RRB JE

RAILWAY RECRUITMENT BOARD

CIVIL ENGINEERING

ENVIRONMENTAL ENGINEERING

SELF STUDY MATERIAL

CIVIL ENGINEERING FOR ALL

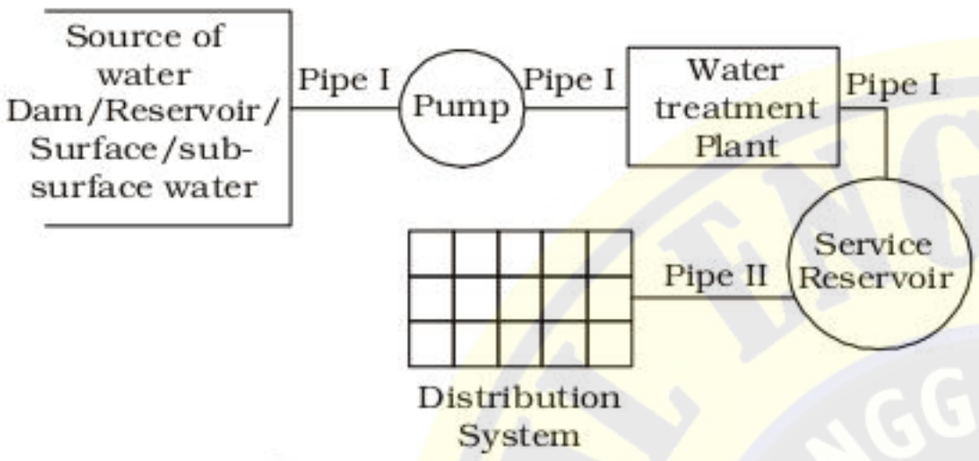
ENVIRONMENTAL ENGINEERING

RAW WATER ENGINEERING

- **RAW WATER :**

The water which is extracted from natural environment, over which no artificial treatment is being performed is knoun as row water.

- **POINTS TO BE DISCUSSED :**



– Source of water.
– Quality of water.
– Treatment of water.
– Conduits Required for transportation of water.
– Water Demand & Distribution System.

1. **SOURCES OF WATER :** There is a long list of sources of water, being classified as natural sources or mankind sources such as dam, desalination plants, etc.
2. **QUALITIES OF RAW WATER :**

– The parameters which helps in determining the characteristic of water is called Water quality parameters. The parameter are generally of three types.

– Physical, Chemical & Biological parameters.

- **Physical water Quality Parameter :**

– The parameter which helps in determining the physical quality of water is termed as physical water quality parameters. These are the parameter which can be felt or sensed by any of our senses.

(i) Suspended Solid
(ii) Turbidity
(iii) Colour
(iv) Taste
(v) Odour
(vi) Temperature

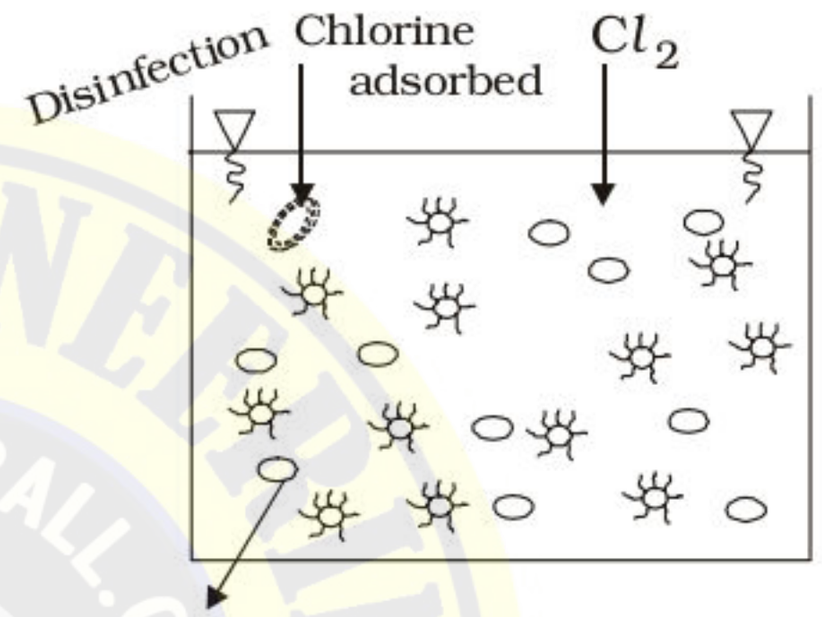
(i) SUSPENDED SOLIDS : (SOURCE)

– It may be added in water due to inorganic particles like, clay, silt, sand, glass, egg shells, etc, or it may come in water due to organic particles like plant fibres, algae & planktons or they may also be added in the water such as immissible liquid like oil & grease.

Note : Suspended solid is a physical water quality parameter but dissolved solid is chemical quality parameter.

– **Carbon** is present in organic particles & hence can be decomposed by any micro-organism (Biological activities) & this is known as biodegradable disc, it is non-biodegradable.

Whereas in inorganic matter no carbon is present hence cannot be decomposed by micro-organism.



Adsorbed micro-organism

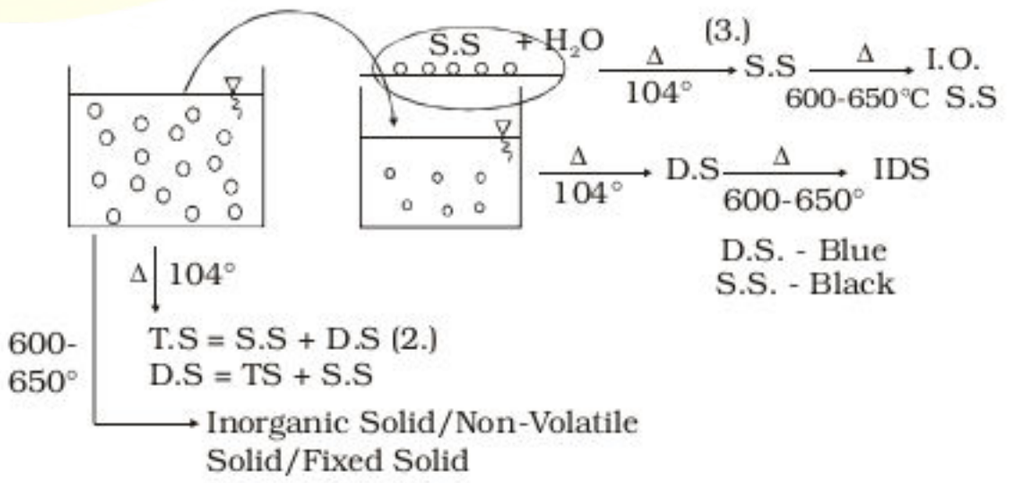
Type of absorption that occurs only on surface.

Chlorine provided for disinfection is adsorbed by S.S. decreasing the efficiency of chlorine (reagent).

Suspended Solid Impact :

1. It's presence induces Psychological effect as it makes the water aesthetically displeasing.
2. If suspended solid are biological in nature, it may lead to the infections and diseases.
3. Suspended solids provides adsorption sites for chemical & biological reagents, thereby reduces the efficiencies of treatment of the water. (Eg: Disinfection).

MEASUREMENT OF SUSPENDED SOLIDS :



Organic Solids = T.S – I.S
(Volatile nature)
O.D.S = O.S – O.SS.
IDS = I.S – ISS

1. Suspended solids presence in water is determined by graviometric method. [These are the methods in which weight of the unknown parameter is calculated to determine its quantity].
2. T.S. in water can be determined by simply heating it at 104°C & recording the weight of retained solids.
3. Suspended solid in water can be determined by passing the water through three filter & heating the residue left over the filter at 104°C.
4. In Organic solids (Both in total & suspended form) can be determined by heating the original water sample & residue left over the filter at 600°C – 650°C respectively.
5. At this temperature, O.S gets converted into water vapour & CO_2 leave behind the inorganic solid (non–volatile or Fixed solid).

PERMISSIBLE LIMIT :

Acceptable / Permissible limit	Cause of Rejection value / limit
500 mg/*l*.	2000 mg/*l*.
T.S. (permitted)	= [D.S + S.S]

Note : Suspended solid matter smaller in size than the filter pores gets measured as dissolved solid. Hence to avoid this, classification of the solids is done as **filterable & non-filterable solids** when non filterable solids corresponds to dissolved solid and filterable solid corresponds to suspended solid.

T.S = S.S + D.S.

S.S $_{600-650\ C}$ ISS

D.S $_{600-650\ C}$ IDS

O.S = T.S – I.S

IDS = IS – ISS

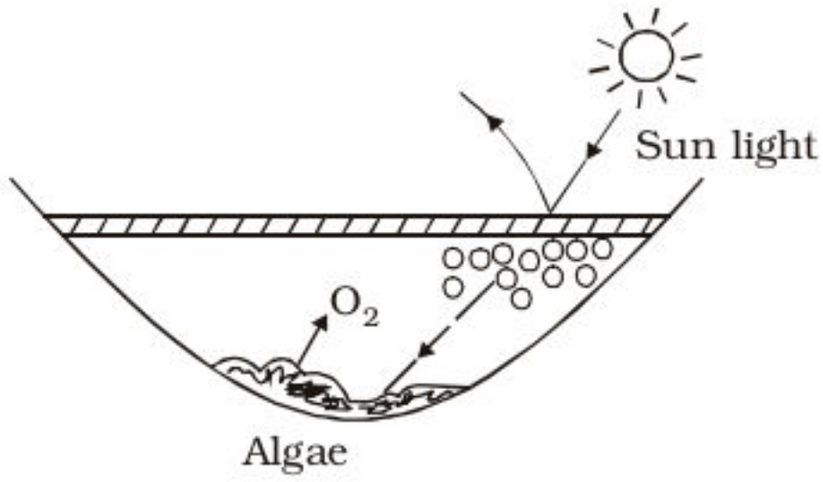
water sample $_{600-650\ C}$ I.S

O.DS = O.S – I D S

(ii) TURBIDITY :- (Cause is presence of colloides)

- It is the measure of extent to which light is either adsorbed or scattered by the suspended solid present in it.
- It is not the direct quantitative measure (mathematical relation) suspended solid present in water.
- **IMPACT OF TURBIDITY (Impacts of Suspended solid matter) :**

1. It interfers with the penetration of the sunlight in natural water body, thereby, affecting the survival of aquatic animals.



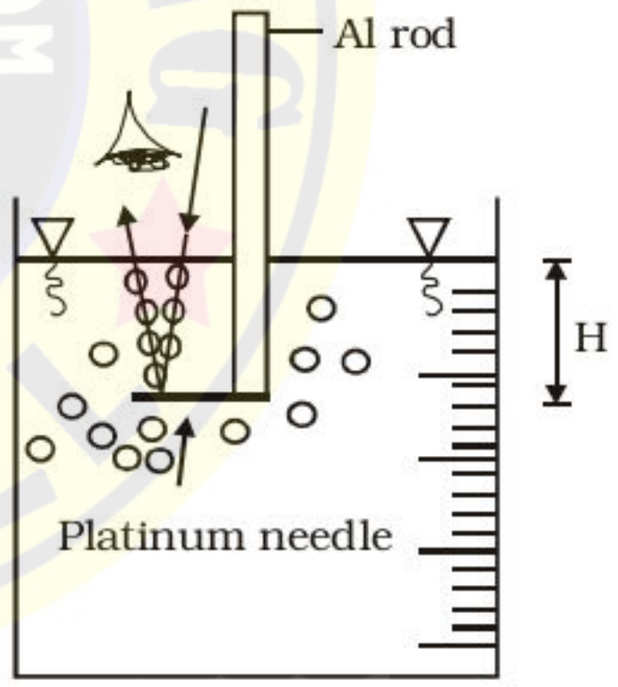
Due to presence of suspended solid (colloids) penetration of sunlight in water bodies is not possible & no photosynthesis can be performed. Hence, no oxygen is released, leading to deficiency of oxygen which is essential for the, aquatic life survival.

MEASUREMENT :

1. Turbidity Rod Method.
2. Jackson Turbidimeter reflective index & so, it is easily visible.
3. Baylis Turbidimeter &
4. Nephlometer

1. Turbidity Rod method :

1 mg of silica per litre.



It is a field method in which an aluminium rod having a platinum needle at its tip is inversed in the water sample & the height at which this needle becomes invisible is noted to give the turbidity of the water in standard units which is obtained by addition of 1mg of silica in powdered form as SiO_2 (Silicon dioxide) also known as Fuller's Earth) in one litre of pure water.

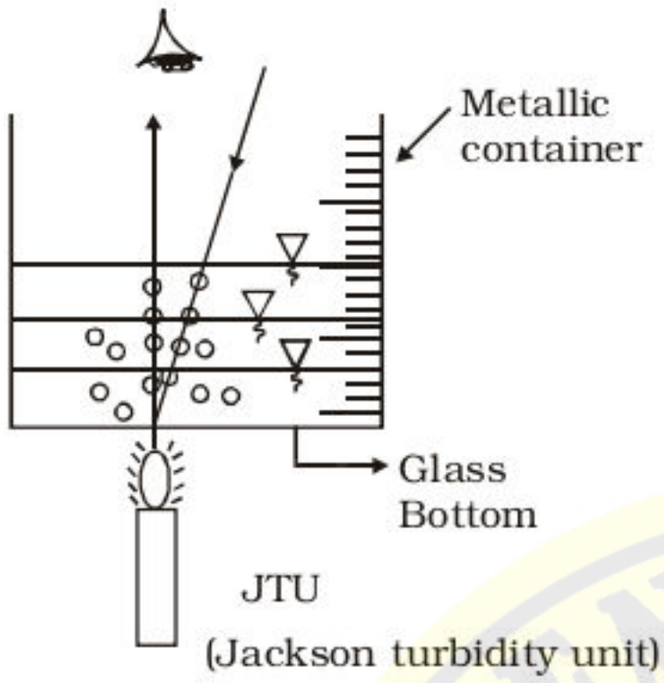
The unit is 1unit / 1mg/l/1ppm/STU (Silica Turbidity Unit).

Note : Turbidity if greater than 5 units can easily be detected by naked eye.

Longer is the length of the path travelled by light, lesser is the turbidity.

