg/l

DO of diluted sample after 5 days of incubation is 0.8 mg/l

De-oxygeration constant is 0.234 per day. Calculate BOD_5 and Ultimate BOD of the given sample is

Soln:-

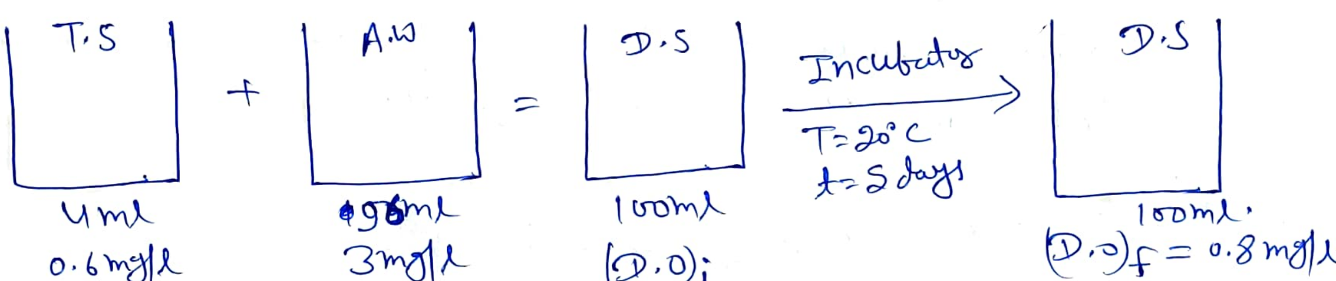
dilution 4%

$(D.O)_{aerated\ water} = 3\ mg/l$

$(D.O)_{original\ sample} = 0.6\ mg/l$

$(D.O)_{5\ days} = 0.8\ mg/l$

De-oxidation const = 0.234 per day.



$(D.O)_i = \dfrac{0.6 \times 4 + 3 \times 96}{100} = 2.9\ mg/l$

$\therefore (BOD)_{5/20^\circ C} = [(D.O)_i - (D.O)_f] \cdot D.F$

$= [2.9 - 0.8] \times 100/4 = 52.6\ mg/l$

$\Rightarrow 52.6\ mg/l = L_0[1 - 10^{-0.234 \times 5}] \Rightarrow \boxed{L_0 = 76.27\ mg/l}$

6). Ultimate BOD / COD ratio :-

→ $(BOD)_u$ / COD ratio represents the quality of the waste water with respect to the type of organic matter present in it i.e either biodegradable or non-biodegradable.

→ If the value of this ratio is more than 0.8 then waste water is consider to be treated biologically and if the ratio is less than 0.5. than waste water can not be treated biologically.

7). COD / TOC ratio :-

→ COD/TOC ratio signifies the quality of waste water with respect to the type of organic matter present in it i.e either simple or complex.

→ The value of this ratio varies in the range of 0-5.33. It is 5.33 for CH_4 & 0 for those organic matter which could not be decompose even by the action of $K_2Cr_2O_7$.

→ Higher is the value of COD/TOC simple is the organic matter.

—x—

** Disposal of Sewage Effluent:-

→ Disposal of sewage effluent can be done either by dilution or on land.

1). Disposal by dilution:-

→ It is the process in which sewage effluent is disposed in the large water body which may either be static or running after which it undergo the process of self purification.

→ A degree of treatment required to the given in the amount of waste water which can be disposed, depends upon the self purification capacity of the water body.

a). Disposal by dilution in river stream:-

→ When sewage effluent is disposed in the river it undergo the process of self purification by the following Natural mechanism.

i) Dilution and dispersion:-

→ In real term it is not the mechanism of self purification. It only reduces the potential hazard of the sewage effluent in the river.

Dilution ratio	Degree of treatment required.
> 500	No treatment required
300 - 500	plain sedimentation
150 - 300	Sedimentation
< 150	Complete treatment.

ii) Sedimentation:-

→ As per the turbulance available in the river stream organic suspended particles gets settled in it these by helping the river stream to get self purified.

iii) Sunlight:-

→ In the presence of the sunlight photosynthesis reaction takes place during which oxygen is release, which is utilize by the microorganism for the decomposition of organic matter thereby helping the river stream get self purified.

iv) oxidation & Reduction:-

→ Aerobic decomposition of the organic matter over the surface of the river stream and anerobic decomposition over the bed of the river stream collectively helps the river water get self purified.

Zones of polution in river stream:-

i) Zone-I :- Zone of Degradation:-

→ This zone of river is found at a certain distance D/S of the point of disposal of sewage effluent into the river.

→ water in this zone is dark & turbid in comparision to the water prior to it.

→ Due to the decomposition of organic matter taking place in this zone dissolved oxygen level decreases.

→ Algae is not found in this zone but fishes may survive.

ii) Zone-II :- Zone of activity Decomposition:-

→ This is the zone of heavy polution, water in this zone is dark and turbid in compare to water prion to it

→ Aerobic microorganism is replace by anaerobic microorganism.

→ Due to the decomposition of organic matter anaerobically acid, alchols and gases are formed which may rise to the surface leads to formation of dirty scour layer.

→ D.O level in this zone decreases upto its minimum value.

→ Both algae and fishes are not found ~~...~~ in this zone.

iii) Zone-III :- Zone of active recovery :-

→ Due to almost complete decomposition of the organic matter taking place in this zone dissolve oxygen level increases and try to match its saturated value.

→ Both algae and fishes re-appear in the river water in this zone.

→ D.O level and nitrate level is increases in this zone and BOD level Decreases.

b) Disposal by dilution in lake water :-

i). Lake Stratification :-

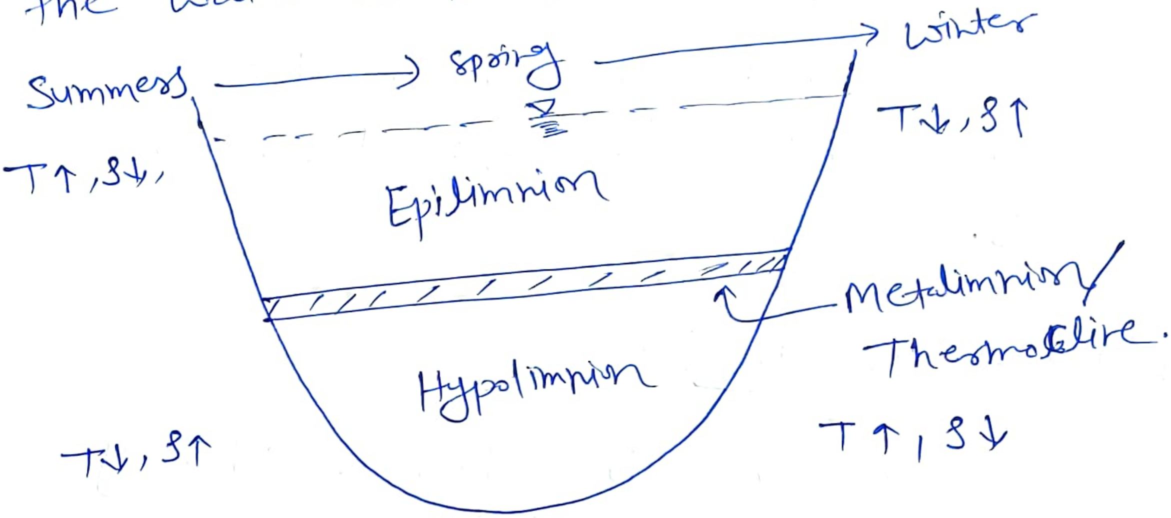
→ Study of lake is important to understand the phenomenon of self purification in it.

→ Water in lakes and reservoir in templet region in summer devide itself into two layers of warm circulating water termed as "Epilimnion", and lower cooler layer having difficiency of oxygen termed as "Hypolimnion".

→ Both these layers are seperates by narrow layer of steep tempr gradient termed as "metalimnion".

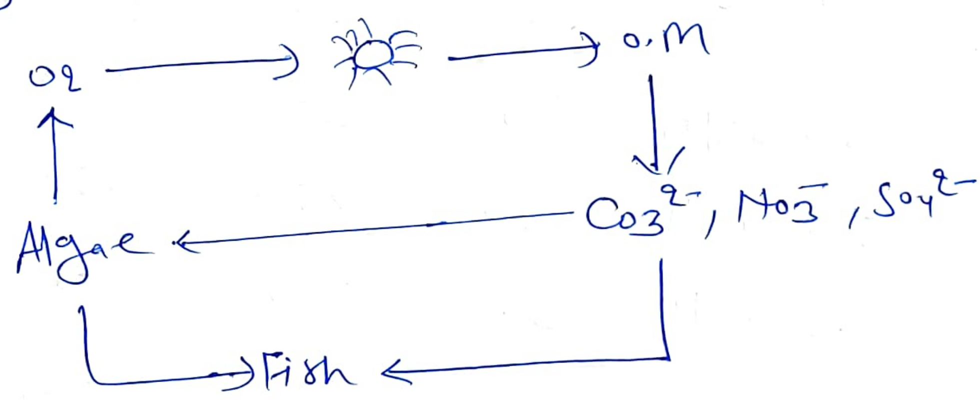
→ Stratification is entrapped twice in the year, once during spring and once during extream winter.

→ Maxm killing of the aquatic life takes place at particular point during the winters when the tempr of the water in upper layer becomes tempr of the water in the lower layer.



ii). productivity of lakes:-

→ Ability of the lakes support the food chain is termed as productivity or it may also be defined as ability of lake to support the growth of algae.



c) Disposal by dilution in sea water:-

→ Sea water consist of 20% less dissolved oxygen than river water at any given tempr due to the high concn of salts present in it.

→ But dilution offered by sea water is multiple no. of times more than river water. hence its consider to be better source of disposal than river water.

→ Disposal of the sewage in the sea water must be done far away from shore below the water surface level and only at the time of low tides.

2) Disposal on land:-

→ Disposal on land is achieved either by effluent irrigation or by sewage farming.

→ prime concern in effluent irrigation is disposal of the solids and prime concern in sewage farming is growth of crops.

→

parameters	Surface water	Inland water	Marine water	Land water.
BOD (mg/l)	20	30	100	500
COD (mg/l)	250	250	250	—
S.S (mg/l)	30	100	100	2100
PH	5.5-9	5.5-9	5.5-9	5.5-9.0

—x—

** Designing of Sewers **

→ About 80% of the water supply into the Community flows into the sewers.

→ The sewers are necessarily designed for the partially full flow condition to maintain an open channel flow conditions and also to be provide the space above the surface of the sewage for proper ventilation.

→ The sewers must be designed for a depth of flow 'd' which should be at least half of the diameter 'D' i.e 0.5D and it is also should not be more than 0.8D at the peak flow condition.

→ If the size of sewer is in the range of 400-900 mm than they are design to run 2/3rd full and If the size of sewer is more than 900mm than they are design to run 3/4th full. If size is less than 400mm then we are design to run half full.

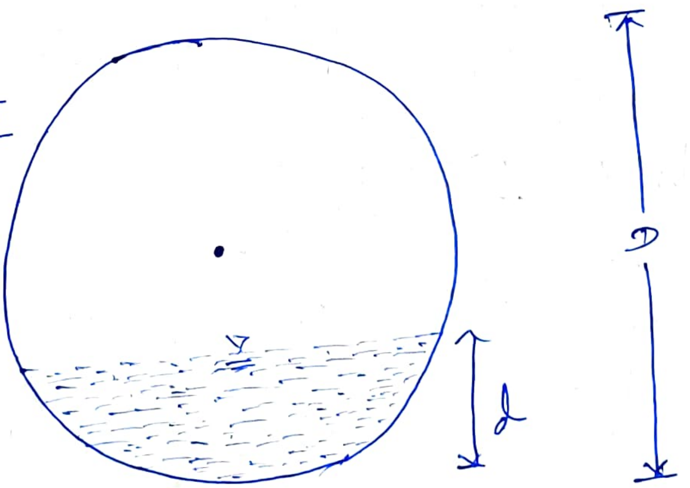
If $D < 400mm$, $d = \frac{D}{2}$

$400 \leq D \leq 900mm$

$d = \frac{2}{3}D$

$D \geq 900$,

$d = \frac{3}{4}D$



→ Need to maintain the minimum and maximum velocities in the sewers.

→ The sewage has considerable proportion of organic and Inorganic matter so If the pipe to cause obstraction to the flow of sewage. So it is necessary to maintain the minimum velocity of flow to control such deposition in the sewers.

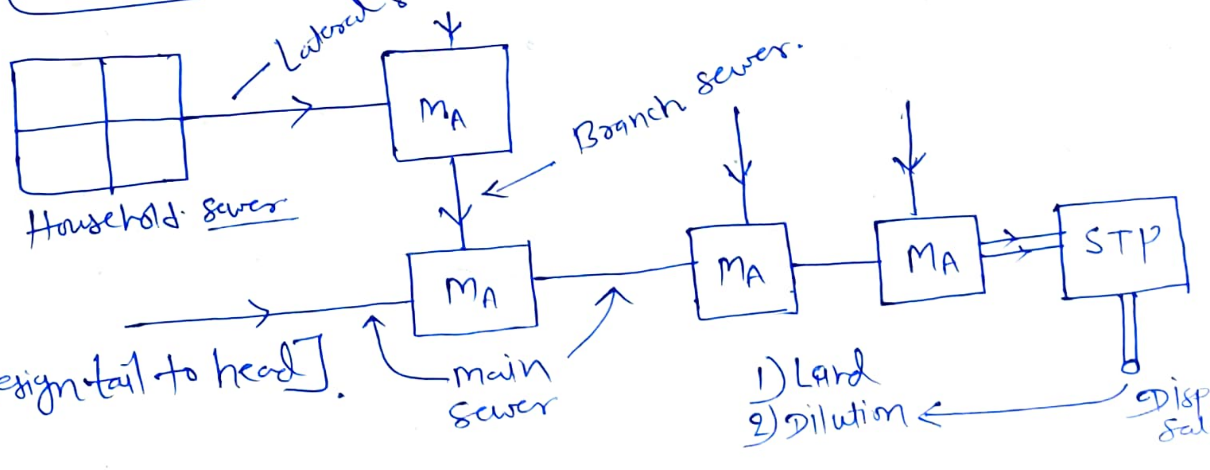
→ These velocity is called self cleansing velocity. It must be maintained at least once in a day, during the peak flow of the sewage at all the sections of the sewerage system.