2. Jackson Turbidity meter :

– It is the lab method, that can measure the turbidity of the water if it is greater than 25 units. [Turbidity due to 25 mg of silica in 1 litre of water].



(Jackson turbidity unit)

– Hence, it is not used for testing of the water supplies, but is readily used in testing of the natural water bodies.
– In this method, metallic container with glass bottom is placed over the ignited flame.
– The water whose turbidity is to be measured is poured in the container & the depth at which flame ceases to be seen is noted to give turbidity of the water in standard units.

JTU/STU/mg/l/ppm/units

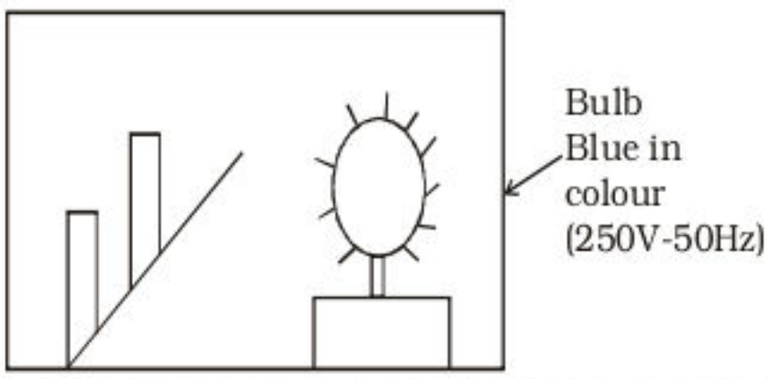
$$1\text{ppm} = \frac{1}{10^6}$$

$$1\ \text{mg}/l = \frac{1}{1000}\ \text{gm}.\ \frac{1}{1000}\ \text{ml} = \frac{1}{10^6}\ \frac{\text{gm}}{\text{ml}}$$

Note : The principle involved in both the above tests is same, i.e. longer is the length of the path travelled by the light, smaller is the value turbidity & vice - versa.

3. Bacylis Turbidimeter & Nephelometer :

– Both the above methods are based upon colour matching techniques. These methods can measure the turbidity of **less than one unit** hence, are readily used in the testing of water supply.



– In this method, colour produced in the test & standard sample is matched, after passing the lights through them from standard source. [Bulb; Blue in colour – 250 V & 50 Hz].
– If the colour observed in test sample is same as that of standard sample, then the turbidity of the test sample is equal to that of standard sample.
– In order to improve the effectiveness of this method, intensity of current is measured instead of intensity of colour with the help of photometer (semiconductor) placed along the test sample.
– Photometer is a device which produces current when light is incident on it.
– In Baylis turbidity meter (Base is silica), the intensity of light is measured in the direction of incidence only, whereas in Nephlometer intensity of light is measured at right angles to the direction of incidence. Hence, Nephlometer is based upon scattering principle & Baylis turbidity meter is based upon absorbtion principle.
– In Nephlometer, turbidity is expressed in standard unit which is obtained by addition of 1 mg of Formazine (Hexamethylene). Tetraniline as base instead of silica in 1 litre of pure water. Hence, this unit is also known as most appropriate **FTU** (Formazine Turbidity unit).

Principle NTU (Nephlometer Turbidity unit)
PPM
mg/l
Unit
Farmazine is used because it provides better scattering of light as compared to silica.

PERMISSIBLE LIMIT :

	Permissible / acceptable limit		Cause of Rejection Value / limit
Turbidity	—	1 NTU	10 NTU

(iii) COLOUR:
- TRUE COLOUR (D.S)
- APPARENT COLOUR (S.S + D.S)

Impacts of suspended solid :-

1. It has a psychological effect & makes the water asthetically displeasing.
2. Coloured water cannot be used for washing & dying of clothes.
3. Certain colour causing organic compounds increases chlorine demand.

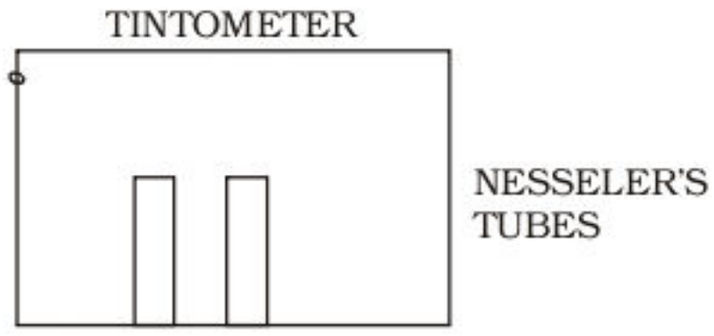
   As chlorine is a strong oxidizing agent it carries out the oxidation of organic matter present in water, thereby reducing the availability of chlorine for disinfection.
4. Certain colour causing compounds reacts with chlorine to form carcinogenics [compounds capable of causing cancer].
5. Certain colour causing organic compounds reacts with chlorine to induce taste & odour in water.

MEASUREMENT :

1. The intensity of colour is measured with the help of colour matching technique & is expressed in the standard unit which is obtained by addition of 1mg of Platinum in chloro platinate ion form in one litre of pure.

This unit is termed as TCU [True colour unit].

2. The testing of colours is done in the apparatus known as Tintometer using Nesseler's Tubes.



3. The testing of colour should be done within 72 hours of the collection of the water sample as with increase in storage period colour intensity change, due to biological activities.

LIMITS :

	Acceptable limit	Cause for rejection limit
Colour.	5 TCU	25 TCU

(iii) TASTE & ODOUR :

1. Taste & odour in the water may be induced due to the presence of mineral salts or due to the presence of organic matter in the water.

   Eg : Algae secretes severals types of oil which add load taste to the water.

2. Taste & odour may also be due to the presence of dissolved gases.

   Eg : H_2S adds rotten egg smell to the water.

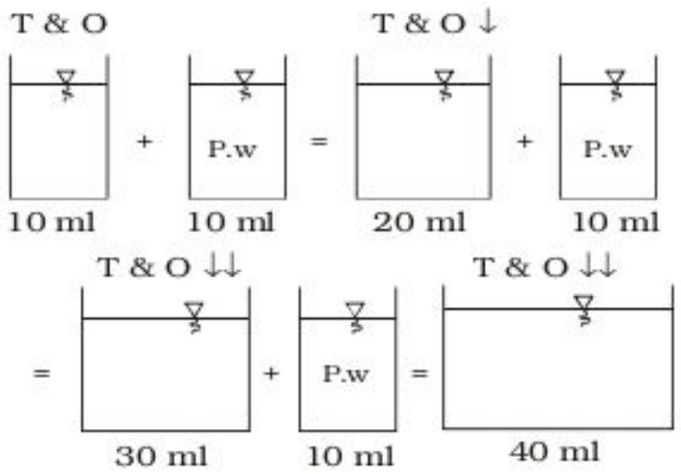
   CO_2 add carbonated stingy taste to the water.

IMPACTS.

1. Taste & odour causing compounds may be Carcinogenic. (Cancer causing)

MEASUREMENTS;

1. The intensity of taste & odour is measured by diluting the water sample upto an extent, taste & odour is hardly detectable & the result is expressed in standard unit **TON** [Threshold odour Number]. It signifies the dilution ratio at which taste & odour is hardly detectable.

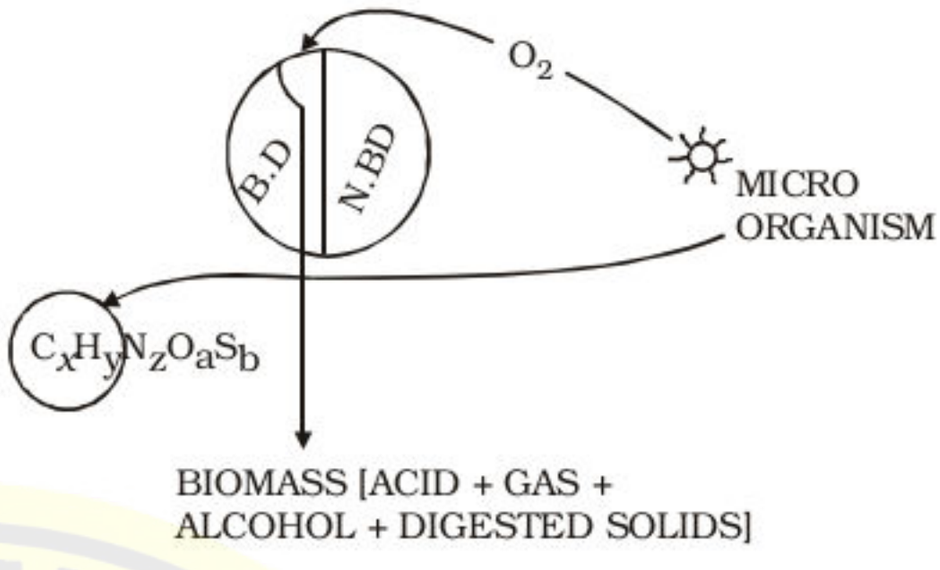


$$\therefore \text{TON} = \text{D.R} = \frac{\text{Final Vol}}{\text{Initial Vol}} = \frac{40}{10} = 4$$

– Instrument for measurement of Taste & odour of water is known as osmoscope.

2. Testing of taste & odour should be done at normal temperature condition (NTP).

BIOLOGICAL ACTIVITY :



$$\text{Temp} \uparrow \xrightarrow[\text{Limit}]{\text{Permissible}} \text{Biological activity} \uparrow \Downarrow \text{Micro-organism} \times 2$$

$$2 \times (\text{Biomass}) \leftarrow \frac{1}{2}\left[\begin{matrix}\text{Organic}\\ \text{matter}\end{matrix}\right] \leftarrow \left[\overline{O_2}\ \text{content}\right] \times \frac{1}{2}$$

With increase in temperature, biological activities increases due to increase in tendency of the micro-organisms of utilizing carbon from organic matter.

LIMITS :	Acceptable limit	Cause of rejection
Colour	**1 TON** (No dilution of collected sample)	**3 TON** (2 times of dilution)

(iv) TEMPERATURE :

With increase in temperature rate of both chemical & biological reactions increases [within limit].

- An average increase of 10°C of temperature almost doubles the biological activities.
- The normal temperature range for water supplies varies between 10°C to 25°C.

Increase in temperature should be within the limit.

- **Chemical water Quality Parameter :**

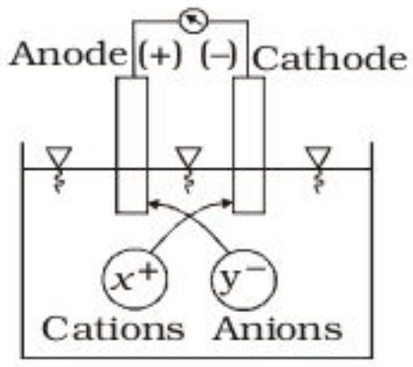
- Dissolved solids
- Alkalinity
- pH
- Hardness
- Gases
- Chlorine content
- Nitrogen content
- Fluoride content
- Metals content

(i) DISSOLVED SOLIDS :

1. An approximate analysis of TDS can be done by determining the electrical conductivity or specific conductance of the water.

   [commonions : Na^2 , mg^2 , Cl^- ,

   SO_4^{2-} , NO_4^{2-} , CO_3^{2-} , HCO_3^-]



2. Electrical conductivity of the water is due to the movement of the solids that are present in ionic forms. Hence, this method does not accounts for those organic dissolved solid which are not present in ionic form. Thereby indicating the concentration of TDS, less than the actual value.

$$\left[\left(\text{Electrical conductivity in } \frac{\text{mho}}{\text{cm}} \text{ at } 25\ C\right)\right] \times 0.65$$

= Total dissolved solids in mg/*L*

3. The instrument used on the basis of electrical conductivity for the measurement of TDS is known as **Di-ionic tests.** It measures the concentration of common ions present in the water.

(ii) ALKALINITY :

– It is the measure of ability of the water to neutralize the acids or it may also be defined as concentration of the ion present in the water that reacts with hydronium ion (H_3O^+) to neutralize it.

CO_3^{2-}, HCO_3^-, OH^-, **(major constituents)**

HS^-, HPO_4^-, $HSiO_3^-$ **(minor constituents)**

Alkalinity can be
Bicarbonate Alkalinity → presence of HCO_3
Caustic Alkalinity → presence of OH

Note : For all the practical purposes, alkalinity due to minor constituent can be neglected because their concentration is very less.

– Phosphorous gets added in the water due to the use of fertilizers, insecticides and detergents. It is the prime pollutant of the **lake** as it serves as a nutrient for algae, resulting in the growth of algae in the lakes thereby polluting them (algal-bloom).

SOURCES :

1. Alkalinity in the water can be induced due to the presence of mineral salts or due to the decomposition of biological solids in the water or due to the presence of dissolved gases in water.

OCCURENCE OF ALKALINITY IN WATER :

$$CO_2 + H_2O \rightleftharpoons H_2CO_3$$

$$H_2CO_3^- \rightleftharpoons HCO_3^-$$

$$HCO_3^- \rightleftharpoons HCO_3^{2-}$$

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

Note : The last reactions is a very weak reaction but of value to algae present in the water, it consumes HCO_3^- (bicarbonate ions) [as it contains carbon which acts as a source of energy for algae leading to the accumulation of OH^- in the water which results in increased alkalinity of the water Hence, if algae is present in water, pH of water will be in the range of 8 to 10].

IMPACT :

1. If alkalinity is present in water ; then the prime objection of alkalinity is that it leads to incrustation in pipe.
It is the process in which precipitate present in the water gets settled over the surface of the pipe thereby reducing the area of slope in these pipes which results a decrease in discharge carrying capacity of the pipes.

Reactions of incrustation:

$$Ca^{2+} + CO_3^{2-} \longrightarrow Ca\,CO_3 \downarrow$$

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

$$Mg(OH)_2 \rightarrow CO_2 \rightarrow MgCO_3$$

$MgCO_3$ is soluble in water

$$Fe^{3+} + 3OH^- \longrightarrow Fe(OH)_3 \downarrow$$

2. Alkalinity in water induces bad taste in it.

DISTRIBUTION SYSTEM

General Introduction :

After the water has been properly treated and mode safe and whole some, it has to be supplied to the consumers in their individual homes. The water has therefore to be taken from the treatment plant to roads and streets in the city, and finally to the individual was houses. This function of carrying water from the treatment plant to the individual homes is accomplished through a well planned distribution system. A distribution system may, therefore, consist of pipe lines of various sizes for carrying water to the streets; values for controlling the flow in the pipes, hydrants for providing connections with the water mains for releasing water during fires; meters for measuring discharges; service connections (called services) to the individual homes; pumps for lifting and forcing the water into the distribution pipes, distribution pipes, etc. Further, the water may be supplied to the public either continuously for all the 24 hours of the day or it may be supplied intermittently during certain fixed hours of the day, Also the water may either be pumped directly into the distribution pipes; or it may first be stored in a distribution reservoir and then fed into the distribution pipes.

Requirements of Good Distribution System-

The various requirements for proper functioning of a distribution system are-

(i) It should be capable of supplying water at all intended places within the city with a reasonably sufficient pressure head.

(ii) It should be capable of supplying the requisite amount of water for fire fighting during such needs.

(iii) It should be cheap with the least capital construction cost. The economy and cost of installating the distribution system is very important factor, because the distribution system is very important factor, because the distribution system is the most costly item in the entire water supply scheme. So much so, that it gobbles up, upto about 70% of total cost of the scheme.

(iv) It should be simple and easy to operate and repair, thereby keeping the RMO cost and troubles to the minimum.

(v) It should be safe against any future pollution of water. This aim may be achieved by keeping the water pipe lines above and away from the sewerage and drainage lines by sufficient amounts and also by improving the general sanitary conditions of the area through which the distribution pipes have to pass.

(vi) It should be safe as not to cause the failure of pipe lines by bursting etc.

(vii) It should be fairly water-tight as to keep the "losses due to leakage" to the minimum.

Arrangement of Distribution pipes and other Accessories-

The distribution pipe system consists of supply mains, sub mains branches and laterals; usually made of cost iron and jointed by means of spigot and socket joints. The service connections are made of galvanized cost iron pipes. These water mains and sub mains are usually laid sloping from the high level to the low level areas, So as to achieve the maximum advantages of the available head, and thus to keep their sizes minimum.

The distribution pipes are generally laid on one side of the roads and the streets, usually below the footpaths and at 2 m above (i.e, Vertically) and 3 m away (i.e, horizontally) from the sewers so as to avoid any future contamination of water through the leak joints. Generally sewer lines run on one side of the streets and water pipes run on other sides of the streets.

The sizes of the distribution pipes mainly depends upon the amount of flow to be carried, and the permissible loss in the pressure head. The methods of solving the pipe networks for determining their sizes shall be very vast for this stage. It may however be mentioned here that the smallest lateral should normally be not less than 8 to 10 cm in diameter; and if it has to supply water to a fire hydrant, it should be at least 15 to 20 cm in diameter.

Note: Laying the pipes below the footpaths instead of laying them below the carpeted roadway helps in easy excavation during repairs.

Layouts of Distribution Networks-

The distribution pipes are generally laid below the road pavements, and as such their layouts will generally follow the layouts of the roads. There are, in general four different types of pipe networks; any one of which, either singly or in combinations, can be used at a particular place depending upon the local conditions and orientation of roads. There systems are

(i) **Dead and System**- This system is also sometimes called Tree system. In this there is one main supply pipe, from which originates a number of submain pipes (generally at right angles). This type of layout may have to be adopted for older towns which have developed in a haphazard manner, without properly planned roads. The advantage of this system are that" the distribution network can be no solved easily and it is possible to easily and accurately calculate the discharge and pressure at different points in the system.

(ii) **Grid-Iron system**- In this system which is also known as interlaced system or Reticulation system, the main, sub mains and branches are all inter-connected with each other. In fact in a well planned city or a town, the roads are generally developed in a grid-iron pattern and the pipe lines in such placed can follow them easily. This system has been used in Chandigarh. The advantages of this system are- Since the water reaches at different places through more than one route, the discharge to be carried by each pipe, the friction loss, and the size of the pipe, therefore get reduced.

(iii) **Ring system**- This system is also sometimes called circular system. In this system a closed ring, either circular or rectangular of the main pipes, is formed around the area to be served. The distribution area is divided into rectangular or circular blocks and main water pipes are laid on the periphery of these blocks.

(iv) **Radial system**- It a city or a town having a system of radial roads emerging from different centres, the pipe lines can be best laid in a radial method by placing the distribution reservoirs at these centres. In this system water is therefore taken from the water mains, and pumped into the distribution reservoirs placed at different centres.

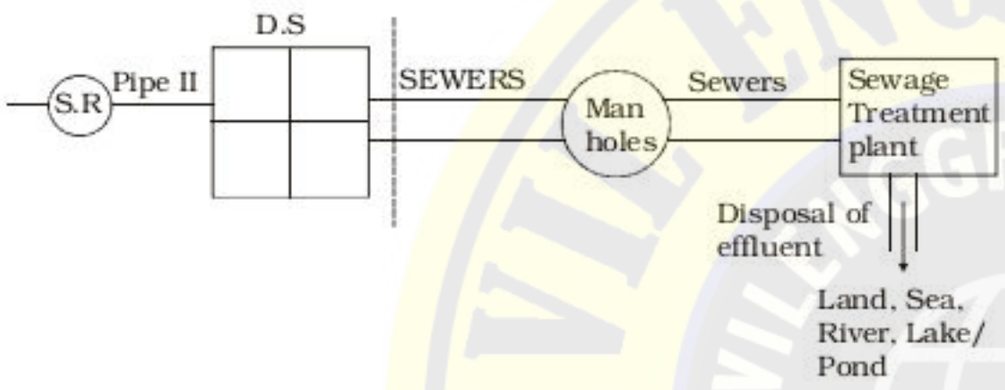
Methods of Distribution- The main object of a distribution system is to develop adequate water pressures at various points of the consumer's taps. Depending upon the level of the source of water and that of the city, topography of the area and other local conditions and considerations the water may be forced into the distribution system in the following three ways-

(i) **Gravational system**- In this system, the water from the high levelled source is distributed to the consumers at lower levels by the mere action of gravity without any pumping.

(ii) **Pumping system**- In the pumping system, the treated water's directly pumped into the distribution mains without storing it anywhere. For this reasons this system is also sometime called pumping without storage system.

(iii) **Combined Gravity and pumping system**- In this system, the treated water is pumped at a constant rate and stored into an elevated more action of gravity. Sometimes the entire water is first of all pumped into the distribution reservoir and many a times, it is pumped into the distribution mains and reservoirs, simultaneously. This method thus combines pumping as well as gravity flow and is sometimes called pumping with storage system.

WASTE WATER ENGINEERING



I. Qualities of Waste Water :

Sewage is generally of 3 types :

i) Domestic sewage

ii) Industrial sewage

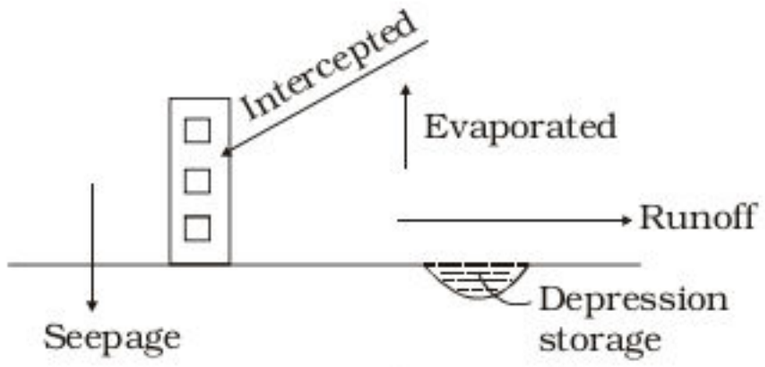
iii) Drainage — Runoff, Storm water

Waste water originated due to domestic activities is termed as domestic sewage and that due to Industries is termed as Industrial sewage.

Note : 1. Mixture of Industrial and domestic sewage is termed as sanitary sewage.

2. Kitchen and bathroom waste is collectively known as sullage.

Drainage is waste water originated due to rain storm



Note : Drainage S.D is 25 times of sanitary S.D.

In partially separate sewerage system, some amount of drainage specially originate from the roof and paved courtyard is allowed to mix with the sanitary sewage.

About 80% of the water supplied in the city get converted into the sewage (20% of water lost any how).

Sewage consisted of both organic solids and Inorganic solids.

O.S may be biodegradable or non-biodegradable

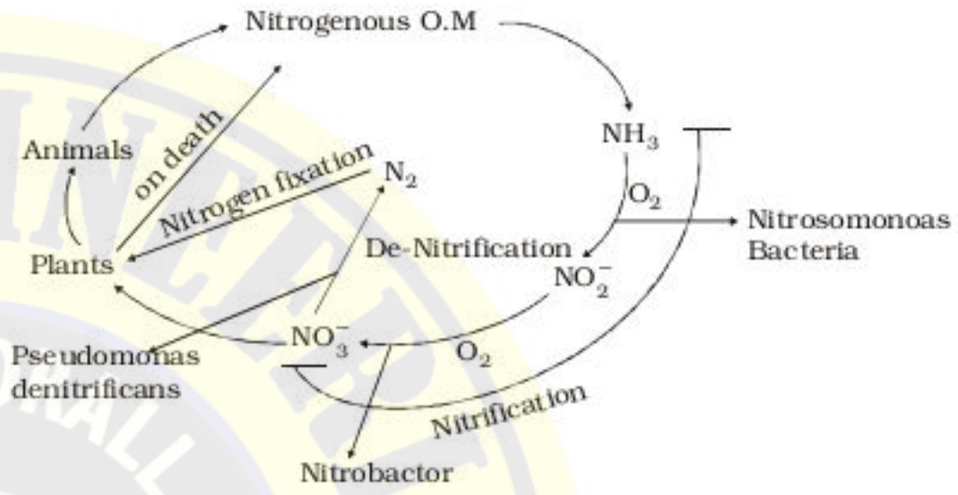
Biodegradable organic matter is that can be decomposed by the action of micro-organism in presence or absence of oxygen.

In presence of oxygen → aerobic process

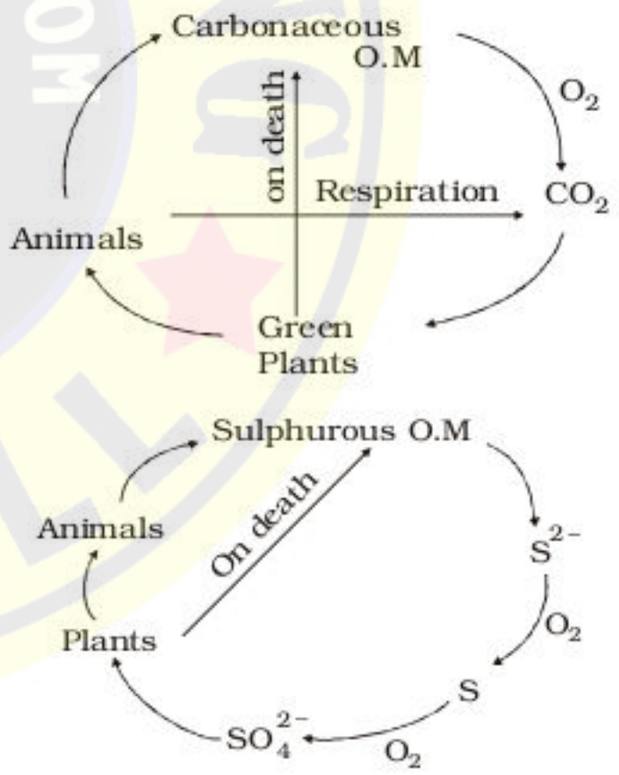
In absence of oxygen → anaerobic process

Depending upon the method of decomposition of organic matter treatment of waste water is carried.

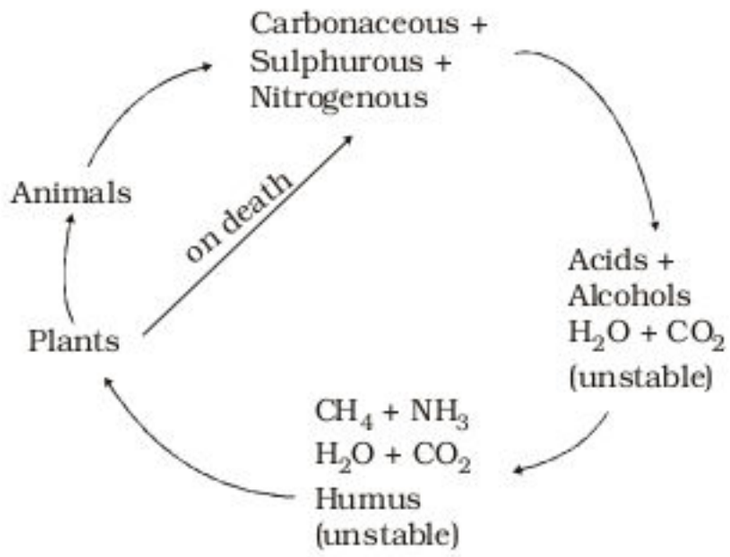
Aerobic Method : NITROGEN CYCLE



CARBON CYCLE :



Anaerobic process :



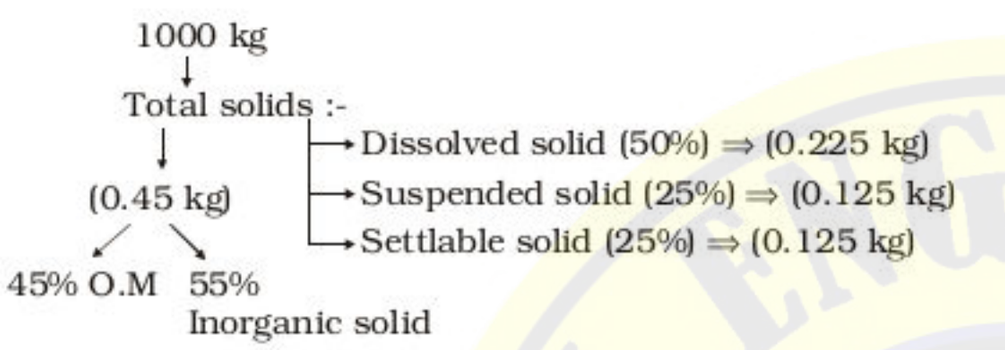
◆ Treatment Method based on Anaerobic process of decomposition of organic matter:-

1. Septic tank
2. Runoff tank
3. Upflow Anaerobic Sludge Blanket Reactor (UASBR)
4. Anaerobic lagoons

◆ Treatment method Based on Aerobic Decomposition of Organic Matter :

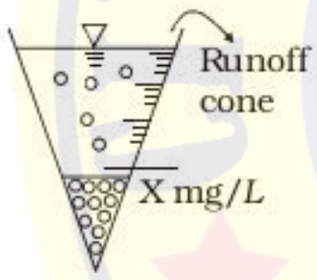
1. Trickling Filters (T.F.)
2. Activated Sludge Process (A.S.P)
3. Rotated Biological Contractor (R.B.C)
4. Oxidation Pond (O.P.)