→ on the other hands the velocity should not be too high, to cause erosion of the pipe material of the sewers to reduce the life of the sewers. This velocity is called as non-scouring velocity. Generally it is kept limited up to 3.0 m/sec.

→ The velocity of flow is maximum when the depth of flow is 0.81 D. $\boxed{V_{max} = 1.125 V}$

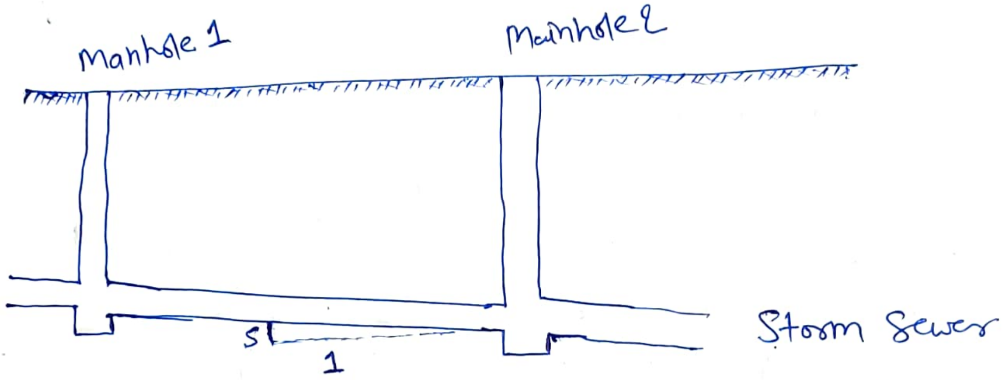
→ The carrying capacity of the sewer is maximum when the depth of the flow is equal to 0.95 D.

$\boxed{q_{max} = 1.07 Q}$

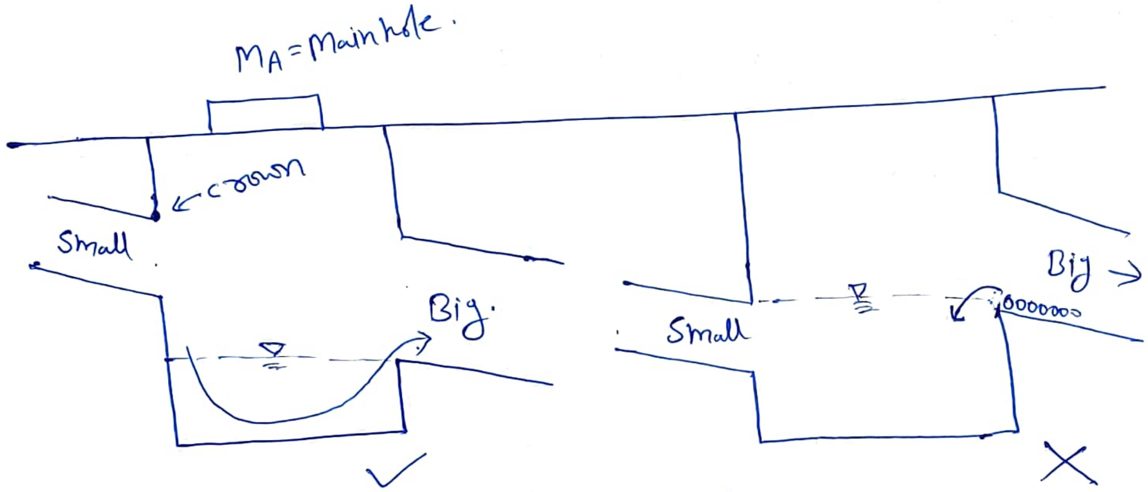
→ 

[Always design tail to head].

→ Sewer flow is under gravity so some slope always provided.



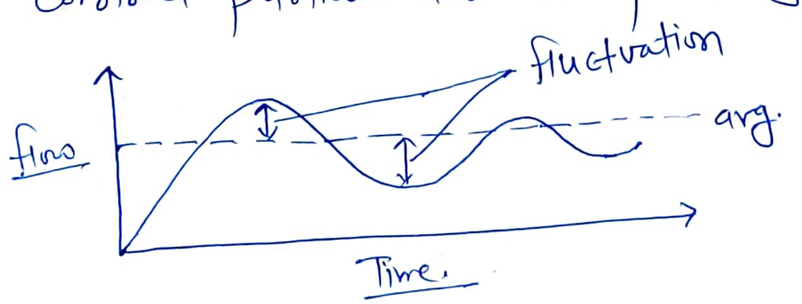
[θ is nearly equal to 1:1000].



→ Manhole provided.
- → when slope change
- → where direction of flow change
- → where two sewer line meets.
- → where dia of sewer line change.

→ Construction is always done from tail to head because construction of sewerline taking more time so we construct partial and use partially with time to full.

→



→ $\boxed{\text{Max}^m \text{ daily Discharge} = 2 \times \text{Avg. daily discharge.}}$

$\boxed{\text{Max}^m \text{ hourly discharge} = 1.5 \times \text{max}^m \text{ daily discharge.}}$

$\boxed{\text{Max}^m \text{ hourly discharge} = 3 \times \text{Avg. Daily discharge.}}$

$\boxed{\text{Min Daily discharge} = 2/3 \text{ Avg. daily discharge}}$

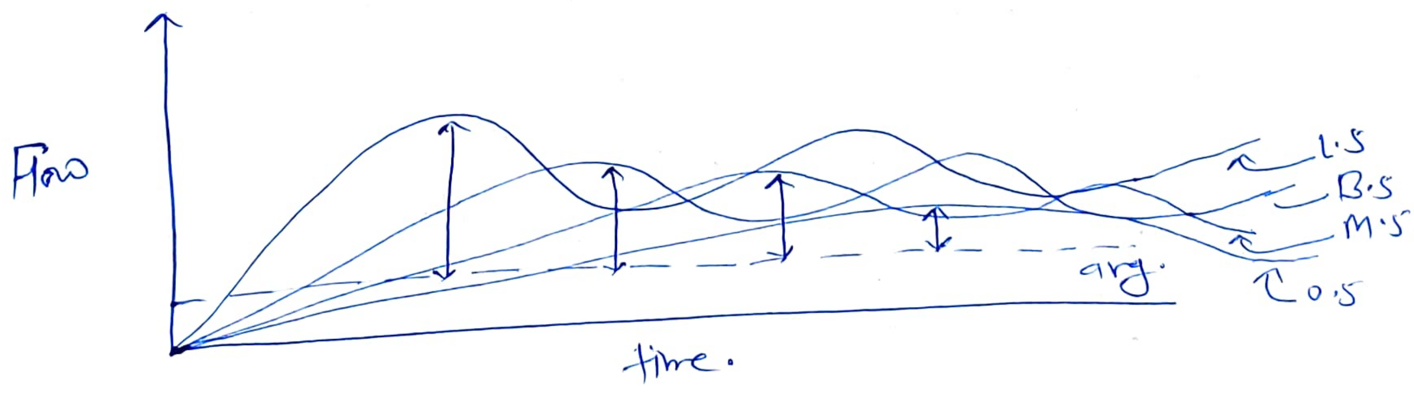
$\boxed{\text{min hourly discharge} = 1/3 \text{ Avg. daily discharge}}$

→ Unless given fluctuation in the rate of flow of sewage in different sewage as taken follows.

Type of sewer	Dia (m)	Fluctuations;
Lateral	0.25	4
Branch	0.5	3
main	1.0	2
outfall	1.25	1.25

[If not given in data we assume B.S].

→ Fluctuation in lateral sewers are observed to be max^m, and it tappers off from lateral to branch, branch to main and main to outfall sewage due to increase in sample size.



→ Sewers are design to carry maxm hourly discharge and are checked at minm hourly discharge for the developement of self cleaning velocity.

→ Self cleansing velocity is that which do not permit the silting of the solid in the sewers moreover also carried out the removal of solids which are already settled in it.

→ For 1mm inorganic particle and 5mm organic particle self cleansing velocity is 0.45 m/sec.

→ Self cleansing velocity in sewers is given by.

$$\boxed{V_{sc} = \sqrt{\frac{8K}{f}(n-1)g.d}}$$

Where. K = Const which depends upon type of the solids present in the sewage.

f = friction factor

n = specific gravity

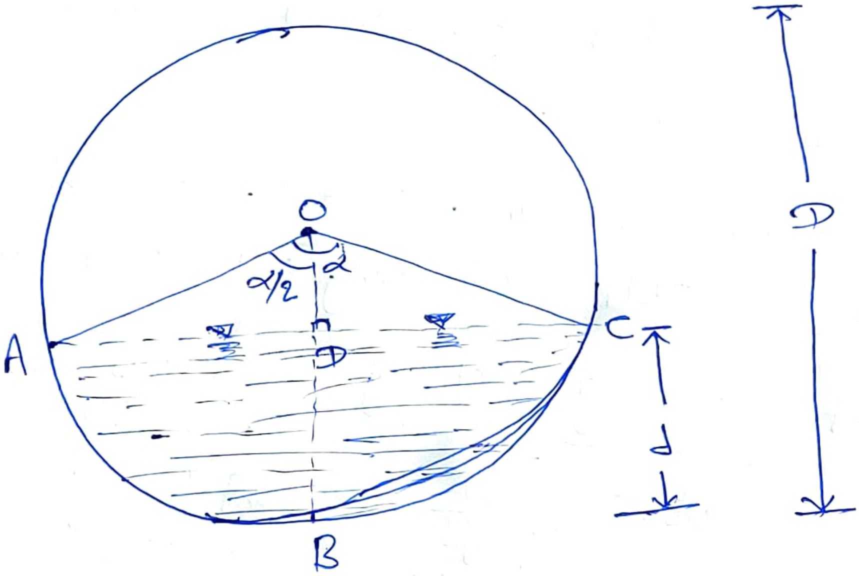
g = accn due to gravity

d = size of the particles to be removed.

→ maxm velocity of flow in cement concrete sewers is in the range of 2.5 to 3.5 m/sec and in cast iron sewers is in the range of 3.5 – 4.5 m/sec.

Hydraullic properties of the flow in the sewers running partially full and completely full:-

upper case — full flow condition
Lower case — partial flow condition



$\sin \alpha/2 = \frac{AD}{OA}$; $\Rightarrow AD = D/2 \sin\alpha/2$

$\cos \alpha/2 = \frac{OD}{OA}$; $\Rightarrow OD = D/2 \cos\alpha/2$

i). Depth of flow:-

$$d = BD = OB - OD$$

$$\Rightarrow d = D/2 - D/2 \cos\alpha/2$$

$$\Rightarrow d = \frac{D}{2}\left[1 - \cos\alpha/2\right]$$

$$\Rightarrow \boxed{\frac{d}{D} = \frac{1-\cos\alpha/2}{2}}$$ **.

ii) Area of flow:-

$a =$ Area of ABCD $=$ Area of OABC $-$ Area of OAC

If $\alpha = 360^\circ$, $A = \frac{\pi}{4} D^2$

So if $\alpha = \alpha^\circ$, Area of OABC $= \frac{\pi D^2}{4} \times \frac{\alpha}{360^\circ}$

$\therefore$ Area of OABC $= \frac{A\alpha}{360^\circ}$

Now Area of OAC $= \frac{1}{2} \times AC \times OD = \frac{D}{2} \sin\frac{\alpha}{2} \cdot \frac{D}{2} \cos\alpha/2$

$= \frac{D^2}{4} \sin\alpha/2 \cdot \cos\alpha/2$

$= \frac{D^2}{8} \sin\alpha \cdot = \frac{A \sin\alpha}{2\pi}$

$\therefore a = \frac{A\alpha}{360^\circ} - \frac{A\sin\alpha}{2\pi}$

$\Rightarrow \boxed{\frac{a}{A} = \frac{\alpha}{360^\circ} - \frac{\sin\alpha}{2\pi}}$ **

iii) perimeter of flow:-

$p =$ length of ABC

If $\alpha = 360^\circ$, $P = \pi D$

$\therefore \alpha = \alpha^\circ$, $p = \frac{\pi D}{360^\circ} \times \alpha$ $\Rightarrow \boxed{\frac{p}{P} = \frac{\alpha}{360^\circ}}$

iv). Hydraulic mean depth of flow:-

$$\Rightarrow r = \frac{a}{p} \; ; \quad R = \frac{A}{P}$$

$$\Rightarrow \left(\frac{r}{R}\right) = \left(\frac{a}{A}\right)\left(\frac{P}{p}\right)$$

$$\Rightarrow \boxed{\left(\frac{r}{R}\right) = \frac{\frac{\alpha}{360^\circ} - \frac{\sin\alpha}{2\pi}}{\alpha/360^\circ}}$$

v) velocity of flow:-

$v = f(F, r, i)$

$v = \frac{1}{n} r^{2/3} s^{1/2}$

$V = \frac{1}{N} R^{2/3} S^{1/2}$

$$\Rightarrow \boxed{\frac{v}{V} = \frac{N}{n}\left(\frac{r}{R}\right)^{2/3}\left(\frac{s}{S}\right)^{1/2}}$$

$s = S$, and assume $n = N$ than.

$$\boxed{\frac{v}{V} = \left(\frac{r}{R}\right)^{2/3}}$$

$$\Rightarrow \boxed{\frac{v}{V} = \left(\frac{\frac{\alpha}{360^\circ} - \frac{\sin\alpha}{2\pi}}{\alpha/360^\circ}\right)^{2/3}}$$

vi). Rate of flow:-

$q = av, \quad Q = A \cdot V$

$$\frac{q}{Q} = \left(\frac{a}{A}\right)\left(\frac{v}{V}\right) \Rightarrow \frac{q}{Q} = \left(\frac{\alpha}{360^\circ} - \frac{\sin\alpha}{2\pi}\right)\left[\frac{\frac{\alpha}{360^\circ} - \frac{\sin\alpha}{2\pi}}{\alpha/360^\circ}\right]^{2/3}$$

Case-I :- If n is Const & sewer is running Half full :-

$$\boxed{\frac{d}{D} = \frac{1-\cos\alpha/2}{2} = \frac{1}{2}}\ ;\ \boxed{\alpha = 180^\circ}$$

$$\boxed{\frac{a}{A} = \frac{1}{2}}\ ,\ \boxed{\frac{p}{P} = 1/2}\ ,\ \boxed{\frac{r}{R} = 1}\ ,\ \boxed{\frac{v}{V} = 1}\ ,\ \boxed{\frac{q}{Q} = 1/2}$$

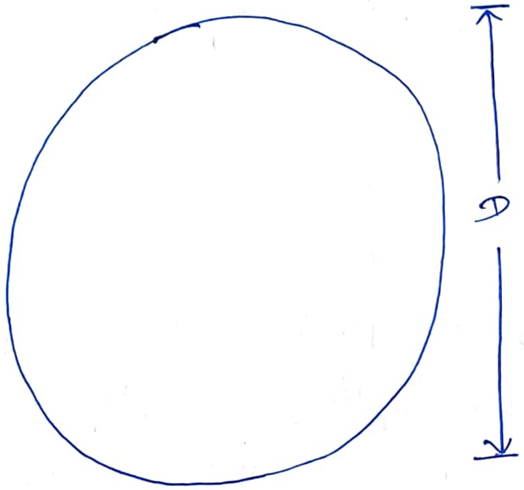
** * Egg shaped sewer :-

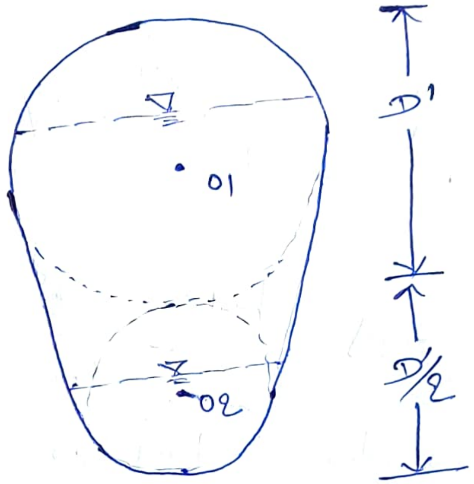
→ Circular section for the sewers are provided generally in seperate sewerage system as its advantage is available throughout the year in this case.

→ But in case of combined sewarage system their is single section is provided to carry both drainage and sanitary sewage.

→ The advantage of circular section to be available only during the rainy season and for most part of the year the sewer is run less than half full hence in such a case in order to take advantage of circular section throughout the year two such sections are placed one over each other such that upper bigger circular section is effective during the rainy season and lower smaller circular section is effective during dry weather.

→ The section apperes like an egg in shape it is termed as egg shape sewer.





egg shape

$\boxed{D' = 0.84D}$

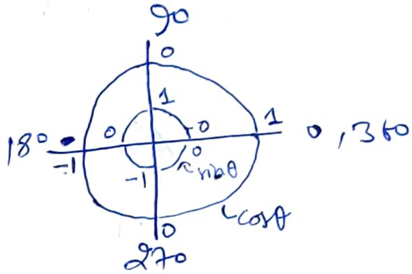
Note:- If two section of different shapes are hydrically equivalent than they will carry same discharge while running full on the same grade [slope] and are of same material.

—x—

Q) A 20 cm diameter sewer is laid at a slope of 0.004 and is designed to carry a discharge at a depth of 10 cm with mannings $n = 0.014$, then find out the design discharge in lit/sec.

Soln

given:-



$D = 20$ cm

$S = 0.004$

$d = 10$ cm

$n = 0.014$

We know

$$\frac{d}{D} = \frac{1 - \cos\alpha/2}{2} \Rightarrow \frac{10}{20} = \frac{1 - \cos\alpha/2}{2}$$

$$\Rightarrow \boxed{\alpha = 180^\circ}$$

Now

$$\frac{q}{Q} = \left(\frac{a}{A}\right)\left(\frac{v}{V}\right) = \left(\frac{\alpha}{360^\circ} - \frac{\sin\alpha}{2\pi}\right)\left(\frac{\alpha/360^\circ - \frac{\sin\alpha}{2\pi}}{\alpha/360^\circ}\right)^{2/3}$$

$$\Rightarrow \frac{q}{Q} = \frac{1}{2} \quad \Rightarrow q = \frac{Q}{2} = \frac{A.V}{2}$$

$$\therefore q = \frac{\frac{\pi}{4}D^2 \cdot \frac{1}{N}\left(\frac{D}{4}\right)^{2/3} S^{1/2}}{2}$$

$$= \frac{\frac{\pi}{4} \times (0.2)^2 \times \frac{1}{0.014} \times \left(\frac{0.2}{4}\right)^{2/3} \times (0.004)^{1/2}}{2}$$

$$\left[\because V = \frac{1}{N} R^{2/3} S^{1/2} \quad R = \frac{A}{P} = \frac{\pi R^2}{2\pi R} = R/2 = D/4\right]$$

$$\Rightarrow q = 0.00963093\,6 \ m^3/sec$$

$$\Rightarrow \boxed{q = 9.63 \text{ lit/sec}}$$ Ans

Q) An existing 300 mm diameter circular sewer is laid at a slope 1:280 and carries a peak discharge of 1728 m3/day. ~~Use the~~ use the below table and assume manning's $n = 0.015$.
At the peak discharge, the depth of flow and the velocity are respectively will be.

q/Q	v/V	d/D
0.1	0.2	0.1
0.2	0.25	0.1
0.3	0.345	0.3
0.4	0.7	0.4
0.5	0.8	0.5

Soln

$q = 1728 \text{ m}^3/\text{day}$

$$Q = A \cdot V = \frac{\pi}{4} D^2 \times \frac{1}{N} \left(\frac{D}{4}\right)^{2/3} (S)^{1/2}$$

$$= \frac{\pi}{4} (0.3)^2 \times \frac{1}{0.015} \times \left(\frac{0.3}{4}\right)^{2/3} \times \left(\frac{1}{280}\right)^{1/2} \times 86400$$

$$= 4327.29 \text{ m}^3/\text{day}$$

$$\therefore \frac{q}{Q} = \frac{1728}{4327.29} = 0.4$$

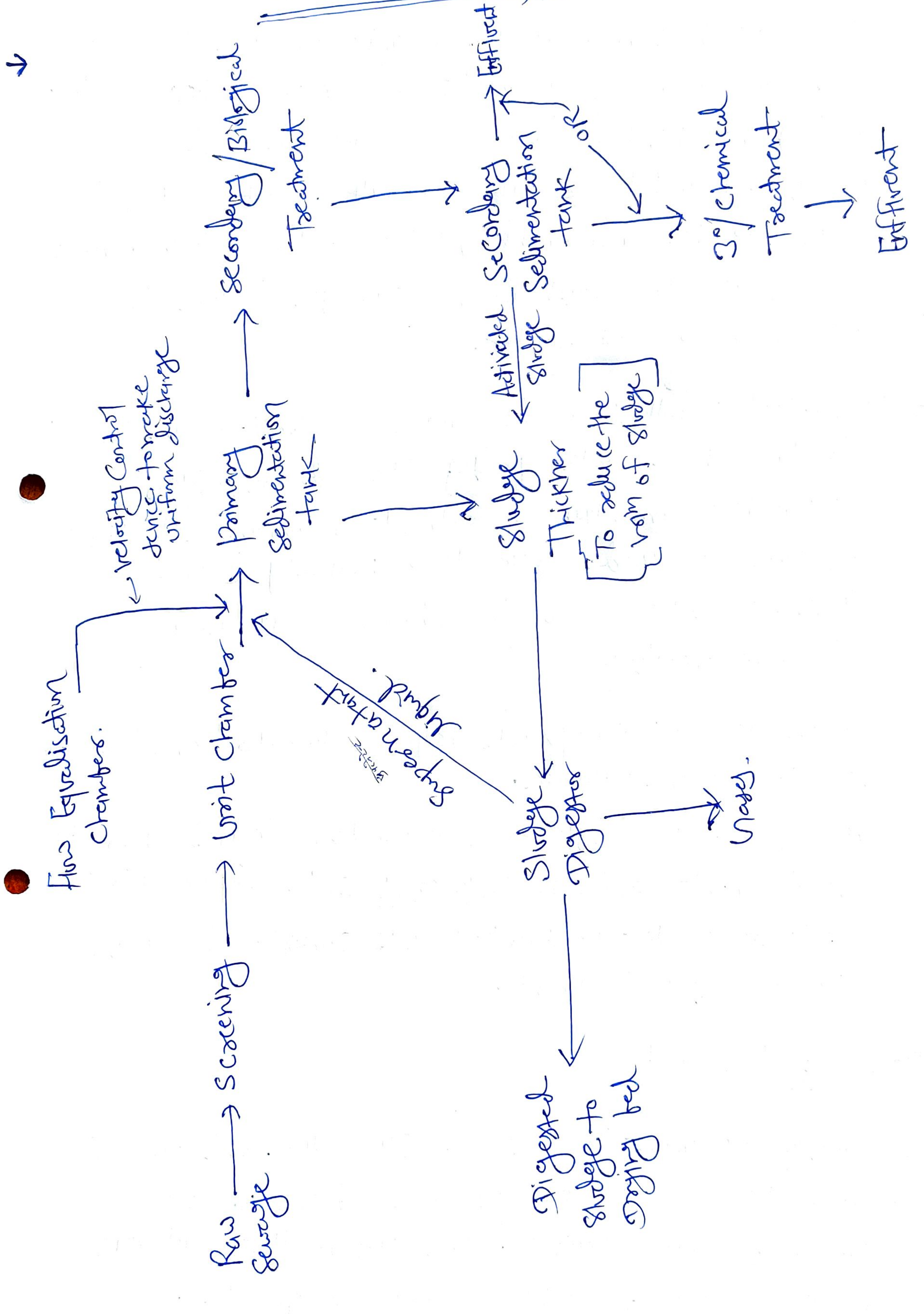
Now $q/Q = 0.4$, corresponding value of

$v/V = 0.7$ & $d/D = 0.4$

$$\therefore d = 0.4 \times D = 0.4 \times 300 = 120 \text{ mm}.$$

$$v = 0.7 \times V = 0.7 \times \frac{1}{0.015} \times \left(\frac{0.3}{4}\right)^{2/3} \times \left(\frac{1}{280}\right)^{1/2} = 0.49 \text{ m/s}$$

** Domestic waste water treatment **



→ The objective of wastewater treatment is to reduce the pollutants to less than maximum permissible limits to prevent the threat to the environment and human ~~he~~ health. To achieve this, wastewater is collected and treated in large plants before it is permitted to be released back into the environment. All the water used in homes that flows into drains on the sewage system is referred as wastewater.

→ Waste water follows a determined treatment path in order to achive water quality standards, regardless of whether conventional treatment or advanced treatment systems are used. Wastewater is normally called influent as it passes through the waste water treatment facility.

→ wastewater treatment plants helps return to defend water from excessive pollution.

→ The degree and type of wastewater decides the return of the plant. of treatment and the engineering scale
Most wastewater treatment plants consist of primary and secondary treatment.

i). Primary treatment:-

→ Primary treatment involves the separation and removal of solid matter and homogenization of the ~~remaining~~ remaining liquid waste. This solid matter will either float or readily settle out due to gravity.

→ physical processes such as screening and grit removal may be used during primary treatment.

→ Large objects, such as sticks or stones, which could block tank inlets or plug lines are removed during the screening process.

→ Grit chambers are used to slow down the wastewater flow and allow grit to fall out.

→ Solids that can settle in a sedimentation tank are pumped away

ii) <u>Secondary treatment:-</u>

→ The secondary treatment involves a biological process. wastewater is exposed to aerobic bacteria where the biological oxygen demand (BOD) is reduced.

→ Aerobic bacteria are used to break down pathogens, other contaminants and suspended organic matter into carbon dioxide, water and biosolids.

→ Aerobic bacteria are naturally supplied in wetland habitats. Baffles with a special coating of aerobic bacteria are often used by sewage treatment plants.

→ municipal wastewater is normally disinfected with the use of chlorine or other disinfecting compounds.

→ occasionally, ultraviolet light or ozone is used.

iii). Tertiary treatments:-

→ Tertiary treatments is carried out to improve the 'final look' of water, making it indistinguishable from any freshwater source.

→ Tertiary treatment involves removing ~~xxx~~ nutrients from wastewater. The removal of nutrients such as phosphorus and Nitrogen from wastewater.

→ The removal of nutrients is an important step in restricting downstream effects such as algal blooms and eutrophication, which destroy ecosystems and habitats.

→ Based on the influent, wastewater treatment plants may be a sewage treatment, municipal wastewater treatment, Industrial wastewater effluent treatment or agricultural wastewater plant.

x

solid-waste management

solid-waste management, the collecting, treating, and disposing of solid material that is discarded because it has served its purpose or is no longer useful. Improper disposal of municipal solid waste can create unsanitary conditions, and these conditions in turn can lead to pollution of the environment and to outbreaks of vector-borne disease—that is, diseases spread by rodents and insects. The tasks of solid-waste management present complex technical challenges. They also pose a wide variety of administrative, economic, and social problems that must be managed and solved.

sanitary landfill
Bulldozers working on a sanitary landfill.
© SergeyZavalnyuk—iStock/Getty Images

Solid-waste characteristics

Composition and properties

The sources of solid waste include residential, commercial, institutional, and industrial activities. Certain types of wastes that cause immediate danger to exposed individuals or environments are classified as hazardous; these are discussed in the article hazardous-waste management. All nonhazardous solid waste from a community that requires collection and transport to a processing or disposal site is called refuse or municipal solid waste (MSW). Refuse includes garbage and rubbish. Garbage is mostly decomposable food waste; rubbish is mostly dry material such as glass, paper, cloth, or wood. Garbage is highly putrescible or decomposable, whereas rubbish is not. Trash is rubbish that includes bulky items such as old refrigerators, couches, or large tree stumps. Trash requires special collection and handling.