◆ **Physical Sewage Quality Parameter :**



◆ **Settlable Solid :**

If the sewage is allowed to stand in the runoff concentration for 2 hrs, the quantity of solids settled in it is termed as settlable solids.



Sewage contains more than 99.9% of water and less than 0.1% of solid, such that in 1000 kg of sewage 0.45 kg of total solids are obtained.

3. THEORETICAL OXYGEN DEMAND (ThOD)

If the exact formula and organic matter concentration is known then amount of oxygen required for its decomposition can be computed theoretically and termed as ThOD.

Eg : 300 mg/L (concentration of O.M) $\rightarrow C_6H_{12}O_6$ (Formula of O.M)

$\therefore\ C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2\uparrow + 6H_2O$

1 mole 6 mole

180 gm 192 gm

$\therefore$ 180 g of glucose is decomposed by 192 gm of O_2

1 g of glucose is decomposed by $\frac{192}{180} = 1.06$

300 mg/L of glucose is decomposed by 1.06×300

= 320 mg/Litre

= Th OD

Eg :

100 mg/l

$CH_4 + 2O_2 \rightarrow CO_2\uparrow + 2H_2O$

1 mole 2 mole

16 gm 64 gm

16 gm of CH_4 requires 64 gm of O_2

1 gm of CH_4 requires $\frac{64}{16} = 4$ gm

100 mg/L of CH_4 requires $4 \times 100 = 400$ mg/l of O_2

= ThOD

◆ **Chemical Waste Water Quality Parameter**

1. Dissolved Oxygen (D.O)

At a particular temperature maximum quantity of O_2 which may be present in water is termed as saturation dissolved oxygen.

Any deficiency in the oxygen with respect to its saturation value indicates the Biological activity in the water.

At any temperature minimum oxygen present in the water for survival of fishes is 4 ppm.

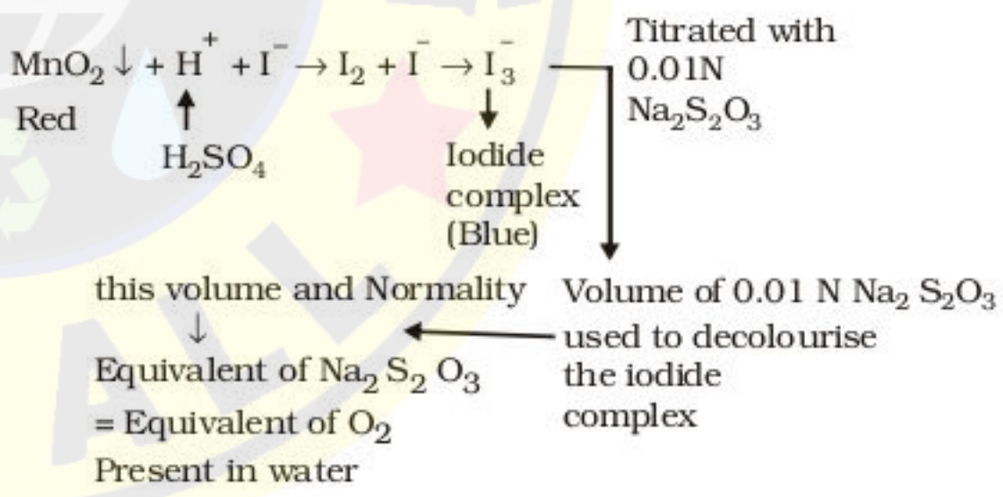
Dissolved oxygen in water is determined using the Wrinkler's method.

◆ **WRINKLER'S METHOD :**

Water sample + $MnSO_4$ + (NaOH + KI) $\rightarrow$ Mn $(OH)_2$ $\downarrow$ white (No oxidation has taken place) $\rightarrow$ No dissolved oxygen.

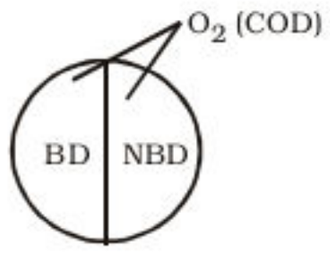
Water sample + $(MnSO_4)$ + (NaOH + KI) $\rightarrow$ $MnO_2\downarrow$(Oxidation of Mn has taken place) $\uparrow$ Red $\rightarrow$ Dissolved oxygen is present

To calculate amount of D.O present in water



2. Chemical Oxygen Demand (COD) :

The amount of O_2 required for decomposition of both biodegradable and non- biodegradable organic matter present in the waste water is termed as C.O.D.



It can be determined by adding $K_2Cr_2O_7$ and H_2SO_4 in the water sample and noting down the amount of oxygen consumed that represents chemical oxygen demand. $K_2Cr_2O_7$ strong oxidizing agent oxidizes organic matter along with the organic materi-

al present in the waste water, resulting in the increased value of chemical oxygen demand. This gives more than actual value to be on the safer side as oxygen calculation also include some decomposition of inorganic matter. Hence, this demand is also referred as dichromate demand.

For all practical purposes COD = ThOD.

4. Total Organic Carbon (TOC) :

It is just another way to express the organic matter present in the waste water in terms of its carbon contents.

Eg ; 300 mg/ l $C_6H_{12}O_6$

1 mole of $C_6H_{12}O_6 \rightarrow$ 6 mole Carbon

180 gm of $C_6H_{12}O_6 \rightarrow$ 72 g Carbon

1 gm of $C_6H_{12}O_6 \rightarrow \frac{72}{180}$ g = 0.4 of Carbon

300 mg/L $\rightarrow C_6H_{12}O_6 \rightarrow 0.4 \times 300 = 120$ mg/L of Carbon

100 mg/L CH_4

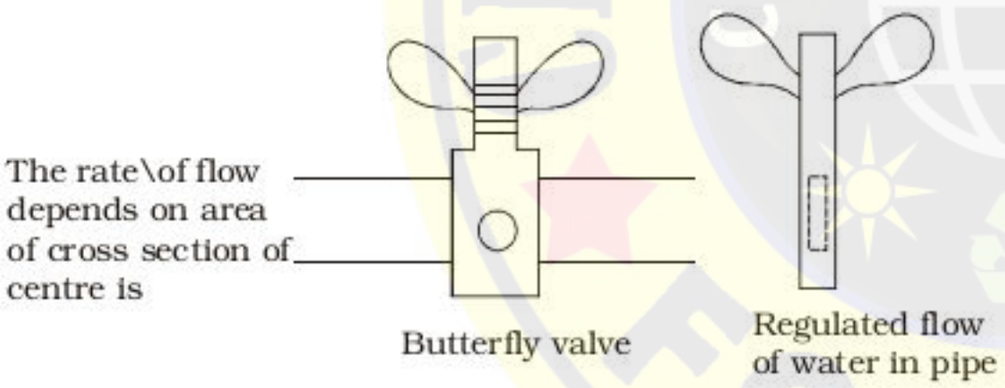
16 mg of $CH_4 \rightarrow$ 12 g of carbon

1 gm of $CH_4 \rightarrow \frac{12}{16}$ g of carbon

100 mg/L of $CH_4 \rightarrow 100 \times 0.75 = 75$ mg/L

Types of gate valve

1. Butterfly Valve

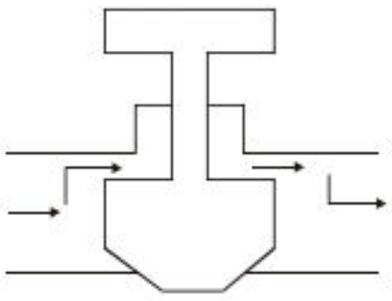


2. Globe Valve

Rotating plate
(it lies in plane of pipe)
→ no flow

Moved $\perp^r$ to the plane
of pipe → flow is allowed

3. Plug Valve



(Maximum losses
takes place)

◆ **Types of Pipe and Conduit in Water supply system**:

i) **Cast Iron Pipe :** These pipes are resistant to corrossion, have long life are highly durable but cannot resist the pressure more than 700 N/m^2. These are generally used for highly durable distribution means .

ii) **Steel Pipe :**
These pipes can take high pressure but cannot resist high load.
These pipes light in weight are generally used for pumping water from stores to treatment plant.

iii) **Galvanized iron (G.I) Pipes :**
These pipes can carry acidic and alkaline water.
All properties of C.I pipe are applicable.

iv) **Reinforced cement concrete (RCC) spun pipes:-**
These pipes can resist high compressive load, corrosion and can withstand high head (can carry water under high pressure).

v) **Asbestos pipe :**
Light in weight, resistant to corrossion and highly flexible hence, no joints are required in laying of these pipes.

vi) PVC pipe are used for individual house hold supply.

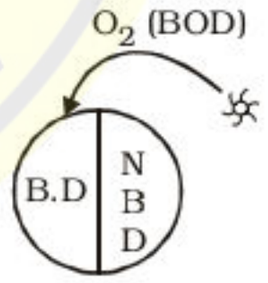
5. BIOCHEMICAL OXYGEN DEMAND (BOD) :

The amount of oxygen required to carry out the decomposition of biodegradable organic matter present in waste water is termed as BOD.

BODs amount of oxygen utilized by 🦠 during total BOD the 5 days during decomposition of organic matter.

BOD during the 5 days and at 20°C is taken as (standard BOD which is approximately equal to 68% of ultimate BOD).

Infinite time → time more than the time required for normal decomposition.

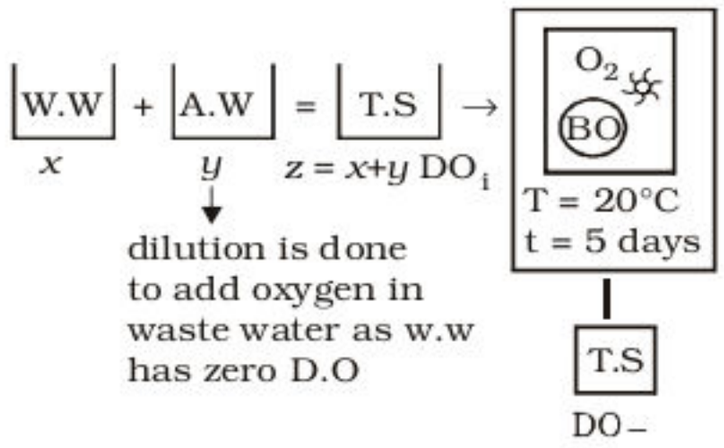


Time consuming process

In domestic waste water, main pollutant is organic matter

∴ By calculating BOD and COD we can find the extent of presence of organic matter in waste water.

Aerated water :



$BOD_5 = (DO_i - DO_f) \times D.F$

$$D.F = \frac{\text{Final Volume}}{\text{Initial Volume}} = \frac{Z}{x}$$

1. B.O.D is determined by diluting the known volume of waste water sample with the known volume of aerated W.S and calculating the D.O. of diluted W.S before and after the incubation of 5 days at 20°C

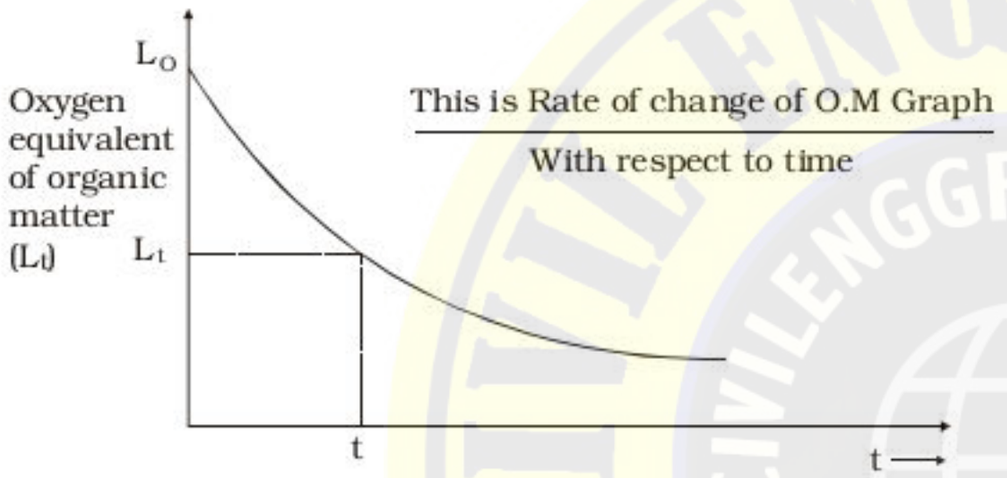
   $\therefore (BOD)_5 = (DO_i - DO_f) \cdot D.F$

   D.F = Dilution factor

2. Normally 300 ml sized water are used (Z = 300 ml) and all the sources of light must be excluded from the incubator in order to avoid the growth of algae in test sample during the incubation.

   It may result in release of oxygen in T.S during photosynthesis.

   If BOD_5 calculated is less with more DO_f, BOD is less. It will harm less in treatment.



So, At any time t ; $\frac{dL_t}{dt} \propto -L_t$

When O.M decreases then rate of change O.M decreases.