Construction and demolition (C&D) waste (or debris) is a significant component of total solid waste quantities (about 20 percent in the United States), although it is not considered to be part of the MSW stream. However, because C&D waste is inert and nonhazardous, it is usually disposed of in municipal sanitary landfills (*see below*).

Another type of solid waste, perhaps the fastest-growing component in many developed countries, is electronic waste, or e-waste, which includes discarded computer equipment, televisions, telephones, and a variety of other electronic devices. Concern over this type of waste is escalating. Lead, mercury, and cadmium are among the materials of concern in electronic devices, and governmental policies may be required to regulate their recycling and disposal.

electronic waste
Electronic waste in a garbage dump.

Solid-waste characteristics vary considerably among communities and nations. American refuse is usually lighter, for example, than European or Japanese refuse. In the United States paper and paperboard products make up close to 40 percent of the total weight of MSW; food waste accounts for less than 10 percent. The rest is a mixture of yard trimmings, wood, glass, metal, plastic, leather, cloth, and other miscellaneous materials. In a loose or uncompacted state, MSW of this type weighs approximately 120 kg per cubic metre (200 pounds per cubic yard). These figures vary with geographic location, economic conditions, season of the year, and many other factors. Waste characteristics from each community must be studied carefully before any treatment or disposal facility is designed and built.

Generation and storage

Rates of solid-waste generation vary widely. In the United States, for example, municipal refuse is generated at an average rate of approximately 2 kg (4.5 pounds) per person per day. Japan generates roughly half this amount, yet in Canada the rate is 2.7 kg (almost 6 pounds) per person per day. In some developing countries the average rate can be lower than 0.5 kg (1 pound) per person per day. These data include refuse from commercial, institutional, and industrial as well as residential sources. The actual rates of refuse generation must be carefully determined when a community plans a solid-waste management project.

Most communities require household refuse to be stored in durable, easily cleaned containers with tight-fitting covers in order to minimize rodent or insect infestation and offensive odours. Galvanized metal or plastic containers of about 115-litre (30-gallon) capacity are commonly used, although some communities employ larger containers that can be mechanically lifted and emptied into collection trucks. Plastic bags are frequently used as liners or as disposable containers for curbside collection. Where large quantities of refuse are generated—such as at shopping centres, hotels, or apartment buildings—dumpsters may be used for temporary storage until the waste is collected. Some office and commercial buildings use on-site compactors to reduce the waste volume.

Solid-waste collection

Collecting and transporting

Proper solid-waste collection is important for the protection of public health, safety, and environmental quality. It is a labour-intensive activity, accounting for approximately three-quarters of the total cost of solid-waste management. Public employees are often assigned to the task, but sometimes it is more economical for private companies to do the work under contract to the municipality or for private collectors to be paid by individual home owners. A driver and one or two loaders serve each collection vehicle. These are typically trucks of the enclosed, compacting type, with capacities up to 30 cubic metres (40 cubic yards). Loading can be done from the front, rear, or side. Compaction reduces the volume of refuse in the truck to less than half of its loose volume.

The task of selecting an optimal collection route is a complex problem, especially for large and densely populated cities. An optimal route is one that results in the most efficient use of labour and equipment, and selecting such a route requires the application of computer analyses that account for all the many design variables in a large and complex network. Variables include frequency of collection, haulage distance, type of service, and climate. Collection of refuse in rural areas can present a special problem, since the population densities are low, leading to high unit costs.

Refuse collection usually occurs at least once per week because of the rapid decomposition of food waste. The amount of garbage in the refuse of an individual home can be reduced by garbage grinders, or garbage disposals. Ground garbage puts an extra load on sewerage systems, but this can usually be accommodated. Many communities now conduct source separation and recycling programs, in which homeowners and businesses separate recyclable materials from garbage and place them in separate containers for collection. In addition, some communities have drop-off centres where residents can bring recyclables.

Transfer stations

If the final destination of the refuse is not near the community in which it is generated, one or more transfer stations may be necessary. A transfer station is a central facility where refuse from many collection vehicles is combined into a larger vehicle, such as a tractor-trailer unit. Open-top trailers are designed to carry about 76 cubic metres (100 cubic yards) of uncompacted waste to a regional processing or disposal location. Closed compactor-type trailers are also available, but they must be equipped with ejector mechanisms. In a direct discharge type of station, several collection trucks empty directly into the transport vehicle. In a storage discharge type of station, refuse is first emptied into a storage pit or onto a platform, and then machinery is used to hoist or push the solid waste into the transport vehicle. Large transfer stations can handle more than 500 tons of refuse per day.

Solid-waste treatment and disposal

Once collected, municipal solid waste may be treated in order to reduce the total volume and weight of material that requires final disposal. Treatment changes the form of the waste and makes it easier to handle. It can also serve to recover certain materials, as well as heat energy, for recycling or reuse.

Incineration

Furnace operation

Burning is a very effective method of reducing the volume and weight of solid waste, though it is a source of greenhouse gas emissions. In modern incinerators the waste is burned inside a properly designed furnace under very carefully controlled conditions. The combustible portion of the waste combines with oxygen, releasing mostly carbon dioxide, water vapour, and heat. Incineration can reduce the volume of uncompacted waste by more than 90 percent, leaving an inert residue of ash, glass, metal, and other solid materials called bottom ash. The gaseous by-products of incomplete combustion, along with finely divided particulate material called fly ash, are carried along in the incinerator airstream. Fly ash includes cinders, dust, and soot. In order to remove fly ash and gaseous by-products before they are exhausted into the atmosphere, modern incinerators must be equipped with extensive emission control devices. Such devices include fabric baghouse filters, acid gas scrubbers, and electrostatic precipitators. (*See also* air pollution control.) Bottom ash and fly ash are usually combined and disposed of in a landfill. If the ash is found to contain toxic metals, it must be managed as a hazardous waste.

Municipal solid-waste incinerators are designed to receive and burn a continuous supply of refuse. A deep refuse storage pit, or tipping area, provides enough space for about one day of waste storage. The refuse is lifted from the pit by a crane equipped with a bucket or grapple device. It is then deposited into a hopper and chute above the furnace and released onto a charging grate or stoker. The grate shakes and moves waste through the furnace, allowing air to circulate around the burning material. Modern incinerators are usually built with a rectangular furnace, although rotary kiln furnaces and vertical circular furnaces are available. Furnaces are constructed of refractory bricks that can withstand the high combustion temperatures.

Combustion in a furnace occurs in two stages: primary and secondary. In primary combustion, moisture is driven off, and the waste is ignited and volatilized. In secondary combustion, the remaining unburned gases and particulates are oxidized, eliminating odours and reducing the amount of fly ash in the exhaust. When the refuse is very moist, auxiliary gas or fuel oil is sometimes burned to start the primary combustion.

In order to provide enough oxygen for both primary and secondary combustion, air must be thoroughly mixed with the burning refuse. Air is supplied from openings beneath the grates or is admitted to the area above. The relative amounts of this underfire air and overfire air must be determined by the plant operator to achieve good combustion efficiency. A continuous flow of air can be maintained by a natural draft in a tall chimney or by mechanical forced-draft fans.

Energy recovery

The energy value of refuse can be as much as one-third that of coal, depending on the paper content, and the heat given off during incineration can be recovered by the use of a refractory-lined furnace coupled to a boiler. Boilers convert the heat of combustion into steam or hot water, thus allowing the energy content of the refuse to be recycled. Incinerators that recycle heat energy in this way are called waste-to-energy plants. Instead of a separate furnace and boiler, a water-tube wall furnace may also be used for energy recovery. Such a furnace is lined with vertical steel tubes spaced closely enough to form continuous sections of wall. The walls are insulated on the outside in order to reduce heat loss. Water circulating through the tubes absorbs heat to produce steam, and it also helps to control combustion temperatures without the need for excessive air, thus lowering air pollution control costs.

Waste-to-energy plants operate as either mass burn or refuse-derived fuel systems. A mass burn system uses all the refuse, without prior treatment or preparation. A refuse-derived fuel system separates combustible wastes from noncombustibles such as glass and metal before burning. If a turbine is installed at the plant, both steam and electricity can be produced in a process called cogeneration.

Waste-to-energy systems are more expensive to build and operate than plain incinerators because of the need for special equipment and controls, highly skilled technical personnel, and auxiliary fuel systems. On the other hand, the sale of generated steam or electricity offsets much of the extra cost, and recovery of heat energy from refuse is a viable solid-waste management option from both an engineering and an economic point of view. About 80 percent of municipal refuse incinerators in the United States are waste-to-energy facilities.

Composting

Another method of treating municipal solid waste is composting, a biological process in which the organic portion of refuse is allowed to decompose under carefully controlled conditions. Microbes metabolize the organic waste material and reduce its volume by as much as 50 percent. The stabilized product is called compost or humus. It resembles potting soil in texture and odour and may be used as a soil conditioner or mulch.

Composting offers a method of processing and recycling both garbage and sewage sludge in one operation. As more stringent environmental rules and siting constraints limit the use of solid-waste incineration and landfill options, the application of composting is likely to increase. The steps involved in the process include sorting and separating, size reduction, and digestion of the refuse.

Sorting and shredding

The decomposable materials in refuse are isolated from glass, metal, and other inorganic items through sorting and separating operations. These are carried out mechanically, using differences in such physical characteristics of the refuse as size, density, and magnetic properties. Shredding or pulverizing reduces the size of the waste articles, resulting in a uniform mass of material. It is accomplished with hammer mills and rotary shredders.

Digesting and processing

Pulverized waste is ready for composting either by the open windrow method or in an enclosed mechanical facility. Windrows are long, low mounds of refuse. They are turned or mixed every few days to provide air for the microbes digesting the organics. Depending on moisture conditions, it may take five to eight weeks for complete digestion of the waste. Because of the metabolic action of aerobic bacteria, temperatures in an active compost pile reach about 65 °C (150 °F), killing pathogenic organisms that may be in the waste material.

Open windrow composting requires relatively large land areas. Enclosed mechanical composting facilities can reduce land requirements by about 85 percent. Mechanical composting systems employ one or more closed tanks or digesters equipped with rotating vanes that mix and aerate the shredded waste. Complete digestion of the waste takes about one week.

Digested compost must be processed before it can be used as a mulch or soil conditioner. Processing includes drying, screening, and granulating or pelletizing. These steps improve the market value of the compost, which is the most serious constraint to the success of composting as a waste management option. Agricultural demand for digested compost is usually low because of the high cost of transporting it and because of competition with inorganic chemical fertilizers.

Sanitary landfill

Land disposal is the most common management strategy for municipal solid waste. Refuse can be safely deposited in a sanitary landfill, a disposal site that is carefully selected, designed, constructed, and operated to protect the environment and public health. One of the most important factors relating to landfilling is that the buried waste never comes in contact with surface water or groundwater. Engineering design requirements include a minimum distance between the bottom of the landfill and the seasonally high groundwater table. Most new landfills are required to have an impermeable liner or barrier at the bottom, as well as a system of groundwater-monitoring wells. Completed landfill sections must be capped with an impermeable cover to keep precipitation or surface runoff away from the buried waste. Bottom and cap liners may be made of flexible plastic membranes, layers of clay soil, or a combination of both.

Constructing the landfill

The basic element of a sanitary landfill is the refuse cell. This is a confined portion of the site in which refuse is spread and compacted in thin layers. Several layers may be compacted on top of one another to a maximum depth of about 3 metres (10 feet). The compacted refuse occupies about one-quarter of its original loose volume. At the end of each day's operation, the refuse is covered with a layer of soil to eliminate windblown litter, odours, and insect or rodent problems. One refuse cell thus contains the daily volume of compacted refuse and soil cover. Several adjacent refuse cells make up a lift, and eventually a landfill may comprise two or more lifts stacked one on top of the other. The final cap for a completed landfill may also be covered with a layer of topsoil that can support vegetative growth.

sanitary landfill
Two methods of constructing a sanitary landfill. (The top and bottom liners and the leachate collection systems are not shown.)
Encyclopædia Britannica, Inc.

Daily cover soil may be available on-site, or it may be hauled in and stockpiled from off-site sources. Various types of heavy machinery, such as crawler tractors or rubber-tired dozers, are used to spread and compact the refuse and soil. Heavy steel-wheeled compactors may also be employed to achieve high-density compaction of the refuse.

The area and depth of a new landfill are carefully staked out, and the base is prepared for construction of any required liner and leachate-collection system. Where a plastic liner is used, at least 30 cm (12 inches) of sand is carefully spread over it to provide protection from landfill vehicles. At sites where excavations can be made below grade, the trench method of construction may be followed. Where this is not feasible because of topography or groundwater conditions, the area method may be practiced, resulting in a mound or hill rising above the original ground. Since no ground is excavated in the area method, soil usually must be hauled to the site from some other location. Variations of the area method may be employed where a landfill site is located on sloping ground, in a valley, or in a ravine. The completed landfill eventually blends in with the landscape.

Controlling by-products

Organic material buried in a landfill decomposes by anaerobic microbial action. Complete decomposition usually takes more than 20 years. One of the by-products of this decomposition is methane gas. Methane is poisonous and explosive when diluted in the air, and it is a potent greenhouse gas. It can also flow long distances through porous layers of soil, and, if it is allowed to collect in basements or other confined areas, dangerous conditions may arise. In modern landfills, methane movement is controlled by impermeable barriers and by gas-venting systems. In some landfills the methane gas is collected and recovered for use as a fuel, either directly or as a component of biogas.

A highly contaminated liquid called leachate is another by-product of decomposition in sanitary landfills. Most leachate is the result of runoff that infiltrates the refuse cells and comes in contact with decomposing garbage. If leachate reaches the groundwater or seeps out onto the ground surface, serious environmental pollution problems can occur, including the possible contamination of drinking-water supplies. Methods of controlling leachate include the interception of surface water in order to prevent it from entering the landfill and the use of impermeable liners or barriers between the waste and the groundwater. New landfill sites should also be provided with groundwater-monitoring wells and leachate-collection and treatment systems.

Importance in waste management

In communities where appropriate sites are available, sanitary landfills usually provide the most economical option for disposal of nonrecyclable refuse. However, it is becoming increasingly difficult to find sites that offer adequate capacity, accessibility, and environmental conditions. Nevertheless, landfills will always play a key role in solid-waste management. It is not possible to recycle all components of solid waste, and there will always be residues from incineration and other treatment processes that will eventually require disposal underground. In addition, landfills can actually improve poor-quality land. In some communities properly completed landfills are converted into recreational parks, playgrounds, or golf courses.

Recycling

Separating, recovering, and reusing components of solid waste that may still have economic value is called recycling. One type of recycling is the recovery and reuse of heat energy, a practice discussed separately in incineration. Composting can also be considered a recycling process, since it reclaims the organic parts of solid waste for reuse as mulch or soil conditioner. Still other waste materials have potential for reuse. These include paper, metal, glass, plastic, and rubber, and their recovery is discussed here.

Separation

Before any material can be recycled, it must be separated from the raw waste and sorted. Separation can be accomplished at the source of the waste or at a central processing facility. Source separation, also called curbside separation, is done by individual citizens who collect newspapers, bottles, cans, and garbage separately and place them at the curb for collection. Many communities allow “commingling” of nonpaper recyclables (glass, metal, and plastic). In either case, municipal collection of source-separated refuse is more expensive than ordinary refuse collection.

In lieu of source separation, recyclable materials can be separated from garbage at centralized mechanical processing plants. Experience has shown that the quality of recyclables recovered from such facilities is lowered by contamination with moist garbage and broken glass. The best practice, as now recognized, is to have citizens separate refuse into a limited number of categories, including newspaper; magazines and other wastepaper;

commingled metals, glass, and plastics; and garbage and other nonrecyclables. The newspaper, other paper wastes, and commingled recyclables are collected separately from the other refuse and are processed at a centralized material recycling facility, or MRF (pronounced "murf" in waste-management jargon). A modern MRF can process about 300 tons of recyclable wastes per day.

At a typical MRF, commingled recyclables are loaded onto a conveyor. Steel cans ("tin" cans are actually steel with only a thin coating of tin) are removed by an electromagnetic separator, and the remaining material passes over a vibrating screen in order to remove broken glass. Next, the conveyor passes through an air classifier, which separates aluminum and plastic containers from heavier glass containers. Glass is manually sorted by colour, and aluminum cans are separated from plastics by an eddy-current separator, which repels the aluminum from the conveyor belt.

Reuse

Recovered broken glass can be crushed and used in asphalt pavement. Colour-sorted glass is crushed and sold to glass manufacturers as cullet, an essential ingredient in glassmaking. Steel cans are baled and shipped to steel mills as scrap, and aluminum is baled or compacted for reuse by smelters. Aluminum is one of the smallest components of municipal solid waste, but it has the highest value as a recyclable material. Recycling of plastic is a challenge, mostly because of the many different polymeric materials used in its production. Mixed thermoplastics can be used only to make lower-quality products, such as "plastic lumber."

In the paper stream, old newspapers are sorted by hand on a conveyor belt in order to remove corrugated materials and mixed papers. They are then baled or loose-loaded into trailers for shipment to paper mills, where they are reused in the making of more newspaper. Mixed paper is separated from corrugated paper for sale to tissue mills. Although the processes of pulping, de-inking, and screening wastepaper are generally more expensive than making paper from virgin wood fibres, the market for recycled paper has grown with the establishment of more processing plants.

Rubber is sometimes reclaimed from solid waste and shredded, reformed, and remolded in a process called revulcanization, but it is usually not as strong as the original material. Shredded rubber can be used as an additive in asphalt pavements and artificial turf and is also sold directly as an outdoor mulch. Discarded tires may be employed as swings and other recreational structures for use by children in “tire playgrounds.”

In general, the most difficult problem associated with the recycling of any solid-waste material is finding applications and suitable markets. Recycling by itself will not solve the growing problem of solid-waste management and disposal. There will always be some unusable and completely valueless solid residue requiring final disposal.

Jerry A. Nathanson

Citation Information

Article Title: solid-waste management

Website Name: Encyclopaedia Britannica

Publisher: Encyclopaedia Britannica, Inc.

Date Published: 10 November 2020

URL: https://www.britannica.com/technology/solid-waste-management

Access Date: November 29, 2021

MODULE -1

AIR POLLUTION (CHAPTER-1)

Introduction: Air pollution refers to the release of pollutants into the air that are detrimental to human health and the planet as a whole. The Clean Air Act authorizes the U.S. Environmental Protection Agency (EPA) to protect public health by regulating the emissions of these harmful air pollutants. The NRDC has been a leading authority on this law since it was established in 197.Air pollution is a change in the physical, chemical and biological characteristic of air that causes adverse effects on humans and other organisms. The ultimate result is a change in the natural environment and ecosystem. The substances that are responsible for causing air pollution are called air pollutants. These air pollutants can be either natural (e.g. wildfires) or synthetic (man-made); they may be in the form of gas, liquid or solid.

Types of Air Pollutants:

An air pollutant is known as a substance in the air that can cause harm to humans and the environment. Pollutants can be in the form of solid particles, liquid droplets, or gases. In addition, they may be natural or man-made. Pollutants can be classified as either primary or secondary. Usually, primary pollutants are substances directly emitted from a process, such as ash from a volcanic eruption, the carbon monoxide gas from a motor vehicle exhaust or sulphur dioxide released from factories.

Secondary pollutants are not emitted directly. Rather, they form in the air when primary pollutants react or interact. An important example of a secondary pollutant is ground level ozone is one of the many secondary pollutants that causes photochemical smog.

(1) Major primary pollutants produced by human activity

Sulphur oxides (SO_x):

SO_2 is produced by volcanoes and in various industrial processes. Since coal and petroleum often contain sulphur compounds, their combustion generates sulphur dioxide. Further oxidation of SO_2, usually in the presence of a catalyst such as NO_2, forms H_2SO_4, and thus acid rain. This is one of the causes for concern over the environmental impact of the use of these fuels as power sources.

ii. Nitrogen oxides (NO_x):

Especially nitrogen dioxide is emitted from high temperature combustion. Nitrogen dioxide is the chemical compound with the formula $N0_2$. It is responsible for photochemical smog, acid rain etc.

iii. Carbon monoxide:

It is a colourless, odourless, non-irritating but very poisonous gas. It is a product by incomplete combustion of fuel such as natural gas, coal or wood. Vehicular exhaust is a major source of carbon monoxide.

iv. Carbon dioxide (CO_2):
A greenhouse gas emitted from combustion but is also a gas vital to living organisms. It is a natural gas in the atmosphere.
v. Volatile organic compounds:
VOCs are an important outdoor air pollutant. In this field they are often divided into the separate categories of methane (CH_4) and non-methane (NMVOCs). Methane is an extremely efficient greenhouse gas which contributes to enhanced global warming.
Other hydrocarbon VOCs are also significant greenhouse gases via their role in creating ozone and in prolonging the life of methane in the atmosphere, although the effect varies depending on local air quality. Within the NMVOCs, the aromatic compounds benzene, toluene and xylene are suspected carcinogens and may lead to leukaemia through prolonged exposure. 1, 3-butadiene is another dangerous compound which is often associated with industrial uses.
vi. Particulate matter:
Particulates alternatively referred to as particulate matter (PM) or fine particles, are tiny particles of solid or liquid suspended in a gas. In contrast, aerosol refers to particles and the gas together. Sources of particulate matter can be manmade or natural.
Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray. Human activities, such as the burning of fossil fuels in vehicles, power plants and various industrial processes also generate significant amounts of aerosols.
Averaged over the globe, anthropogenic aerosols—those made by human activities—currently account for about 10 per cent of the total amount of aerosols in our atmosphere. Increased levels of fine particles in the air are linked to health hazards such as heart disease, altered lung function and lung cancer.
vii. Persistent free radicals – connected to airborne fine particles could cause cardiopulmonary disease.
viii. Toxic metals – such as lead, cadmium and copper.
ix. Chlorofluorocarbons (CFCs) – harmful to the ozone layer emitted from products currently banned from use.
x. Ammonia (NH_3) – emitted from agricultural processes. Ammonia is a compound with the formula NH_3. It is normally encountered as a gas with a characteristic pungent odour. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to foodstuffs and fertilizers. Ammonia, either directly or indirectly, is also a building block for the synthesis of many pharmaceuticals. Although in wide use, ammonia is both caustic and hazardous.
xi. Odours – such as from garbage, sewage, and industrial processes
xii. Radioactive pollutants – produced by nuclear explosions, war explosives, and natural processes such as the radioactive decay of radon.
Secondary pollutants include:

i. **Particulate matter** formed from gaseous primary pollutants and compounds in photochemical smog. Smog is a kind of air pollution; the word “smog” is a portmanteau of smoke and fog. Classic smog results from large amounts of coal burning in an area caused by a mixture of smoke and sulphur dioxide. Modern smog does not usually come from coal but from vehicular and industrial emissions that are acted on in the atmosphere by sunlight to form secondary pollutants that also combine with the primary emissions to form photochemical smog.

ii. **Ground level ozone (O_3)** formed from NO_x and VOCs. Ozone (O_3) is a key constituent of the troposphere (it is also an important constituent of certain regions of the stratosphere commonly known as the Ozone layer). Photochemical and chemical reactions involving it drive many of the chemical processes that occur in the atmosphere by day and by night. At abnormally high concentrations brought about by human activities (largely the combustion of fossil fuel), it is a pollutant, and a constituent of smog.

iii. **Peroxyacetyl nitrate (PAN)** – similarly formed from NO_x and VOCs and is a dangerous air pollutant mostly affects our respiratory system and nervous system.

Sources of Air Pollution:

Sources of air pollution refer to the various locations, activities or factors which are responsible for the releasing of pollutants in the atmosphere. These sources can be classified into two major categories which are:

1.Anthropogenic sources (human activity)

It mostly related to burning different kinds of fuel:

i. “Stationary Sources” include smoke stacks of power plants, manufacturing facilities (factories) and waste incinerators, as well as furnaces and other types of fuel-burning heating devices.

ii. “Mobile Sources” include motor vehicles, marine vessels, aircraft and the effect of sound etc.

iii. Chemicals, dust and controlled burn practices in agriculture and forestry management. Controlled or prescribed burning is a technique sometimes used in forest management, farming, prairie restoration or greenhouse gas abatement. Fire is a natural part of both forest and grassland ecology and controlled fire can be a tool for foresters. Controlled burning stimulates the germination of some desirable forest trees, thus renewing the forest.

iv. Fumes from paint, hair spray, varnish, aerosol sprays and other solvents.

v. Waste deposition in landfills, which generate methane. Methane is not toxic; however, it is highly flammable and may form explosive mixtures with air. Methane is also an asphyxiate and may displace oxygen in an enclosed space. Asphyxia or suffocation may result if the oxygen concentration is reduced to below 19.5% by displacement.

v. Military, such as nuclear weapons, toxic gases, germ warfare and rocketry.

2.Natural sources:

i. Dust from natural sources, usually large areas of land with little or no vegetation.

ii. Methane, emitted by the digestion of food by animals, for example cattle.

iii. Radon gas from radioactive decay within the Earth's crust. Radon is a colourless, odourless, naturally occurring, radioactive noble gas that is formed from the decay of radium. It is considered to be a health hazard. Radon gas from natural sources can accumulate in buildings, especially in confined areas such as the basement and it is the second most frequent cause of lung cancer, after cigarette smoking.

iv. Smoke and carbon monoxide from wildfires.

v. Volcanic activity, which produce sulphur, chlorine, and ash particulates.

Effects and fate of Air Pollutants:

There are Various Harmful Effects of the air Pollutants:

i. Carbon monoxide (source- Automobile exhaust, photochemical reactions in the atmosphere, biological oxidation by marine organisms, etc.)- Affects the respiratory activity as haemoglobin has more affinity for CO than for oxygen. Thus, CO combines with HB and thus reduces the oxygen-carrying capacity of blood. This results in blurred vision, headache, unconsciousness and death due to asphyxiation (lack of oxygen).

ii. Carbon di oxide (source- Carbon burning of fossil fuels, depletion of forests (that remove excess carbon dioxide and help in maintaining the oxygen-carbon dioxide ratio) – causes global warming.

iii. Sulphur dioxide (source- Industries, burning of fossil fuels, forest fires, electric generation plants, smelting plants, industnal boilers, petroleum refineries and volcanic eruptions)- Respiratory problems, severe headache, reduced productivity of plants, yellowing and reduced storage time for paper, yellowing and damage to limestone and marble, damage to leather, increased rate of corrosion of iron, steel, zinc and aluminium.

iv. Hydrocarbons Poly-nuclear Aromatic Compounds(PAC) and Poly-nuclear Aromatic Hydrocarbons(PAH) (source- Automobile exhaust and industries, leaking fuel tanks, leaching from toxic waste dumping sites and coal tar lining of some water supply pipes)- Carcinogenic (may cause leukaemia).

v. Chloro-fluoro carbons (CFCs) (source- Refrigerators, air conditioners, foam shaving cream, spray cans and cleaning solvents)- Destroy ozone layer which then permits harmful UV rays to enter the atmosphere. The ozone layer protects the earth from the ultraviolet rays sent down by the sun. If the ozone layer is depleted by human action, the effects on the planet could be catastrophic.

vi. Nitrogen Oxides (source- Automobile exhausts, burning of fossil fuels, forest fires, electric generation plants, smelting plants, industrial boilers, petroleum refineries and volcanic eruptions)- Forms photochemical smog, at higher concentrations causes leaf damage or affects the photosynthetic activities of plants and causes respiratory problems in mammals.

vii. Particulate matter Lead halides (lead pollution) (source- Combustion of leaded gasoline products) , Toxic effect in man.

viii. Asbestos particles (source- Mining activities) – Asbestosis – a cancerous disease of the lungs.

ix. Silicon dioxide (source- Stone cutting, pottery, glass manufacturing and cement industries) Silicosis, a cancerous disease.

x. Mercury (source- combustion of fossil fuel & plants)-brain & kidney damage.

Air pollutants affect plants by entering through stomata (leaf pores through which gases diffuse), destroy chlorophyll and affect photosynthesis. During the day time the stomata are wide open to facilitate photosynthesis. Air pollutants during day time affect plants by entering the leaf through these stomata more than night.