Also, O.M decreases with increase in time

i.e., rate of change of time = (positive)

rate of change of O.M = (negative)

So, $\frac{dL_t}{dt} = -K L_t$

$$\int_{L_t = L_o}^{L_t = L_t} \frac{d L_t}{L_t} = -k \int_{t=o}^{t=t} dt$$

$$ln \left| l_t \right|_{l_o}^{l_t} = -K_t \Rightarrow ln \left(\frac{L_t}{L_0} \right) = -K_t$$

$$2.303 \log_{10} \frac{L_t}{L_0} = -K_t \Rightarrow \log 10 \frac{L_t}{L_0} = \frac{-K.t}{2.303}$$

$$\therefore \frac{K}{2.303} = K_D \Rightarrow K_D = 0.434K$$

$\therefore L_t = L_0 e^{-Kt}$ or $L_t = L_0 \, 10^{-K_D t}$

$\therefore (BOD)_t = L_o - L_t$

$= L_0 - L_0 e^{-Kt}$ or $L_0 - L_0 \, 10^{-K_D t}$

$\therefore$ Initial O_2 required for decomposition of O.M = 10

at time t, O_2 required for decomposition of O.M = L_t.

$\therefore (BOD)_t = L_0 (1 - e^{-kt})$ (or)

$(BOD)_t = L_0 (1 - 10^{-k_D t})$

where, K and K_D = deoxygenation constant at base e and at base 10 respect, which determines the speed of the BOD reaction without affecting the ultimate BOD.

Unit of K or K_D are per day

Ultimate BOD ; t = infinity $t = \infty$

$BOD_u = L_o (1 - 10^{-KD} \cdot \infty)$

$(BOD)_u = L_o$

K, K_D = affects the speed or decreasing rate but not affects $(BOD)_u$.

The values of these constant depends upon the type of organic matter present in the system.

For simple organic matter like sugar, its value is more and like complex organic matter like

Easily decomposible → Rate of BOD is more

Value of $K.K_D$ is more → O_2 required faster though of same amount.

For municipal sewage de-oxygenation constant at base 10 and temperature 20°C for Municipal sewage varies between 0.05 per day to 0.2 per day. Normally, it is taken to be 0.1 per day.

For tap water, it is less than 0.05 per day

For surface water, it is in the range of 0.05 per day to 0.1 per day.

For untreated sewage, it is in the range of 0.1 per day to 0.15 per day

For treated sewage : 0.05 day^{-1} to 0.1 day^{-1}

With increase in temperature of the system, deoxygenation constant increases as Biological activity speed up with increase in temperature.

$K_{DT^\circ c} = K_{D20^\circ c} \, [1.047]^{T-20}$

But no-effect on $(BOD)_u$

$(BOD_5) = L_o (1 - 10^{-KDt})$

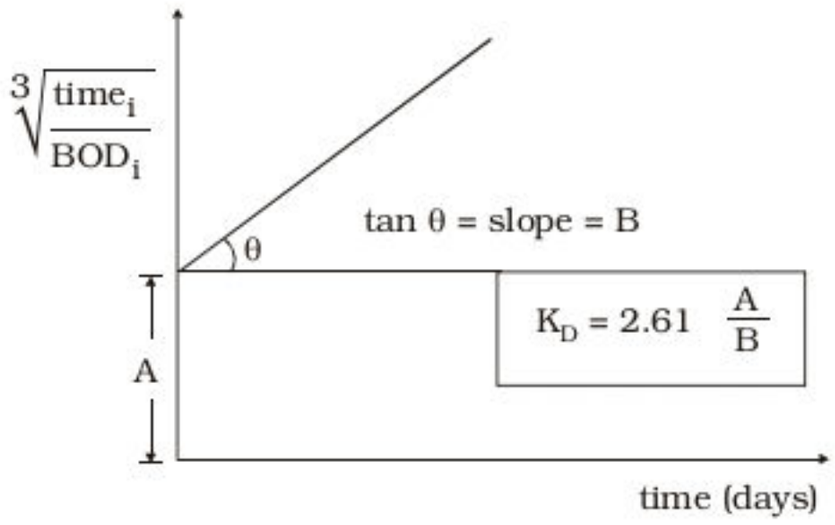
$= L_o (1 - 10^{-0.1 \times 5})$

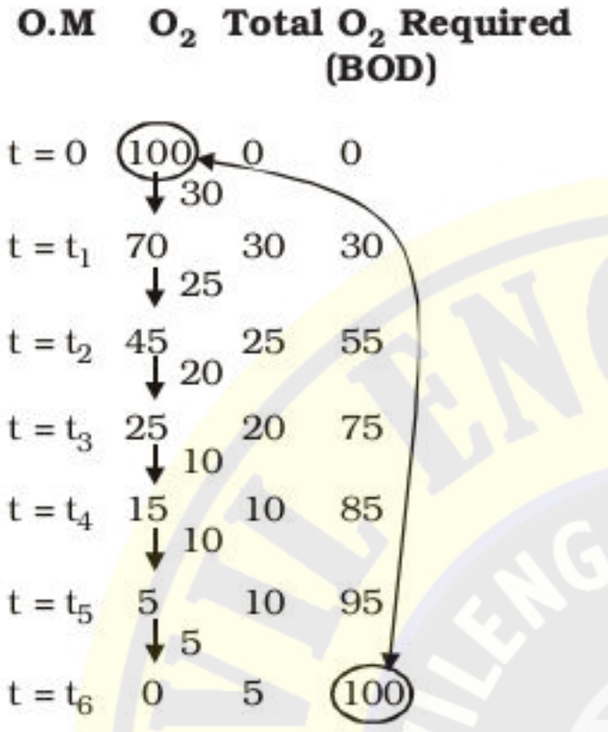
$= 0.68 \, L_o$

$\therefore (BOD)_5 = 0.68 (BOD)_u \Rightarrow (k_D)_{average} = 0.1$ is taken.

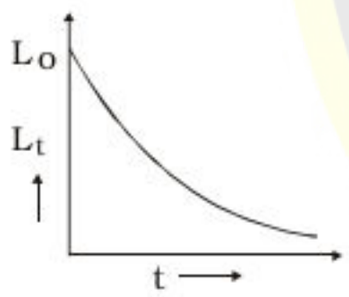
Experimentally deoxygenation constant. (K_D) is determined by following method ;

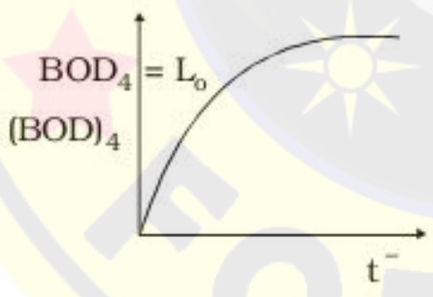
time (day)	DO_i	DO_f	BOD_i	$(DO_i - Do_f)$ D.F
1	DO_i	DO_{f1}	BOD_1	$= L_O (1 - 10^{-K_{D.1}}) = K_D = ?$
2	DO_i	DO_{f2}	BOD_2	$= L_O (1 - 10^{-K_{D.2}}) = K_D = ?$
3	DO_i	DO_{f3}	BOD_3	$= L_O (1 - 10^{-K_{D.3}}) = K_D = ?$
4	DO_i	DO_{f4}	BOD_4	$= L_O (1 - 10^{-K_{D.4}}) = K_D = ?$
⋮	⋮	⋮	⋮	⋮
n	DO_i	DO_{fn}	BOD_n	$= L_O (1 - 10^{-K_{D.n}}) = K_D = ?$



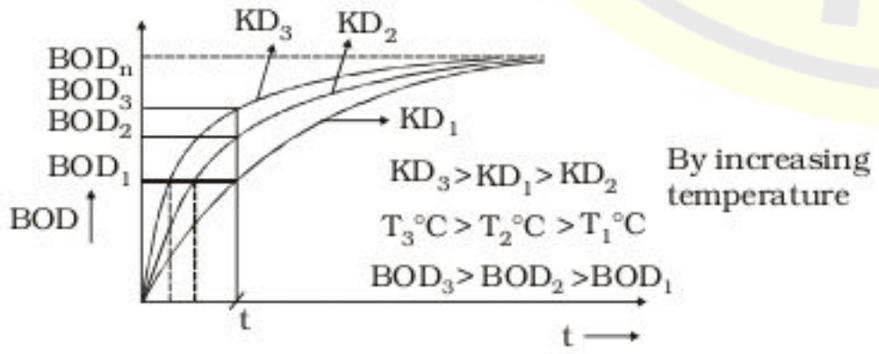


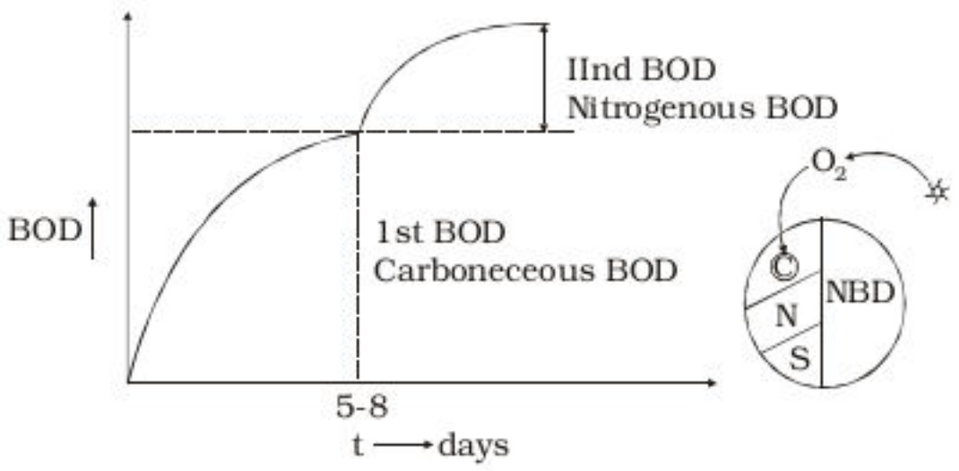
Total O_2 required (BOD)





1st stage BOD curve





Micro-organisms require carbon from the organic matter that serves as the source of energy for them.

Micro-organisms can utilize this carbon from organic carbon or from CO_2.

that utilizes organic carbon are termed as HETEROTROPHS.

that utilizes carbon from CO_2 are termed as AUTOTROPHS.

Conversion of carbon from CO_2 to cellular carbon is a reduction process and requires energy due to which it results in lower cell mass growth of autotrophs.

Carboneous BOD is satisfied by heterotroph.

Nitrogenous BOD is satisfied by autotrophs. Hence, 1st stage BOD is almost satisfied before the utilization of the oxygen by autotrophs for 2nd stage.

BOD of municipal sewage at 20°C varies between 100 – 500 mg/L.

$\frac{(BOD)u}{COD} \leq 1$ or $\frac{BOD_5}{COD} \leq 0.68$

When entire organic matter is Biodegradable then $(BOD)_u = COD$

$\frac{(BOD)u}{COD} = O$ [when entire organic matter is non-Biodegradable]

COD indicates both Biodegradable and non-Biodegradable oxygen demand (O.D).

$\frac{(BOD)u}{COD} > 0.8$ then the waste water can be./reated by Biolocigal method.

$\frac{BOD_5}{COD} > 0.544$ considered easily treatable by Biological methods

$\frac{(BOD)u}{COD} < 0.5$ then waste water cannot be treated by Biological method

$\frac{BOD_5}{COD} < 0.34$

$\frac{COD}{TOC}$ also indicates the quality of the waste water.

It varies between 0 - 5.33

For CH_4, it is 5.3

COD = O for organic matter which cannot be decomposed by $K_2Cr_2O_7$.

SOLID WASTE MANAGMENT

The term solid waste includes all those solid and semi soted materials that are discarded by a community. The solid waste generated through domestic and commercial activities is classified as municipal solved waste (MSW) and is also called "refuse". The solid waste generated by industries is known as industrial solid waste solid waste may also be generated ley agricultural activities, a large portion of which may also become a part of the municipal solid waste. The biochemical solid waste from hospital and nurshing homes, similiary finds entry into the municipal solid waste, though is supposed to be dispossed off seperately. as a hazardous municipal waste. The animal excreta (gobar) and human excreta, also does not stand included in the municipal solid waste, though a portion of this type of semi solid waste may also find entry into the municipal solid waste. In general therefore, the solid waste are usually divided into the following two categories i.e.,

(i) Municipal solid waste, and
(ii) Industrial solid waste.

The municipal solid waste is disposed of by the municipal corporations and such local bodies; while the industrial solid waste is disposed off by the respective industries.

The safe disposal of a solid waste of a society was not a serious problem as long as the pollution was small and the land available for assimilation of wastes was large. However in olden socities, no proper collection and safe disposal practices for getting rid of the solid wastes were in vogue.

MUNICIPAL SOLID WASTE (MSW) :

The municipal solid waste (MSW) is a heterogeneous mixture of various kinds of solid waste which are not transported with water as sewage and may include biodegradable (Putrescible) solid wastes called garbage, and the non-putrescible solid wastes like paper, grass, rags, metal items, etc. called rubish.

The garbage includes all sorts of putrescible (biodegradable) organic wastes obtained from kitchnes, hotels, restaurants etc. All waste food articles vegetable, Pedings, fruits peelings, etc. are thus included in this term.

The rubbish can include a variety of materials, which may either be combustible (such as paper, plastic, textile, etc.) or incombustible (such as broken glass, crockery, metal, masonry etc.)

In addition, the incombustible ashes from household hearth (Chulhas) called ashes, may also stand included in the MSW, atthough its quantity is getting reduced in modern urban homes, due to increasing use of cooking gas. Kerosene oil, stoves and lesser use of cooking coal or firewood. The density of ashes generally varies between 700 to 850 kg/m^3.

The quantity of municipal solid waste produced by a society depends upon the living standards of its residents. The degree of commercialisation, urbanisation and industrialisation infact has resulted in a vast increase in the amount of refuse generated per person. For example, the average per capita daily refuse production in united state is as high as about 2.8 kg; whereas, the figure is only about 0.5 kg in India. That is why a city like Newyork with a population of 20 million produces MSW of about 50,000 tonnes/day; while a city like Delhi with about 15 million population produces MSW of about 6000 tonnes/day.