Pollutants also erode waxy coating of the leaves called cuticle. Cuticle prevents excessive water loss and damage from diseases, pests, drought and frost. Damage to leaf structure causes necrosis (dead areas of leaf), chlorosis (loss or reduction of chlorophyll causing yellowing of leaf) or epinasty (downward curling of leaf), and abscission (dropping of leaves).

Particulates deposited on leaves can form encrustations and plug the stomata and also reduce the availability of sunlight. The damage can result in death of the plant. $S0_2$ causes bleaching of leaves, chlorosis, injury and necrosis of leaves. N02 results in increased abscission and suppressed growth. O3 causes flecks on leaf surface, premature aging, necrosis and bleaching.

Peroxyacetyl nitrate (PAN) causes silvering of lower surface of leaf, damage to young and more sensitive leaves and suppressed growth. Fluorides cause necrosis of leaf-tip while ethylene results in epinasty, leaf abscission and dropping of flowers.

4. Control of Air Pollution:

The following items are commonly used as pollution control devices by industry or transportation devices. They can either destroy contaminants or remove them from an exhaust stream before it is emitted into the atmosphere.

i. Particulate Control:

Mechanical collectors (dust cyclones, multi-cyclones)- Cyclonic separation is a method of removing particulates from an air, gas or water stream, without the use of filters, through vortex separation. Rotational effects and gravity are used to separate mixtures of solids and fluids.

A high speed rotating (air) flow is established within a cylindrical or conical container called a cyclone. Air flows in a spiral pattern, beginning at the top (wide end) of the cyclone and ending at the bottom (narrow) end before exiting the cyclone in a straight stream through the centre of the cyclone and out the top.

Larger (denser) particles in the rotating stream have too much inertia to follow the tight curve of the stream and strike the outside wall, falling then to the bottom of the cyclone where they can be removed.

In a conical system, as the rotating flow moves towards the narrow end of the cyclone the rotational radius of the stream is reduced, separating smaller and smaller particles. The cyclone geometry, together with flow rate, defines the cut point of the cyclone. This is the size of particle that will be removed from the stream with 50% efficiency. Particles larger than the cut point will be removed with a greater efficiency and smaller particles with a lower efficiency.

ii. Electrostatic Precipitators:

An electrostatic precipitator (ESP), or electrostatic air cleaner is a particulate collection device that removes particles from a flowing gas (such as air) using the force of an induced electrostatic charge. Electrostatic precipitators are highly efficient filtration devices that minimally impede the flow of gases through the device, and can easily remove fine particulate matter such as dust and smoke from the air stream.

In contrast to wet scrubbers which apply energy directly to the flowing fluid medium, an ESP applies energy only to the particulate matter being collected and therefore is very efficient in its consumption of energy (in the form of electricity).

iii. Particulate Scrubbers:

The term Wet scrubber describes a variety of devices that remove pollutants from a furnace flue gas or from other gas streams. In a wet scrubber, the polluted gas stream is brought into contact with the scrubbing liquid, by spraying it with the liquid, by forcing it through a pool of liquid, or by some other contact method, so as to remove the pollutants.

The design of wet scrubbers or any air pollution control device depends on the industrial process conditions and the nature of the air pollutants involved. Inlet gas characteristics and dust properties (if particles are present) are of primary importance.

Scrubbers can be designed to collect particulate matter and/or gaseous pollutants. Wet scrubbers remove dust particles by capturing them in liquid droplets. Wet scrubbers remove pollutant gases by dissolving or absorbing them into the liquid.

Any droplets that are in the scrubber inlet gas must be separated from the outlet gas stream by means of another device referred to as a mist eliminator or entrainment separator (these terms are interchangeable). Also, the resultant scrubbing liquid must be treated prior to any ultimate discharge or being reused in the plant:

i. Vehicular pollution can be checked by regular tune-up of engines; replacement of more polluting old vehicles; installing catalytic converters; by engine modification to have fuel efficient (lean) mixtures to reduce CO and hydrocarbon emissions; and slow and cooler burning of fuels to reduce NOx emission.

ii. Using low sulphur coal in industries.

iii. Minimise or modify activities which cause pollution e.g. transportation and energy production.

Global Warming and Greenhouse Effect

The history of the greenhouse effect and global warming. First of all, predicted by Svante Arrhenius was a Swedish scientist that was the first to claim in 1896 that fossil fuel combustion may eventually result in enhanced global warming. He proposed a relation between atmospheric carbon dioxide concentrations and temperature

When we burn organic materials (i.e. carbon-containing) fuels, or organic matter decomposes, carbon dioxide is released into the air. It is transparent to incoming solar radiation, but opaque to some wavelengths of heat radiated from the warmed surface of the Earth, and so traps heat, leading eventually to a warming of the lower atmosphere" This is known as the greenhouse effect, as in principle, the atmosphere behaves in a similar manner to a garden greenhouse, it allows sunlight to penetrate, but heat is trapped within the atmosphere in the same way that it is trapped within the glass walls of a greenhouse. This trapped hot air is causing the earth to heat up, resulting in global warming, and ultimately climate change.

Greenhouse gases include naturally occurring gases, such as carbon dioxide, methane, and even water vapor. In fact, water vapor is the most abundant greenhouse gas. However, human activities, such as burning of coal, exhaust fumes from vehicles, and burning of trees during deforestation activities, are contributing huge amounts of additional greenhouse gases into the atmosphere, where they enhance the greenhouse effect further and contribute to global warming.

The Albedo Effect

Snowcapped mountains and ice sheets reflect radiation away from the Earth which is a phenomenon that is known as the albedo effect. This helps reduce the amount of heat absorbed by the Earth, and therefore plays a vital role in keeping the Earth cool.

When ice sheets melt, it exposes dark rock or vegetation that doesn't have the same reflective properties as ice, and thus tends to absorb rather than reflect heat.

Life sustains on Earth by depending on the energy coming from the sun. About 60 percent of the energy and light reaching the surface of the Earth passes through the air and clouds where the harmful gases get segregated and absorbed. These gases are radiated upwards in the form of infrared heat. About 89 percent of this heat is then taken by the greenhouse gases and radiated back to the surface. Due to depletion of the ozone

Health hazards

In terms of health hazards, every unusual, suspended material in the air, which causes difficulties in normal function of the human organs, is defined as air toxicants. According to available data, the main toxic effects of exposure to air pollutants are mainly on the respiratory, cardiovascular, ophthalmologic, dermatologic, neuropsychiatric, hematologic, immunologic, and reproductive systems. However, the molecular and cell toxicity may also induce a variety of cancers in the long term. On the other hand, even small amount of air toxicants is shown to be dangerous for susceptible groups including children and elderly people as well as patients suffering from respiratory and cardiovascular diseases.

Respiratory disorders

Because most of the pollutants enter the body through the airways, the respiratory system is in the first line of battle in the onset and progression of diseases resulted from air pollutants. Depending on the dose of inhaled pollutants, and deposition in target cells, they cause a different level of damages in the respiratory system. In the upper respiratory tract, the first effect is irritation, especially in trachea which induces voice disturbances. Air pollution is also considered as the major environmental risk factor for some respiratory diseases such as asthma and lung cancer. Air pollutants, especially PMs and other respirable chemicals such as dust, O_3, and benzene cause serious damage to the respiratory tract. Asthma is a respiratory disease which may be developed because of exposure to air toxicants. Some studies have validated associations between both traffic-related and/or industrial air pollution and increasing the risk of COPD. Treatment of respiratory diseases due to air pollution is similar to the other toxic chemical induce respiratory disorders.

Cardiovascular dysfunctions

Many experimental and epidemiologic studies have shown the direct association of air pollutant exposure and cardiac-related illnesses. Air pollution is also associated with changes in white blood cell counts which also may affect the cardiovascular functions. On the other hand, a study on animal models suggested the close relationship between hypertension and air pollution exposure. The traffic-related air pollution, especially exposure to high levels of NO_2, is associated with right and left ventricular hypertrophy. In addition to the antidote therapy that exists only for a few cardiotoxic substances like CO, usual treatment of cardiovascular diseases should be carried out.

Neuropsychiatric complications

The relationship between exposure to air suspended toxic materials and nerve system has always been argued. However, it is now believed that these toxic substances have damaging effects on the nervous system. The toxic effect of air pollutants on nerve system includes neurological complications and psychiatric disorders. Neurological impairment may cause devastating consequences, especially in infants. In contrast, psychiatric disorders will induce aggression and antisocial behaviours. Recent studies have reported the relationship between air pollution and neurobehavioral hyperactivity, criminal activity, and age-inappropriate behaviours. Studies have also revealed the association between air pollution and higher risk of neuroinflammation, Alzheimer's and Parkinson's diseases. Some studies showed that aggression and anxiety in megacities are in close relationship with the high level of air pollutants.

Other long-term complications

Skin is the body's first line of defence against a foreign pathogen or infectious agent, and it is the first organ that may be contaminated by a pollutant. The skin is a target organ for pollution in which the absorption of environmental pollutants from this organ is equivalent to the respiratory uptake. Research on the skin has provided evidence that traffic-related air pollutants, especially PAHs, VOCs, oxides, and PM affect skin aging and cause pigmented spots on the face.

Theoretically, toxic air pollutants can cause damage to organs when inhaled or absorbed through the skin. Some of these pollutants are hepatocarcinogen chemicals. There are some proven data which highlighted the role of air pollutants, especially traffic-related air pollution on the incidence of autism and its related disorders in foetus and children. Disrupting endocrine by chemical components of pollutants has been described as a possible mechanistic pathway of autism or other neurological disorders. Some studies showed that there are relationships between air pollution exposure and fatal head size in late pregnancy, fatal growth, and low birth weight.

Many of the diseases that are linked to immune system dysfunction can be affected by several environmental factors such as poor air quality. Poor air quality can cause serious complications in the immune system such as an abnormal increase in the serum levels of the immunoglobulin (Ig); IgA, IgM, and the complement component C_3 in humans as well as chronic inflammatory diseases of the respiratory system. Exposure to these immunotoxicity may also cause immune dysfunction at different stages which can serve as the basis for increased risks of numerous diseases such as neuroinflammation, an altered brain innates immune response. Air pollutants modify antigen presentation by up-regulation of costimulatory molecules such as CD80 and CD86 on macrophages.

The eye is a neglected vulnerable organ to the adverse effects of air suspended contaminants even household air pollution. Clinical effects of air pollution on the eyes can vary from asymptomatic eye problems to dry eye syndrome. Chronic exposure to air pollutants increases the risk for retinopathy and adverse ocular outcomes. In addition, there are now evidence suggesting the association between air pollution and irritation of the eyes, dry eye syndrome, and some of the major blinding. According to data, the level of air pollution is linked to short-term increases in the number of people visiting the ophthalmological emergency department.

National Ambient Air Quality Standards (Source: Central Pollution Control Board)

Pollutants	Time Weighted average	Concentration in ambient air	
		Industrial areas, Residential, Rural, and other areas	Sensitive areas
Sulphur Dioxide (SO_2), $\mu g/m^3$	Annual Average*	50	20

	24 hours**	80	80
Oxides of Nitrogen as (NO_2), µg/m^3	Annual Average*	40	30
	24 hours**	80	80
Particulate Matter (RSPM) (size less than 10 microns), µg/m^3	Annual Average*	60	60
	24 hours**	100	100
Particulate Matter (RSPM) (size less than 2.5 microns), µg/m^3	Annual Average*	40	40
	24 hours**	60	60
Ozone (O_3), µg/m^3	8 hours	100	100
	1 hour	180	180
Lead (Pb), µg/m^3	Annual Average*	0.5	0.5
	24 hours**	1.0	1.0
Carbon Monoxide (CO), mg/m^3	8 hours	2	2
	1 hour	4	4
Ammonia, µg/m^3	Annual Average*	100	100
	24 hours**	400	400

Benzene	Annual Average*	5	5
Benzo Pyrene – particulate phase only, ng/m^3	Annual Average*	1	1
Arsenic, ng/m^3	Annual Average*	6	6
Nickel, ng/m^3	Annual Average*	20	20

* Annual arithmetic means of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals

** 24 hourly or 8 hourly or 1 hourly monitored value, as applicable, shall be compiled with 98 % of the time in a year, 2 % of the time, they may exceed the limits but not on two.

Abatement of air pollution

The air pollution and the resultant air quality can be attributed to emissions from vehicular, industrial, and domestic activities. The air quality has been, therefore, an issue of social concern in the backdrop of various developmental activities. The norms for ambient air quality and industry specific emissions have been notified. For control of air pollution, with a view to initiate policy measures and to prepare ambient air quality management plans, 321 Air Quality Monitoring Stations are operational covering twenty-five States and four Union Territories.

The CPCB has evolved a format for preparation of action plans, which has been circulated to all State Pollution Control Boards/Committees. The action plans emphasize identification of sources of air pollution, assessment of pollution load and adoption of abatement measures for identified sources. Setting up interdepartmental task force for implementation of city specific action plan has also been suggested.

In order to control vehicular pollution, a road map has been adopted as per the schedule proposed in Auto Fuel Policy, which includes use of cleaner fuels, automobile technologies and enforcement measures for in use vehicles through improved Pollution Under control (PUC) certification system. As per the Auto Fuel Policy, Bharat Stage-II norms for new vehicles have been introduced throughout the country from first April, 2005. However, EURO-III equivalent emission norms for all new vehicles, except 2-3 wheelers, have been introduced in 11 major cities from April 1, 2005. To meet Bharat Stage-II, EURO-III and EUROIV emission norms, matching quality of petrol and diesel is being made available.

DISASTERS AND THEIR MANAGEMENT

In nature disaster such as floods, drought, earthquake, tsunami, happen from time to time causing immense damage to life and property. It is important to devise means and methods to manage and minimise from natural disasters as far as possible. Disasters caused by human activities such as fires, accidents, epidemics are no less sudden than natural disasters and may be equally devastating. In this lesson you shall learn about causes, effects, prevention, and management of natural as well as human made disaster.

The Indian sub-continent is highly prone to natural disasters. Floods, droughts, cyclones and earthquakes are recurrent phenomena in India. Susceptibility to disasters is compounded by frequent occurrences of man-made disasters such as fire. The changing topography (topo = land) due to environmental degradation also increasing vulnerability to natural disasters. In 1988, 11.2%of total land area was flood prone, but in 1998 floods inundated 37% geographical area.

Major disasters that India has experienced in the past are the **Great Bengal Famine (1770)** [Affected area: West Bengal, Bihar, Odisha, and Bangladesh. Number of deaths around 1 crore. Cause: Drought], **super cyclone in Orissa (1999)** [Number of deaths around 15000+, Cause: Cyclone of speed 260 km/hr], **the earthquake in Gujarat (2001)** [Number of deaths around 20000, Injured 167000 and nearly 400000 became homeless. Experienced an earthquake of 7.6 to 7.9 on the Richter scale and lasted for 120 sec], **Tsunami in Tamil Nādu and Andhra Pradesh in December (2004)** [Number of deaths 2.30 lac], **Bihar flood disaster (2007)** [Bihar flood had affected an estimated 10 million people in the entire state. There are about 29000 houses were destroyed and 44000 houses are damaged, around 4822 villages and 1 crore hectares of farmland damaged by this flood. It affected 19 districts of Bihar], **Uttarakhand Flash Floods (2013)** [It affected 12 out of 13 districts of the state, Number of deaths was 5700 plus, cause: Heavy rainfall and massive landslides].

Frequent disasters lead to enormous loss of life and property. Physical safety-especially that of the vulnerable groups is routinely threatened by hazards. Natural disasters cannot be prevented but their damaging impact can be reduced through better forecast, and preparedness to take up effective rescue measures. The four major disasters mentioned above have very clearly illustrated that we need multi-hazard prevention, response, and recovery plans for natural hazards so that threat to human life and property is minimized. Disaster risk management is essentially a development problem. Preparedness and planning for disaster management must be taken up along with environmental concerns that the country is facing today.

Type of disasters

There are two types of disasters namely natural disasters and manmade disasters. For example: fire, accidents (road, rail, or air), industrial accidents or epidemics are some of the examples of man-made disasters, both natural and man-made disasters which have devastating input resulting loss of human life, loss of livelihoods, property, and environmental degradation. Disasters disrupts normal functioning of society and leave long lasting impact. Earthquake, cyclone, flood, and drought are examples of natural disasters.

A. Natural disasters

Certain disasters occur in nature, without human provocation. They are described below.

1. Floods

Floods are sudden and temporary inundation of a large area as an overflowing of rivers or reservoirs.

(i) Causes

Floods are caused by rains, high winds, cyclones, tsunami, melting snow or dam burst. Flood can happen gradually or can happen suddenly due to heavy rains, breach of the water storage and control structures, spill over. Siltation of the rivers and reservoirs, and this can enhance the incidence and magnitude of floods.

(ii) Effects

• **Casualties**

Human and livestock death due to drowning, serious injuries, and outbreak of epidemics like diarrhoea, cholera, jaundice, or viral infections are common problems faced in flood affected areas. Even wells, other source of drinking water get submerged resulting in acute shortage of safe drinking water during floods. Consequently, often people are forced to drink the contaminated floodwater, which may cause serious diseases.

• **Structural damage**

During floods mud huts and buildings built on weak foundations collapse endangering human lives and property. Damage may also be cause to roads, rail, dams, monuments, crops, and cattle. Floods may uproot trees and may cause landslides and soil erosion.

• **Material loss**

Household articles including eatables, electronic goods, beds, clothes, furniture get submerged in water and get spoilt all materials mounted on ground e.g., food stock, equipment, vehicles, livestock, machinery, salt pan and fishing boats can be submerged and spoilt.

• **Utilities damage**

Utilities such as water supply, sewerage, communication lines, powerlines, transportation network and railways are put at risk.

• **Crop loss**

Apart from the loss of human and cattle life, floods cause severe devastation of standing agricultural crops. Floods water spoils the stored food-grains or harvested crop. Floods may affect soil characteristics and may turn them infertile due to the erosion of the topsoil or in coastal areas agricultural lands may turn saline due to flooding by sea water.

• **Flood control**

Flood control can be achieved through various means. The floodwater can be reduced by reducing the run-off water through afforestation. Forests promote rainwater percolation in the ground, thus recharging the groundwater and reducing the run-off water. Construction of dams also reduces flood water through storage. Dams can store water, which cannot be accommodated in the river downstream may cause floods. Water can be released in a controlled manner from the dam. Desilting, deepening, and increasing embankment increase the capacity of a river/channel/drain.

(iii) Management

The flood damage can be considerable reduced, and loss of human lives can prevent through proper planning of flood control and management measures.

• Identification of flood prone areas
A rational planning for flood management involves identification the flood prone areas and frequency and magnitude of flooding in these areas.

• **Flood forecasting**
Normally there is a reasonable timely warning by alerting people and moving them to safer area well in time. Measurement of intensity of rainfall in the catchment area provide sufficient clue to hydrology engineers to calculate the possible submergence area along a river well before the flooding occurs. Accordingly expected run-off volume people can be warned to evacuate the likely areas to be flooded and advise to go to safer places along with their belongings including livestock. In India has a large network of rain measuring stations, flood warnings are issued by the Central Water Commission (CWC), Irrigation and Flood Control Department and Water Resources Department.

• Land use planning
Land use planning is very important for all the developmental activities. No major development should be permitted in flood prone areas. If construction is unavoidable, it should be able to withstand the flood forces. Buildings should be constructed on elevated areas. Afforestation should be encouraged. Deforestation in the catchments areas should be discouraged because deforestation results in excessive run off water and causes soil erosion, which is the main cause of river siltation resulting in floods. Any construction, which causes obstruction in drainage flow, should not be permitted. Encroachment of the storm water drains should not be allowed.

This reduces the risk of floods. Some precautionary measures are as follows –

• Build houses away from flood prone area.
• Keep yourself alert and updated to weather and flood forecasting information.
• In case evacuation warnings are issued, immediately go to the shelters provided.
• When you are moving to a shelter, move your valuable articles to safer elevated places so that they are not destroyed by flood water.
• Store extra food, such as rice, pulses etc. for emergency.

• Do not touch any loose electric wire to avoid electrocution.
• Do not spread rumours or listen to them.
• Make provision for adults and children who need special diet.
• After the flood is over, get yourself and your family members inoculated against diseases and seek medical care for injured and sick.
• Clear the house and dwellings of debris.
• Report any loss to the revenue authorities

2. Drought

Drought is an event that results from lower-than-normal expected rainfall over a season or period. The low rainfall is insufficient to meet the needs of human beings, plants, animals, and agriculture. Short fall in rain results in drying of rivers, lakes, reservoirs and drying of wells due to excessive withdrawal and poor recharge of ground water and loss of crop yield due to shortage of water are some of the main indicators of drought.

(i) Causes

Drought occurs due to shortage of rainfall. As per Meteorological Department if rainfall is deficient by more than 10% of the annual average rainfall, the condition is said to be that of drought. The severity of drought is determined by the extent of deviation of rainfall from the average. In the recent past frequency of periods of drought have increasing due to deforestation and environmental degradation.

(ii) Effects

Drought has severe effects on agriculture. To start with drought affects mostly rainfed crops and subsequently the irrigated crops. The herdsman, landless labours, subsistence farmers, women, children, and farm animals are most affected.

• Crop failure or food shortage leading to large scale starvation and death.
• Affects dairy activities, timber, and fisheries.
• Increases unemployment.
• Depletion of ground water.
• Increases energy consumption for pumping water from deep aquifers.
• Reduces energy production in hydro-electric power plants.
• Loss of biodiversity; and reduced landscape quality.
• Causes health problems, increased poverty, reduced quality of life and social unrest leading to migration.

(iii) Management

The adverse effects of drought can be minimised if some measures are taken. A regular monitoring of rainfall, water availability in reservoirs, lakes, and rivers as well as in comparison it with the demand. When water availability decreases than demand, water consumption need to be reduced by adopting various water conservation measures. These include economizing water consumption, by increasing water use efficiency, reducing wastage, reusing the wastewater for inferior uses. Use of efficient methods of irrigation and sowing low water-consuming crops are some important measures to overcome drought. Rainwater harvesting increases water availability. Water harvesting is done by either allowing the run-off water from all the catchment areas to a common point and storing it in a reservoir or allowing it to percolate into the ground so far recharging groundwater.

3. Earthquake

Earthquake is a sudden release of energy accumulated in deformed rocks of earth crust causing the ground to tremble or shake. Earthquake can occur suddenly any time of the year without any warning causing severe loss of life and property. We are aware of the severe damage caused by earthquakes of Latur (1993) and Bhuj (2002). The intensity of an earthquake is related to the amount of energy released when rocks give way to the forces within the earth. It is measured with the help of an instrument known as seismograph.

(i) Causes

Earthquakes are natural ways of releasing energy by earth. An earthquake occurs in certain pockets of the earth which has geological faults. Such areas have already been identified.

(ii) Effects

- **Structural damage**

Earthquakes may cause physical damage to the buildings, roads, dams, and monuments. High rise buildings or buildings built on weak foundations are especially susceptible to earthquake damage. Household articles including electronic goods and furniture get damaged. Human and livestock deaths or serious injuries from collapsing of building are common followed by outbreak of epidemics like cholera, diarrhoea, and infectious diseases. Utilities such as water supply, sewerage, communication lines, powerlines, transportation network, and railways get damaged.

(iii). Management

The effects can be minimized if some of the following measures are taken: -

Design of buildings

The buildings should be designed especially in earthquake prone areas in such a manner that they can withstand the stress of earthquake. Physical characteristics of soil should be analysed in order to ensure the strength to withstand the earthquake. Bureau of Indian Standards has formulated building designs and guidelines for constructions that withstand against earthquakes. Generally building design is approved by the concerned municipal authorities according to build by laws and safety requirements. Training of the builders, architects, contractors, designers, house owners and government officials is important. Some of the precautionary measures in the event of an earthquake are as follows:

• Move out in the open.
• Keep calm, do not rush and panic, never use lift, keep away from windows, mirrors, and furniture.
• Stand under strong beams that may not fall or creep under the dining table or a strong bed.
• If you are under a building and unable to move, cover your head and body with your arms, pillows, blankets to protect yourself from falling objects.
• If in a multi storey building stay on the same floor. Do not use elevators or run towards the staircase.
• If travelling stop the vehicle away from building, walls, bridge, trees, electricity poles and wires.
• Check for structural damage and clear the blockage.
• Check for injuries. Apply first aid. Help others.
• If your home is badly damaged by earthquake, come out immediately. Collect all emergency supplies like food, water, first aid kit, medicines, flashlight or torch, candles, matchbox, clothes etc; if possible.
• Keep away from buildings especially old and tall ones, electricity poles, wires, and walls.

4. Cyclone

Cyclones are violent storms, often of vast extent, characterised by strong and high winds rotating about a calm centre of low atmospheric pressure. This centre moves onwards, often with velocity of around 50 km/h. Cyclones strike suddenly though it takes time for them to build up. Cyclone is generally followed by heavy rains causing floods. Satellite tracking can predict on possible affected areas and inhabitants fore warned can be made for warning. Warning and evacuation are done along the projected path.

(i) Effects

Light weight structures built of mud, wood, old buildings with weak walls and structure without proper anchorage to the foundation are at risk. The settlements located in low lying areas of coastal regions are directly vulnerable. Settlements in adjacent areas are vulnerable to floods, mudslide, or landslide due to heavy rain. Telephone and electricity poles and wires, fences, light building structures such as thatched, tin sheds roofs, signboards, hoardings, fishing boats and trees are most vulnerable to cyclone damages. Due to heavy rains people and their property might be washed away in floods or blown away by cyclone itself. The cyclone along in the coastal areas may cause sea waves to enter on land and flood it. This may cause saline water contamination of soil and water in the affected area, affecting water supply and severely affecting agricultural crops.

(ii) Management

It is important to identify the cyclone prone areas. No development should be permitted in cyclone – prone areas. The building should be designed to withstand forces of wind and floods. All the elements holding the structures need to be properly anchored to resist the uplift. Coastal green belt has been found very effective in minimizing the effects of cyclones. Such green belts (trees growing along the coast) need to be developed along the coasts.

5. Tsunami

Tsunami is also called seismic sea wave, or tidal wave, catastrophic ocean wave, usually caused by a submarine earthquake occurring less than 50 km (30 miles) beneath the seafloor, with a magnitude greater than 6.5 on the Richter scale. Underwater or coastal landslides or volcanic eruptions also may cause a tsunami. The term tidal wave is more frequently used for such a wave, but it is a misnomer, for the wave has no connection with the tides.

In a tsunami a train of simple, progressive oscillatory waves is propagated to great distances at the ocean surface in ever-widening circles, much like the waves produced by a pebble falling into a shallow pool. The observation has enormous practical value, enabling seismologists to issue warnings to endangered coasts immediately after an earthquake and several hours before the arrival of the tsunami. As the waves approach the continental coasts, friction with the increasingly shallow bottom reduces the velocity of the waves. This results in increased wave height up to 50 meter and above. Three to five major oscillations generate most of the damage. The effects of tsunami, however, vary widely from place to place.

(i) Effects

The effects of tsunami are quite like those of cyclones or floods. Huge waves of sea water enter with great force and floods the land and washes away human settlements, agricultural crops, and other properties. The famous tsunami of December 2004 has had devastating effects in many countries particularly in Indonesia, Malaysia, Sri Lanka, India etc. One large area of coastal districts of Andhra Pradesh and Tamil Nādu. More than 2 lacs people died in 8 Asian countries including India.

(ii) Management

The mitigation measures are quite like those for cyclone or flood.

B. Manmade or Anthropogenic Disasters

Certain disasters occur in nature by humans’ activities. They are described below:

a. Fires

Fires are events of burning something. They are often destructive taking up toll of life and property. It is observed that more people die in a fire than in a cyclone, earthquake, floods, and other natural disasters combined. Fires are a great threat to forests and wildlife because they spread speedily and cause tremendous damage in a short time. In cities fires break out in home, jhuggis, buildings specially god owns and factories. Fire can spread to a large area. Many people may die of burns and asphyxiation. It may also cause contamination of air, water and soil, which may affect the crops, plants and animals, and soil fertility.