Table : Average composition and other properties of MSW (Refuse)

S. No	Item/constituent	App. Av. Composition (% age by weight at disposal site)	
		For a typical Indian city	For a typical city of U.S.A.
1.	Garbage	45%	20%
2.	Rubbish (Paper glass rogs, etc.)	15%	50%
3.	Ashes	15%	15%
4.	Fire dust, silt and sand	25%	15%
	Density colorific value in kilo. Joule/kg	400 to 600 kg/m^3 5000 – 6600	100 to 250 kg/m^2 15,000
* Heat, which garbage can generate kl/kg = 0.243 /kg			

Collection and Transportation of Municipal Solid waste (MSW)

In India the refuse is generally collected in individual houses in small containers and from there, it is collected by supers in small hand driven loories, carts, and then dumped into the masonary chambers constructed by the municipalities along roadsides. The refuge is finally carted away by municipal trucks for further disposal during some day time. The method adopted here are highly unsatisfactory and need tremendous improvements and changes. TERI (The energy research institute, previously known as Tata energy research institute) has infact carried out a survey of the efficency of the presently prevailing system of collection of refuse in India, wheirin the following conclusion have been drawn.

It takes anywhere from 3 to 7 days for the solid wastes to be disposed of from the time it is generated. The collection, transportation and disposal of MSW in India are totally labour internsive activities, because modern automated systems are not used. The number of municipal workers employed on these jobs are also short, because of the general policy of goverments to restict employment. As a result on an average, less than three fourth of the MSW is collected.

Disposal of Municipal Solid Waste (MSW) :

Most of the land filling practises adopted in the country are confined only to carrying and dumping the waste rather than adopting the engineered land filling technique, which in future is going to be adopted more and more with advancing technologies and shortage of land filling sites. In general the following scientifically managed methods can be used for disposal of municipal solid waste (refuse) :–

(i) **Sanitary land filling :** This method is also known as controlled tipping. In this method of refuse disposal, refuse is carried and dumped into the low lying area (earmarked as land fill site) under an engineered, operation designed and operated in an enviromentallly sound manner, as not to cause any public nuisance or hazards to public health or saftey.

In this method, the refuse is dumped and compacted in layers of about 0.5m thickness, and after the days work-when the depths of filling become about 1.5 m, it is covered by good earth of about 1.5m, it is covered by good earth of about 15 cm thickness. This cover of good earth is called the daily cover.

Disposal of MSW (Refuse) by Shredding and Pulverisation :

The size and volume reduction of municipal solid waste (MSW) is accomplished by the physical processes of shredding and pulverisation Shredding refers to the actions of cutting and tearing whereas, Pulverisation refers to the actions of crushing and grinding. Shredding and pulverisation crushing and grinding. Shredding and pulverising may help in reducing the overall volume of the original MSW, by as much as 40%. The shredding and pulverising not only helps in reducing the volume of MSW, but also helps in changing and physical Chracter of the waste, which becomes paractically odourless and unattractive to the insects.

The pulverised refuse, though contains fertilizing elements like potash, phosphorus and nitrogenous materials, yet cannot be suitably used as manure. It has, therefore to be further disposed of either by filling in trenches or is digested in open windows or closed digestors.

(iii) **Disposal of MSW (Refuse) by composting :**

compositing of refuse is a biological method of decomposing solid wastes. This decomposition can be affected either under aerobic conditions, or under anaerobic conditions, or both. The final end product is a manure, called the compost or humus which is in great demand in european countries as fertilizer for farms.

Basially, composting is considered to be an aerobic process, because it involves piling up of refuse and its regular turning either manually or by mechanical devices, so as to ensure sufficient supply of air and oxygen during its decompostion by bacteria, fungi and other microoganisms, like antinomycetes.

(iv) **Disposal of MSW (Refuse) by Incineration and Thermal Pyrolysis :**

Burning of refuse at high temperature in furances is called incinerators is quite a sanitary method of refuse disposal and is widely adopted in developed countries like USA, where. He collected refuse is of high calorific value, and is hence quite suitable to burning.

Normally however only the combustible matter such as garbage, rubbish and dead animals are burnt and the in combustible matter like broken glass, chinaware, metals etc. are either left unburnt or are separated out for recycling and reuse before burning the solid wastes. Prior Seperation of such materials will reduce the load on the furances, and shall more than compensate the cost of this separation.

(v) **Disposal of MSW (Refuse) by Barging it out into the sea :**

This method had been used in the past to dispose of refuse by throughing it away into the sea, after caraying it at reasonable distance from the coast (say 16 to 20 kilometers inside the sea) on barges. The sea depth at such disposal point should not be less than 30 m or so, and the direction of the currents should be such as not to bring it back towards the shore. This method may however have a limited use and that too in a few costal town.

INDUSTRIAL SOLID WASTE:-

The solid waste produced by industries can be broadly divided into the following two categories :

(i) Non-hazardous Solid wastes : and

(ii) Hazardous solid wastes.

(i) Non-hazardous solid wastes : The non-hazardous solid wastes generated by various industries can be further sub-divided into the following two categories :

(a) **Biodegradable Wastes :** The major industries in urban areas that generates substantial amounts of biodegradable non-hazardous solid wastes are fruit processing, cotton mills, paper mills, sugar mills, textiles factories etc.

(b) **Non-biodegradable wastes :** The non-biodegradable non-hazardous solid wastes of industries are usually referred to as the industrial solid wastes. They are usually produced by industries like thermal power plants – which produce coal ash; integrated iron and steal plants - which produce blast furance slag and steel melting slag; nonferrous industries like aluminium, zinc, and copper-which produce red mud and tailings; fertilizer and allied industries - which produce blast furance slag and steel melting slag; non ferrous idustries like aluminium, zinc and copper-which

produce phosphogypsum. Together these industries produce huge amounts of wastes in India.

(ii) **Hazardous Solid wastes :** Some of the wastes generated by industries are hazardous to be "hazardous wastes" because they contain substances that are toxic to plants, animals, and humans or are flammable, corrosive, explosive or highly reactive chemically.

The major industries that produce hazardous wastes include metals, chemicals, drugs and pharmaceuticals, leather, pulp and paper electroplating, refining, pesticides, dyes, rubber goods etc.

ENVIROMENTAL SANITATION

Enviromental sanitation which evidently means cleaning of the enviroment therefore, becomes the major task of a public health engineer and this task primarily includes; collection and disposal of refuse and sewage from houses, buildings and other public areas. Provision of sufficent and wholesome air to the buildings and residents for controlling indoor air pollution is also included as a work of enviromental sanitation and hence usually included in the subject of "Public Health Engineering"; more so because it is the wholesome air on which depends the health of the public. under this context we are going to study ventilation of Buildings, although strictly speaking, the topic should normally be covered under 'Building construction".

In a developing country like India, the most important source of indoor air pollution is combustion of domestic fuel (Such as cow dung, wood and crop residues) used for cooking on which 80% (1991 census) of our population relies. It has further been estimated by Indian council of medical Research (ICMR) New Delhi that globally 30 lakh people die every year due to air pollution out of which 18 lakh people die annually due to indoor air pollution (4.96 lakh rural areas and 0.93 lakh in urban areas).

The indoor air pollution has infact been found to be much worse than the outdoor air pollution, since a pollutant released indoor is thousand times more likely to reach the lungs than a pollutant released outdoors.

Definition of Ventilation :

Ventilation may be defined as the art of supplying air to a given space, and also includes the art to remove the old viatiated air from that space.

In order to understand as how a particular space is to be provided with sufficient and wholesome air for its residents, it is necessary to understand as to how a particular space gets affected by, the manner in which it is occupied by humans or living creatures.

Effects of occupancy of a space :

When an enclosed space is inhabited by humans and or animals, etc. the following effects are produced :

(i) Oxygen content of the space reduces

(ii) Carbon dioxide content of space increases

(iii) Temperature of the space increases

(iv) Humidity of space increases; and

(v) Organic matter, and odours in the space increases.

Purpose of Ventilation :

Ventilation as stated earlier, is meant for supply of fresh air and to replace the old hot used up (exhausted) air. The ventilation ensures the removal of bad effects of occupancy of an enclosed space :

(i) by providing necessary oxygen to remove oxygen deficit caused by respiration.

(ii) By removing and diluting CO_2 in the air;

(iii) By lowering down the temperature by removing hot used up air and replacing it by colder fresh air;

(iv) by reducing humidity; and

(v) by reducing body odours.

PLUMBING

The sewage produced in houses and buildings has to be conveyed and connected to the municipal sewers by the oweners of the houses. The provision and construction of an efficient plumbing system for collection and movement of the sewage produced in the building till it is carried and discharged into the nearest municipal sewer, is an important aspects of building construction.

Functions and Types of Traps being used in Sanitary Plumbing Systems :

Traps may be defined as fittings, placed at the ends of the soil pipes or the sullage pipes (Waste pipes) to prevent the passage of foul glass from the pipes to the outside. This is possible because traps to enclose or maintains water seal between the pipe and the outside. This water depth does not allow gases to escape to the outside of the pipe. The efficency and effectiveness of a trap will depend upon the depth of the water seal. Greater is this depth, more effective the trap will be. This water seal generally varies from 25mm to 75 mm; 50 mm being quiet common in most of the traps.

Qualities : A good trap should povers the following qualities :

(i) It should provide sufficient water seal (50 mm- or 50) with large surface area ;

(ii) Its interior should be smooth, so as not to obstruct flow and the trap should thus be self cleansing.

(iii) It should be provided with an access door for cleaning; and

(iv) It should be made of some non-absorbent material.

TYPES :

Depending upon their shapes, the traps may be of three types. i.e.,

(i) P-trap (ii) Q-trap; and (iii) S-trap.

These three types of traps are shown in figure below. A trap essentially consist of a U-tube, which retains water, acting as a seal, between the foul gases (inside the pipe) and the outside atmosphere. In all such needs, they are made with enlarged mouth, so that the waste pipe may be thoroughly flushed out.

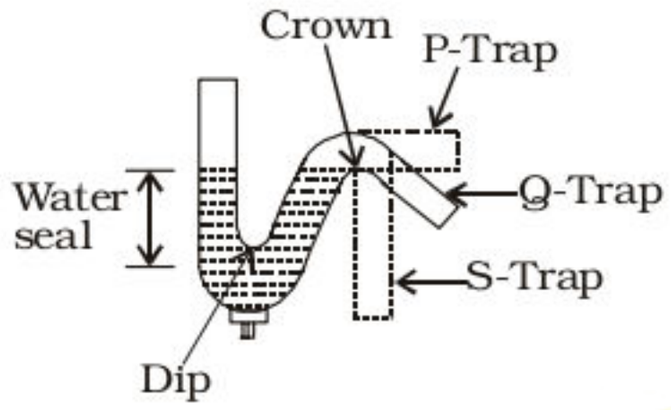


Figure : P, Q and S Traps shown together

SYSTEM OF PLUMBING :

Following are the four principle systems adopted in plumbing of drainage work in a building.

(i) **Two pipe system :** This is the best and the most improved type of system of plumbing. In this system, two sets of vertical pipes are laid i.e., one for draining night soil, and the other for draining sullage. The pipe of the first set carrying night soil are called soil pipes, and the pipes of the second set carrying sullage from baths etc. are called sullage pipes or waste pipes.

(ii) **One Pipe system :** In this system, instead of using two separate pipes (for carrying sullage and night soil, as is done in the above two pipe system). Only one main vertical pipe is provided, which collects the night soil as well as the sullage water from their respective fixtures through branch pipes. This main pipe is ventilated in itself by providing cowl at its top, and in addition to this, a separate vent pipe, however is also provided. This system thus has two pipes, instead of four pipes of the two pipe system.

As pointed out earlier, the two pipe system is the best system for efficient conveyance of sanitary house wastes with minimum use of traps, and is therefore, largely favoured, particularly to large and multistoreyed buildings. This system however requires a large number of pipes and their connections and is hence costly. Moreover, it is also difficult to find suitable place for accommodating so many pipes in small houses and buildings. In that core pipe system is more economical and easy to accommodate, but requires sufficent safe guard to make the drainage effective, in the form of proper ventilation, adequate water-seals, and proper connections between the sanitary fixtures and soil pipe. In multistoreyed buildings, moreover, use of one pipe system, generally makes it imperative to place the lavatory blocks of various floors one above the other.

POLLUTION

Introduction: The word pollution has been taken from the Latin word, Pollutionem meaning defilement from polluere, to soil or defile (make dirty). Later on Oxford English Dictionary used the word pollute with reference to physical contamination of terrestrial or aquatic environments in nineteenth century. In 20th century the word pollution was used with reference to contamination of water, soil and air.

The problem of pollution may be natural or artificial as with the development of the civilization so that the natural waters get polluted from sewage or industrial effluent that are ultimately discharged into these waters. Pollution makes the air foul, it makes the water poisonous to kill the fish and other aquatic animals. Release of unsuitable substances cause damage to human health, plants and animals in the biosphere.

A precise definition of pollution is not an easy task in context of ecology. Logically speaking which cannot be defined may be described.

How Pollution Started?

How pollution get started on earth ? A few authors like Lynn. White (1967) and Ian Mc Harg (1969) blamed Judeo-Christian ethic for pollution. According to them Judeo-Christian ethic taught man to believe that the earth was made for man to do with as he wished, and thereby encouraged exploitation.

Modern ecologists have suggested many factors such as human population explosion, unplanned urbanization, deforestation, profit oriented capitalism and technological advancement, which may have originated pollution crisis on earth. It has been estimated that in countries where there have been the greatest technological advancement, the worst pollution occurs.

What Are Pollutants?

Pollutant means a substance that causes pollution. The term pollutant refers to a substance which increases in quantity due to human activity and adversely affects the environment (e.g. carbon monoxide, sulphur dioxide, lead). A substance which is not present in nature but released during human activity is the contaminant (e.g. methyl isocyanate, DDT, malthion). A contaminant however, is regarded as a pollutant when it exerts detrimental effects. Common pollutants described by Smith (1977) are as follows :

1. **Deposited matter :**soot, smoke, tar dust, etc.
2. **Gases :** Sulphur dioxide, carbon monoxide, carbon dioxide, nitrogen oxide, hydrogen sulphide, ammonia, chlorine, etc.

3. **Chemical compounds :** Aldehyde, arsines, phosgenes, detergent, etc.
4. **Metals :** Lead, zinc, mercury, etc.
5. **Economic poisons :** Herbicides, fungicides, pesticides, insecticides and other biocides.
6. **Fertilizers**
7. **Sewage**
8. **Radioactive substances**
9. **Noise**
10. **Heat**

According to Odum (1971), pollutants are of two types:

1. **Biodegradable pollutants**
2. **Non-degradable pollutants**

The biodegradable pollutants are those which degenerate with time in the ecosystem such as, domestic sewage, heat, etc. They act as pollutant only when their input into the environment exceeds the decomposition or degeneration capacity. The non-degradable pollutants either donot degrade or degrade very slowly in the ecosystem. The non-degradable pollutants not only accumulate but are often "biologically magnified". They frequently combine with other compounds in the environment to produce additional toxins. Some common examples of non-degradable pollutants are mercurial salts, long chain phenolic compounds, DDT, etc.

Following are the man-made sources of pollutant-stationary combustion, transportation, industrial processes and waste disposal sources.

The pollutants are also classified according to their nature, which are more convenient too, such as

1. Chemical air pollutants
2. Biological air pollutants
3. Water pollutants
4. Physical pollutants

1. Chemical air Pollutants : These include substances that are the by products basically formed from combustion sources, e.g. power plants, exhausts of automobiles, etc.
2. Biological air pollutants : These are also referred to as aeroallergens. There is a wide range of such acroallergens (air borne substances) such as micro organisms, pollen grains, dust, etc.
3. Water pollutants : These include uncontrolled disposal of sewage and liquid wastes resulting from industrial effluents which includes-agricultural washes to industrial wastes.

Classification of pollution

Pollution may be classified in various ways, but it is mainly classified on two bases:

1. On the basis of environments—e.g., air, water, soil, etc.
2. On the basis of the type of pollutants—e.g., sewage, chemical effluents, pesticides, smoke, radio-active pollutants, etc.

Natural source: It includes all wind blown or wind assisted pollutants like sea salt, smoke, gases, forest, fires and volcanic gases.

Anthropogenic source: Anthropogenic pollution is caused by maris industrial activities in chemical industries, power plants, fuel burning and agribusiness. It includes pollutants like industrial effluents, organic wastes and automobile exhausts.

Estimated Major air pollutant

	Emission	
Pollutant particulate	Natural	Anthropog
Production of primary particles	1207	9^3
Particle conversion from gas	1105	204
SO_2	194	146
NO_2 (NO)	430	163 (NO_2)
CO	3850	88
Terpene	154	

Sources of pollution

On the basis of the points of generation, the sources of pollution can the classified as follows:

1. **Single point source:** It includes chemical and related industries, power plants and petroleum refineries.
2. **Multiple point source:** In this an entire area is involved in producing pollutants, usually of different types.
3. **Line Source:** Pollution caused by fossil fuel burning in highway automation.
4. **Non-point sources:** They include emissions from transport vehicle, agricultural runoff, and silt into streams and ground water. Urban runoff can carry toxic metals and organics directly into the lakes and rivers.

Biological Magnification

Biological magnification is the tendency of pollutants to become concentrated in successive trophic levels. Often this is to the detriment of the organisms in which these materials concentrate, since the pollutants are often toxic.

Biomagnification occurs when organisms at the bottom of the food chain concentrate the material above its concentration in the surrounding soil or water. Producers, as we saw earlier, take in inorganic nutrients from their surroundings. Since a lack of these nutrients can limit the growth of the producer, producers will go to great lengths to obtain the nutrients.

In order for a pollutant to biomagnify. The following conditions must be met:

1. The pollutant must be long-lived.
2. The pollutant must be concentrated by the producers.

3. The pollutant must be fat-soluble.
4. Mobile.

Bioaccumulation: increase in concentration of a pollutant from the environment to the first organism in a food chain.

Biomagnification: increase in concentration of a pollutant from one link in a food chain to another.

Armed with ecosystem alternating powers, man in now fully equipped to bring about changes in the ecology of perhaps the only life- sustaining environment in the universe-for good or bad it is for posterity to decide.

AIR POLLUTION

Introduction

Our earth is surrounded by air cover upto the height of about one mile from the surface of earth, a reservoir containing 5×10^{18} cubic meters of air. The air contains a number of gases such as O_2, N_2, CO_2, inert gases, etc. in a relatively fixed ratio. When due to certain mixing of undesirable substances in the air the concentration gases or particles other than oxygen increases, the air becomes polluted and this process is known as air pollution. The World Health Organization (WHO) defines air pollution as-the presence of materials in the air in such concentration which are harmful to man and his environment.

Air pollution can also be defined as— presence of undesirable substances in air in such quantities and of such duration as is or tends to be injurious to human health or welfare, animal or plant life, or property, or would unreasonably interfare with the employment of life or property.

So, we can say that rise in concentration of solid, liquid or gaseous materials except oxygen in air by any human or natural activities like volcanic eruptions, forest fires and natural decay of organic and inorganic material will cause air pollution. Man-caused pollution is common in big cities and industrial towns whereas pollution caused by nature may be anywhere. Though man caused pollution has localised effects to some extent yet several times it has created havoc. It is still fresh in our memory the havoc created by methyl isocinate gas leakage at Bhopal on 2nd December 1984. Poisonous gas leakage accident which occurred in delhi on 4th December 1985 caused many deaths.

Major Pollutants In The Air

Any substance which causes undesirable change i.e., poses bad effect in the air is known as air pollutant. Some major categories of air pollutants are as follows:

1. **Gaseous Pollutants :** The pollutants that remain in gaseous form at normal temperature and pressure along with vapours of compounds of those pollutants whose boiling points are up to 200^0C are known as gaseous pollutants.
2. **Mist:** Solid particles having a diameter of more than one micrometer (m) are known as dust whereas the liquid particles with the same range of size are known as mist.
3. **Aerosol:** Smokes and fumes of solid or liquid particles having a diameter less than one micrometer (m) are known as aerosol.

The air pollutants are further divided into three categories:

1. Primary air pollutants
2. Secondary air pollutants
3. Biological air pollutants

1. **Primary air pollutants:** Pollutants released directly in the air are known as primary air pollutants (Fig. 21.1). They are of various Types:
   - **(a) Carbon compounds :** Carbon monoxide, Carbon dioxide.

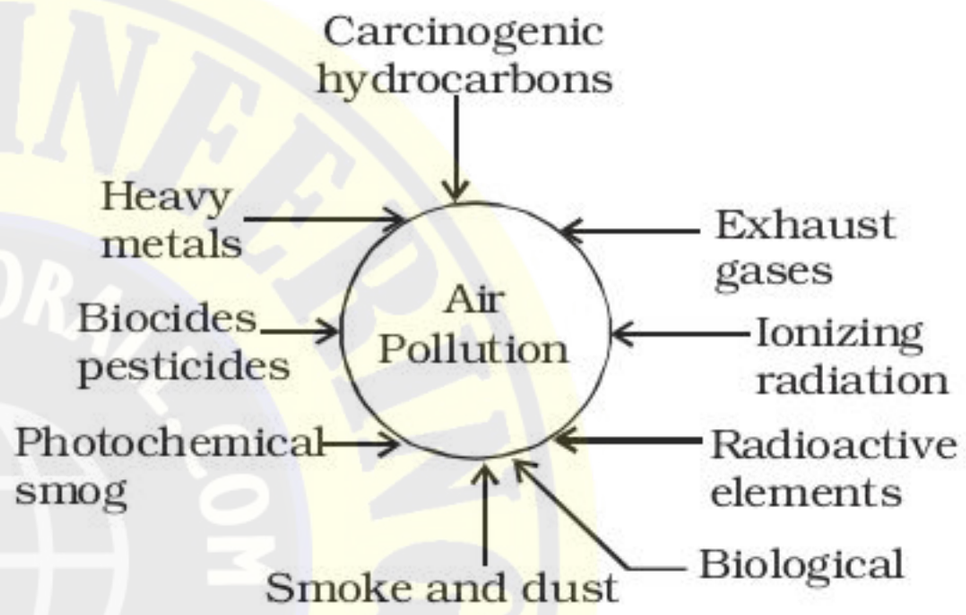


Fig : Hypothetical representation of some important pollutants causing air-pollution.

   - **(b) Nitrogen compounds :** Nitrogen peroxide, Nitrogen Dioxide, Nitrogen oxide, Ammonia.
   - **(c) Sulphur compounds :** Sulphur dioxide, Sulphur tri-oxide, Hydrogen sulphide, Mercaptans.
   - **(d) Halogen compounds :** Hydrogen fluoride, Hydrogen chloride.
   - **(e) Hydrogen compounds**
   - **(f) Organic compounds**
   - **(g) Radio-active compounds**.
2. **Secondary air pollutants :** The pollutants produced as a result of reactions between primary pollutants in the air are known as secondary air pollutants. Nitrogen compounds and ozone formed as a result of reaction between nitrogen oxide and hydrocarbons in the presence of sunlight are examples of secondary air pollutants.

$$\text{Nitrogen oxide + Hydrocarbons} \xrightarrow{\text{Sunlight}} \text{Peroxyacetyl nitrate (PAN)} + O_3$$

Mixture of carbon monoxide, nitrogen, sulphur dioxide, sulphuric acid and PAN ($CH_3C(O)OONO_2$) is known as 'lethal soup' and is an example of secondary air pollutant.

3. **Biological air pollutants :** The air brone pollutants such as bacteria, virus, fungi, pollen grains are known as biological pollutants. These also known as aero-allergens as most of them cause allergic reactions.

SOURCES OF AIR POLLUTION

The air may become polluted by a number of sources, such as power and heat generating systems, industrial and transportation processes, use of insecticides and fungicides and nuclear energy programmes may be a source of air pollution. Important sources of air pollution are as follows:

1. **Industries:** The industries depend upon combustion of various fuels. These fuels are mainly in the form of coal and petroleum products. The burning of fossil fuels emit varieties of air polluting gases such as carbon monoxide, sulphur dioxide, hydrogen sulphide, hydrocarbons, etc. Burning of coal is alone responsible for production of a large number of toxic gases such as carbon monoxide, carbon dioxide, sulphur dioxide and nitrogen oxide. Petroleum also contains sulphur, nitrogen and hydrocarbons. Roasting of sulphide ores of mercury releases mercury vapours. Chemical industries release oxides of various metals in the air such as copper, zinc, lead, arsenic, cadmium, calcium, etc. Industries are the major source of air pollution. It becomes clear from the observation that areas near industrial complex show more pollution in comparison to the rest part of the country.
2. **Mobiles :** Locomotives, automobiles, aeroplanes etc., run by petroleum products. Their exhausts release in the air CO_2, carbon monoxide, nitrogen oxides, hydrocarbons and lead compounds such as tetraethyl and tetramethyl lead. The hydrocarbons produced in the air undergo photo-chemical reactions with nitrogen oxides in the presence of sunlight to produce highly toxic peroxy-acetyl-nitrate (PAN). It has been estimated that combustion of single gallon of petrol in automobiles causes production of three pounds of carbon monoxide and fifteen pounds of nitrogen oxide.
3. **Ionizing radiations :** Ionizing radiations emitted during atomic expulsions testing of nuclear weapons also ... pollution of air. The main ionizing radiations are X-rays, b-rays, ... gamma rays, etc.
4. **Radioactive substances:** Various Radioactive substances spread in the air during ... explosions and testing of nuclear weapons.
5. **Smog:** The accumulation of smoke in fog is known as smog and is the name usually applied to that form of air pollution which arises from the interaction of sunlight with the various constituents of the atmosphere. These reactions proceed with the absorption of energy from the sunlight.

Formation of smog: In cities with many industries and automobile traffic, the atmosphere is polluted by the smoke coming out from the chimneys of factories and the exhaust of cars. The main components of the smoke are unsturated hydrocarbons, NO and some sulphur compounds. In the early morning, atmospheric concentrative of NO is high but after sunrise NO decreases and NO_2 appears, NO_2 is formed by photochemical reactions between NO and O_3. The O_3 is depleted by this reaction and is regenerated by reaction with O-atoms.

$$NO + O_3 \xrightarrow{hv} NO_2 + O_2$$

$$NO_2 + hv \longrightarrow NO + O$$

$$O + O_2 + M \longrightarrow O_3 + M$$

M = third body

Traces of NO_2 can further promote a chain oxidation reaction consesting of following steps initiated by the reaction of signet oxygen $^1O_2$ with hydrocarbons.

Reaction scheme:

$$^1O_2 + \text{defines} \longrightarrow \text{radicals RCO etc.}$$

$$\bullet RCO + 3O_2 \longrightarrow \bullet RCO_3$$

$$\bullet RCO + NO \longrightarrow \bullet RCO_2 + NO_2$$

$$\bullet RCO_2 + NO \longrightarrow \bullet RCO + NO_2$$

$$\bullet RCO_3 + NO_2 \longrightarrow \bullet RCO_3 + NO_2 (PAN)$$

$$R'CH_2 + O_2 \longrightarrow R'CH_2O_2$$

$$R'CH_2O_2 + NO \longrightarrow R'CH_2O + NO_2$$

$$\longrightarrow R'CH_2O + NO_2 (\text{alkyl nitrate})$$

Three specific eye irritants have been identified in photochemical smog: formaldehyde, acrolein and peroxyacetylnitrate.

6. **Insecticides:** Use of various types of insecticides either to drive away or kill the insects in houses and farms (particularly aerial spray) also causes air pollution.
7. **Biological pollutants :** Air borne bacteria, fungi and pollen grains also serves as sources of pollution.

MODELLING THE POLLUTANT TRANSPORT IN THE AIR

Atmospheric transport models are essentially used to predict the concentration of airborne pollutants at various distances and directions to their points of release.

Concentration depend on:

1. Amount of substance released.
2. Wind direction and speed.
3. Atmospheric diffusion (depending on characteristics of the atmospheric turbulence along the transport path).
4. Kinematic processes affecting air flow and turbulence due to terrain roughness and such non uniformities as hills, valleys and forestes, the presence of buildings.
5. Conditions of release such as, release, level of height, thermal and kinetic energy of the carrier fluid.

ECOLOGY OF AIR POLLUTION

Effects of air pollution: Exposure to air pollution is now an almost inexcapable part of everyday life throughout the world. Sufficiently high concentration of prevailing air pollutants in many areas give rise to increase in mortality, morbidity, deficits in pulmonary function, cardiovascular and neurobehavioural effects, damaging buildings and various works of art. Effect of air pollution may be categorized as follows:

1. Effects on human beings
2. Effects on animals
3. Effects on plants
4. Effects on ecosystems
5. effects on materials
6. Effects on weather and climate.