(i) Causes

During summer months such fires results in casualties and enormous economic losses.

There are numerous causes of fires. Some important ones are given here:

• Throwing burning matchsticks or cigarettes irresponsibility.
• Heating sources can cause fire in houses e.g., clothes may catch fire while cooking on kerosene stove or gas stove.
• Cooking accidents are a major cause of fire at home. Fire can result due to unattended cooking.
• A short circuit in an electric wiring can cause fire. Overheating of electric appliances, poor wiring connections, use of sub-standard quality appliances can also result in a fire.
• Rubbish and waste materials often lying on roadsides or near houses may catch fire when people throw burning matchstick or cigarette butt.
• Storage and transportation of inflammable material or explosive chemicals without proper precautions may cause fires.
• Forest fires may result from human negligence or carelessness.

(ii) Effects

• **Causalities**

Death of humans and livestock may occur due to burning or serious injuries from fire. In rural areas often the entire harvested crop stored in securely may catch fire and burn to ashes resulting in heavy loss to the owner.

(iii) Management

• Obey fire safety rules and remember the evacuation route in case of fire.
• Keep and handle inflammable materials with utmost care.
• Keep a fire extinguisher in the house and learn how to use it.
• When you leave home, make sure to shut off all electrical and gas appliances. • Do not plug several devices into one socket.
• Keep matches away from children.
• Do not block access routes by cupboards or any furniture.
• In the event of a fire call the fire department immediately.
• In the smoke-filled corridor, crawl on all floors or on your belly as the smoke is less on the floor.
• Find at least two ways to escape from your home.
• Make sure that you remove all the waste material from workplace and home on regular basis.

• Hazardous materials such as paints, solvents, adhesives, chemicals, or gas cylinders should be kept in separate storage, well away from fire.
• Firecrackers on Diwali is a major cause of fire in our country. Use them carefully under supervision of elders.

b. Road, rail, and air traffic accidents

(i) Road accidents

Road networks are developed for better connectivity and service. Increased number of vehicles, violation of traffic rules, speeding, drunken driving, and poor maintenance of vehicles as well as of roads are some of the main causes of road accidents. To avoid accidents following safety measures can be adopted:

• Look on either side of the road before crossing.
• Use zebra crossing while crossing the road by foot.
• Wear helmet while riding a two-wheeler.
• Use seat belt provided in your car.
• Drive only if you possess a proper driving license.
• Be familiar with road markings and honour them.
• Maintain a safety distance from the vehicle in front.
• Do not jump lanes. It becomes difficult for other vehicles, on the road to anticipate your move.
• Do not be rash and do not try to overtake unnecessarily.
• The best way to be safe on roads is to follow "lane driving"
• While driving avoid sudden acceleration and deceleration.
• Replace the worn tyres and faulty headlamps.
• Check the tyre pressure, radiator water, brake oil and fuel frequently.
• Dip your beam whenever you spot an oncoming vehicle.
• Follow the maintenance schedule prescribed by the manufacturer.
• Overcome impatience, anger, and intoxication during driving. Road rage is dangerous.
• In case a mishap occurs stay calm.
• In case of fire, try to get out as early as possible and do not worry about the baggage.

(ii) Rail accident

The most common type of rail accident is derailment due to human error, sabotage or natural landslide in a hilly track, or fire. Rail accidents lead to large number of casualties and material damage. Indian Railways incur heavy loss due to such accidents every year. Some of the common safety measures are: -

• At railway crossings pay attention to the signal and the swing barrier. Do not get underneath and try to get across.

• In case of an unmanned crossing, get down from the vehicle and look at either sides of the track before crossing.
• Do not stop the train on a bridge or tunnel where evacuation is not possible.
• Do not carry inflammable material in a train.
• Do not lean out of a moving train.
• Do not smoke in train.
• Do not pull the emergency cord unnecessarily.

(iii) Air accidents

Air accidents may occur due to technical problems, fire, poor landing and take-off, weather conditions, hijacking, bombing etc. Some of the common safety measures are:

• Pay attention to the flight crew safety demonstration.
• Carefully read the safety card in the pocket.
• Know where the nearest emergency exit is and learn how to open it.
• Always keep your seatbelt fastened when seated.
• Stay calm, listen to the crew members, and follow their instructions.
• Before you try to open any emergency door yourself, look outside the window. If you see a fire outside the door, do not open it or the flame may spread into the cabin. Try to use an alternate route for escape.
• Remember, smoke rises. So, try to stay down if there is smoke in the cabin.
• If you have a cloth, put it over your nose and mouth.

c. Industrial accidents

Industrial accidents can be due to explosion, fire, and leakage of toxic or hazardous chemicals and lead to heavy loss of life and material. Leakage of chemicals and explosion may be due to human error, technological failure or geological hazards like earthquakes, flood etc. Fire in an industry may result from human error or electrical faults (short circuit).

(i) Effects

The industrial premises and immediate surroundings are at high risk in the event of an industrial accident. Employees and residents of nearby localities and their live-stock and crops in nearby areas are severely affected. The environment over a large area gets polluted. Hazardous chemicals released into the atmosphere or into a water body may travel long distances and may even damage the entire ecosystem around the industrial area. This is what has happened in Bhopal in the year 1984, when about 45 tonnes of methyl isocyanide (MIC) gas leaked into the atmosphere killing more than 2500 people.

Explosion or fire or leakage of corrosive chemicals severely damage structures. If the chemical is in gaseous form the geographical spread is fast and wide. Many people may die either due to mechanical damage from explosion or fire or due to toxicity of the poisonous chemicals. The routes of exposure to chemical released from accidents are from inhalation, eye exposure, skin contact and ingestion. The polluting agents can have both immediate and long-term effects. The immediate effects include death or other symptoms like dizziness, headache, irritation etc. The long-term effects may include cancer, heart failure, brain damage, disfunction of immune system, deformation, genetic disorders or congenital (by birth) disorders in children.

(ii) Management

• Inventory of hazardous chemicals

It is important to have an inventory of hazardous chemicals along with their quality, storage locations, characteristics along with possible hazard associated with hazardous chemicals and this informed all employees and people living in the neighbourhood should informed about the potential risk. The inventory as far as possible high-risk areas demarcated and displayed along with indicating affected zone and safe routes for evacuation in the event of emergency.

• **Location of industries**

Industries should not be sited in residential areas. A large buffer zone, in form of a green belt, for separating an industrial area from residential areas.

• **Community preparedness**

The community should be aware of the hazardous installations and know how to combat the situation. Some members of the community should monitor the potential risk and participate in safety training organised by industries.

• **Other measures**

Limit storage capacity of the toxic chemicals. Improve firefighting capability, warning systems and measures for preventing pollution dispersion. Develop emergency relief and evacuation planning for employees and nearby settlements. Adopt insurance for employees and surrounding population which is mandatory under the law.

C. BIOLOGICAL DISASTERS

1. Epidemics

Epidemic is defined as occurrence of an illness or other health related event that is unusually affecting a large population. An epidemic can be anticipated by a sudden increase in the number of people suffering from a particular disease, increase in the population disease carrier. To control the spread of epidemics urgent measures are essential. Outbreaks of communicable disease to ready epidemic level are potentially high after a disaster.

(i) Cause

The outbreak of diseases is mainly due to poor sanitary condition leading to contamination of water or spread of disease form breeding of the disease vectors. Other factors include seasonal changes that favour breeding of insects. Vectors, exposure of a non-immune population (e.g., tourists or migrants), poverty and overcrowding.

(ii) Effects

Epidemic may cause mass illness or death. There are secondary effects such as disruption in the society and economic losses. Vulnerability is high among those who are poorly nourished, people living in unhygienic in sanitary conditions, poor quality of water supply, lack of access to health services.

(iii) Management Measures

Preventive public health measures need to be strengthened. Personal protection through vaccination is an effective mitigation measure. Improvement of sanitary conditions, fumigation of vector breeding sites and proper disposal of domestic and municipal wastes greatly reduce chances of epidemic spread of diseases. Contingency plan for dealing with the epidemics that are likely to occur in the region. Early warning system and regular surveillance are primary requirements to mount an effective control response in early stages to prevent any outbreaks. Some common diseases that may reach epidemic proportions are described below: -

(a) Dengue

Dengue is also called Breakbone Fever, or Dandy Fever. It is an acute, infectious, mosquito- borne haemorrhagic fever. Besides fever, the disease is characterized by an extreme pain and stiffness of the joints (hence the name “breakbone fever”). Dengue is caused by a virus transmitted through a mosquito called Aedes aegypti or Asian tiger mosquito.

A mosquito becomes infected only if it bites an infected individual (humans) during the first three days of the victim's illness. It then requires 8 to 11 days to incubate the virus before the disease can be transmitted to another individual. Thereafter, the mosquito remains infected for life. The virus is injected into the skin of the victim. There is no specific therapy; therefore, attention is focused on preventive measures involving mosquito control is only effective way to prevent spread of dengue.

(b) HIV and AIDS

The year 2001 was the 20th anniversary of the initial reports of a mysterious deadly immune-system disorder that came to be known as AIDS (or Acquired Immune Deficiency Syndrome). The disease epidemic that had killed more than 21 million people in the World. In 2001 an estimated 36 million people were living with HIV infection. This disease is caused by virus, called HIV (Human Immune Virus) which is mostly transmitted through sexual union and blood transmission

(c) Mad Cow Disease (Bovine spongiform encephalopathy)

Bovine spongiform encephalopathy (BSE or mad cow disease) in cattle is caused by an infectious agent that has a long incubation period, between two and five years. Death usually follows within a year of the onset of symptoms. No treatment or palliative measures are known. First recognized in cattle in the United Kingdom in 1986, Mad cow disease (BSE) became epidemic there, particularly in southern England. After the emergence of mad cow disease, concern grew over a possible relationship between the animal disease and the occurrence of brain fever disease in man (Creutzfeldt-Jacob disease). Possibly due to consumption of infected beef.

COMMUNITY LEVEL DISASTER MANAGEMENT

At the time of disaster, various agencies such as government, NGOs and community plays an important role for disaster management.

These are preparedness, response, recovery, and prevention details are on follows:

Disaster management has four basic components:

Preparedness: Measure to ensure that communities and services are capable of coping with the effect of disaster. It has the following main elements:

• Community awareness and education.

• Preparation of disaster management plans for community, school, individual.
• Mock drill, training, and practice.
• Inventory of resources both material resources and human skill resources.
• Proper warning systems.
• Mutual aid arrangement.
• Identifying the vulnerable group.

Response: Measures taken in anticipation of, during and immediately after a disaster for minimizing its adverse impact. It has following main elements:

• Activate the emergency operation centres (control room).
• Deployment of search and rescue teams.
• Issuing updated warning.
• Setting up community kitchens using local groups.
• Set up temporary living accommodation and toilet facilities.
• Set up medical camps.
• Mobilising resources.

Recovery: Measures are initiated to undertake reconstruction of the physical infrastructure and restoration of economic and emotional wellbeing. The main elements are as follows:

• Community awareness on health and safety measures.
• Counselling programme for those who have lost the near and dear ones.
• Restoring the essential services -roads, communication links, electricity etc.
• Providing shelters; • Collecting usable materials for construction from rubble.
• Providing financial support.
• Finding employment opportunities.
• Reconstructing new buildings.

Prevention: Measures to eliminate or reduce the incidence of severity.

• Land use planning.
• Preventing habitation in risk zones.
• Disaster resistant buildings.
• Finding ways to reduce risk even before the disaster strikes.
• Community awareness and education.

The first few hours before and after a disaster are critical and precious for saving lives and reducing further injury. Often external help may take time to reach the disaster site. In any disaster, often the neighbours are first to respond. The first responders are people who act first in a disaster situation, usually lack basic response skills to deal medical or other emergencies. The aim of community level management is to train the individuals and the members of local community to deal with emergency effectively. Trained community members are lifesaving assets in such situations. Thus, community level management involves people’s participation.

GOVERNMENT INITIATIVES ON DISASTER MANAGEMENT

The Government of India has set up a National Committee on Disaster Management (NCDM) under the Chairmanship of the Prime Minister. The recommendations of this National Committee would form the basis of national disaster risk management programme and strengthening the natural disaster management and response mechanisms. United Nations Development Programmes (UNDP) has also been supporting various initiatives of the government to strengthen disaster management capacities.

The programme components would include the following:

• Development of state and district disaster management plans.

• Development of disaster risk management and response plans at Village/ Ward, Gram Panchayat, Block/Urban Local Body levels.

• Constitutions of Disaster Management Teams and Committees at all levels with adequate representation of women in all committees and team. (Village/ Ward, Gram Panchayat, Block/Urban local body, District and State.)

• Capacity Building of Disaster Management Teams at all levels. Special training for women in first aid, shelter management, water and sanitation, rescue, and evacuation, etc.

• Capacity Building in cyclone and earthquake resistant features for houses in disaster-prone districts, training in retrofitting, and construction of technology demonstration units.

• Integration of disaster management plans with development plans of local self-governments.

Importance of Disaster Management

Disasters are events that have a huge impact on humans and the environment. Disasters are inevitable, we cannot do anything to prevent these, but disaster preparedness is only in our hand. Disasters management requires government intervention and a proper planning as well as funding. It is not necessary that these disasters are always unpredictable. Floods take place in valleys and floodplains, droughts in areas with unstable and low rainfall, and oil spills happen in shipping lanes. This predictability provides opportunities to plan for, prevent and to lessen the impact of disasters. Disasters are inevitable although we do not always know when and where they will happen. But their worst effects can be partially or completely prevented by preparation, early warning, and swift, decisive responses.

Disaster management aims to reduce the occurrence of disasters and to reduce the impact of those that cannot be prevented. The government White paper and Act on Disaster Management define the roles of Local Authorities as well as Provincial and National government in disaster management. Disaster management forces come into action as soon as a disaster strikes and help in the relief, rescue and rehabilitation process. These are trained individuals and are given extensive training to perform in the event of a disaster or a natural calamity and they work as a team to reduce the loss of life and helping the locals getting back to normal life