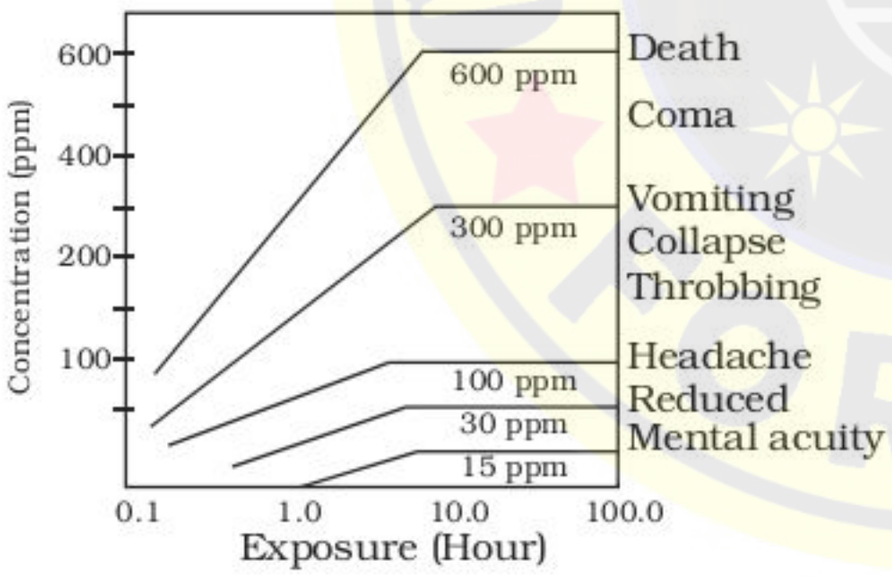


Fig: Effects of carbon monoxide on man.

1. **Effects on human beings**

(a) Though carbon- monoxide is a non-irritant, colourless and odourless gas yet it is highly toxic and retards respiration. It combines with haemoglobin to form a permanent compound carboxyl haemoglobinate. This results in the loss of oxygen carrying capacity of haemoglobin. The symptoms of low level carbon monoxide are reduced reaction times, psychomotor impairment, headache, dizziress and lassitude. At more advanced stages nausea, ringing of the ears, pressure in chest and difficulty in breating occurs.

(b) Sulphur dioxide combines with ways to form sulphuric acid. It causes type irritation in man. It crodes ... tissues and causes drying of the mouth, scratching of throat and lung diseases

(c) Nitrogen oxides such as nitric oxide nitrous oxide and nitrogen peroxide form PAN on combining with hydrocarbon during photochemical reactions in bright sunlight. It causes eye inflammation, respiratory disorder and cancer in man. Nitrogen oxide are relatively less soluble in water, so there cause accumulation of water in air spaces of lungs and retard the functioning of lungs.

(d) Ozone formed during photochemical reaction causes edema i.e., inflammation of air-sacs in lungs injurious dryness of mucous membrane. It may cause change in hair structure and stiffening of joints.

(e) chlorine participates in the formation of harmful polychrominated-diphenyles. It attacks entire respiratory tract and mucous membrane of eyes resulting eye and pulmonary troubles.

(f) Lead compounds produced during combustion of petroleum are also poisonous. These are accumulated in very less quantity, yet these retard the formation of haemoglobin. Lead levels of 20-40 mg/100 g of blood (0.2-0.4ppm) are considered normal and harmless for city dwellers. Both 0.8 ppm lead levels in adult human blood causes over symptoms such as anaemia, kidney disease and convulsions. However, in children 0.6 ppm level of lead in blood my cause lead poisoning and ultimately death occurs.

(g) Air borne pollutants cause various allergic reaction, bronchitis, tuberculosis and lung cancer.

(h) Radioactive substances such as strontium-90 and Caesium-137 are also very dangerous. Both have 'half life' of 28 years. Due to biological accumulation and magnification they may reach at the bone similar to that of calcium and may cause leukemia. Strontium-137 passes directly to body with vegetables and is accumulated in different parts of the body including reproductive organs.

Thus it may cause mutation in genes and affects the next generation.

2. **Effects on animals:** The physiological and biochemical processes in most animals, expecially in mammals, are similar to those of human beings. We can, therefore, presume that the air pollutants will equally affect wildlife and domestic animals. Taking up of fluorine compounds by cattle causes fluorosis. The animals, grazing along the major high ways, are shown to be poisoned by lead emanated by the automobiles.

3. **Effects on plants**

(a) Plants are very much sensitive to sulphur dioxide. SO_2 damages chlorophyll resulting in reduction of photosynthesis, growth and plant yield. Loss or reduction of chlorophyll is known as chlorosis.

(b) Fluorides cause the collapsing of leaf tissues. This is known as necrosis. Maize is highly sensitive to flurides.

(c) Oxides of nitrogen cause drooping of leaves and bud death resulting in stunted growth and small fruits.

(d) Hydrocarbons like ethylene causes epinasty i.e., earlier fruit ripening or drooping of leaves in addition to curling of petals and discolouration of sepals.

(e) Ozone causes decay of chlorenchyma and increases the rate of transpiration.

(f) Acid rains also cause serious damage to plants They leach nutrients from the soil and foliage, and affect nitrogen fixing soil micro-organisms. Acids enhance the uptake of toxic heavy metals from the soil by the plants.

Mosses and lichens are highly sensitive to air pollutants and get severely damaged by such lower levels that cannot induce any response in other animals or plants. These plants are, therefore used to indicate pollution level, thus known as bioindicators.

4. **Effects on ecosystem:** Air pollutants greatly affect the ecosystems, but their effects become visible after a long period of time. In highly industrialized countries, the devastating effects of air pollution on both the aquatic and terrestrial ecosystems have long been evident. The most important contribution towards such a situation has been made by the acid rains. The acid rains cause a worldwide destruction of forest ecosystems, not less than 70,000sq. km of forests in European countries and U.S.A. have already been destroyed. Ozone and other photochemical oxidants, SO_2, deposition of nitrogenous compounds, heavy metal deposition and organic chemicals have boosted up the process of forest destruction in these countries.

Air pollutants in the form of acid rains cause devastative effects on aquatic ecosystems. Similar impact has however been observed in the soil with little buffering capacity.

Chemical substances sulphuric acid (H_2SO_4), nitric acid (HNO_3), hydrogen chloride (HCI) floating in air mixup with dew, frost and rain water, and they precipitate as "Acid Rain".

5. **Effects on non-living substances**

(a) Sulphur dioxide after combining with water form sulphuric acid causing acid rain which erodes the surfaces of buildings, textile and paper. The examples include British Parliament Building, St. Paul's Cathedral and many other notable assets of the world, including Taj Mahal, Fatehpur Sikri and Victoria Memorial Hall, Kolkata.

The present average pH of the acid rain in Kolkata in 5.80, Hyderabad 5.73, Chennai 5.85, Delhi 6.21 and in Mumbai 4.80 with a record of 3.50 (1985-86).

(b) Hydrogen sulphide has a bleaching property and decolourises silver and lead paints.

(c) Ozone oxidises rubber goods

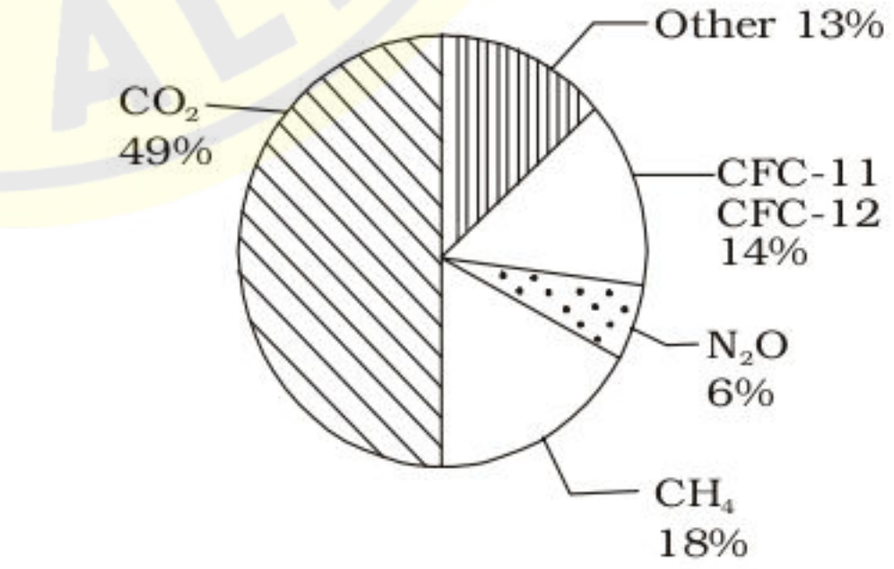
(d) Dust and ash deposits disfigure buildings, it irritates our aesthetic sense.

6. **Effects on weather and climate**

(a) The amount of carbon dioxide is increasing continuously due to deforestation and its increased production with establishment of more and more industries. It traps outgoing terrestrial infra-red readiation. It increases the average temperature of atmosphere. This is known as Global warming. The rise in air temperature causes melting of polar ice and increase of water level in sea. If it is continued it will pose danger of flooding of low lying coastal plains.

(b) Aerosol containing flurocarbons produced by the jet plane emission is continuously depleting the ozone layer in the stratosphere. This depletion will provide more chances of reaching the harmful ultraviolet rays to the earth's surface.

An increase in particulate matters in the atmosphere, in contrast, increases it's Albedo, resulting in a drop in the temperature and plant productivity. Under extreme conditions this may lead to another ice-age.



Percentage contribution of the different green houses gases to global warming

The trouble with making any predictions about climatic changes is that thousands of other factors influence the climate including many that trigger a cascade of other unexpected changes.

Aerosols such as sulphuric acid mists ammonium sulphate mists and vapours, etc., can influence the vertical temperature status of atmosphere and resulting in thermal alterations. Steel mills and automobile emissions release into the atmosphere a kind of particles called ice nuclei. These ice nuclei in low concentrations are responsible for modifying the cloud structure.

Control of Air Pollution

Man made air pollution and its effect can be checked or minimized by adopting following procedures:

1. Carbondioxide level can be checked or minimized by increasing the area of forests and green fields.
2. Sulphur should be removed before burning of fossil fuels.
3. The use of cheap fuels with higher sulphate contents should be replaced with the use of smokeless fuels, natural gas and nuclear power.
4. Automobile exhausts should be checked strictly with air cleaner filters.
5. Industries should separate out harmful particles before releasing their waste gases in the atmosphere by utilizing various devices such as cyclone collectors and electrostatic precipitators.
6. The poisonous gases must be treated chemically before releasing it in the air.

In India almost all the industrial centres have been provided with air monitoring stations by Govt. of India.

GREEN-HOUSE EFFECT

The word Greenhouse means building mostly of glass, used to rise and protect plants. Sunrays enter the greenhouse continuously and increases the temperature inside the greenhouse. The greenhouse helps in the growth of plants by maintaining nearly stable temperature.

Greenhouse effect and origin of life

The global temperature has been as important for the origin of life on the earth as the oxygenic composition of the atmosphere. The heat of the sun is the source of all our energy, driving a multitude of processes from chemical reactions to the movement of winds. Ecosystems absorb the heat energy and maintain an even comfortable temperature. The earth's mean surface temperature is now about 15^0C and has remained constant for over hundreds of thousands of years. This constancy of temperature has helped in origin and maintaining various organisms. Without green house effect, the average temperature on earth would be about - 18^0C and too cold for life.

What is Greenhouse effect ?

The green house effect is the main element responsible for the maintainance of the global heat budgets at a nearly steady value. The greenhouse effect is so-called because the mechanism of the control of temperature of the earth as the same one observes in green houses arranged for plants. Sunrays enter into the glass made-green houses and increase the temperature. Similarly the earth is an unique greenhouse but here glass panes are replaced by various "greenhouse gases" in the atmosphere.

In the earth absorbed solar energy is eventually converted to heat energy by the surface of earth and the plants and animals and other living systems. Now the heat released by the earth as infrared radiations are trapped by green house gases and then released in all directions and maintain global temperature.

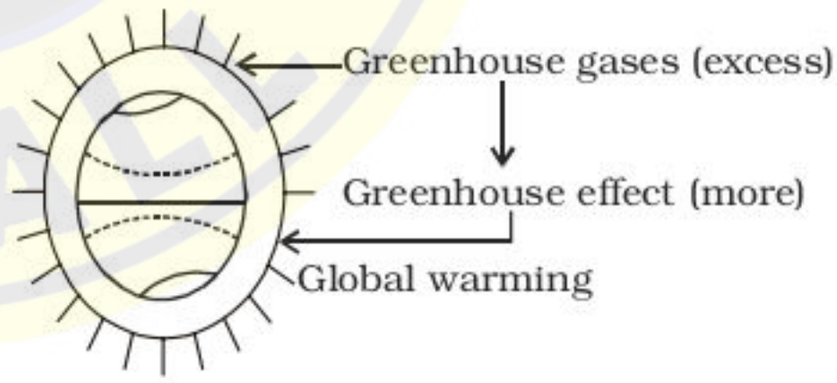
Greenhouse gases

Important global greenhouse gases are—carbondioxide, water vapour, methane, ozone, nitrous oxide (N_2O), chlorofluro carbons (CFCs) and hydrochlorofluro-carbons (HCFCs) etc.

Problems of Greenhouse effect

The green house effect is one of the most hotly debated environmental issues of the current world. Due to various human activities the density of the green house gases increases, they tend to arrest more heat and thereby average temperature on earth increases slowly but steadily. Thus the increase of greenhouse gases results global warming. It is a man made thermal pollution. It poses various kinds of serious threats to the natural resources as well as to the port cities around the world.

In the last two hundred years human activities have added extra quantity of existing greenhouse gases and the effect of these additions has turned the greenhouse effect from a vital life-sustaining, mechanism into what is known as global warming which has now become the most threatening environmental problem.



Global warming and Indian subcontinent

Due to global warming certain major changes may occur in India.

1. The length of the Himalayan ranges is over 1500 miles. The snowline starts, on an average, from the altitude of 1600 feet. Snows and glaciers have been stocked in various depths and dimensions on the ridges and furrowes of this vast area of the mountain ranges. Due to rising of temperature if a major portion of the ice block starts to melt there may be incident of long lasting off season floods. But according to the experts the impact will not be perceived immediately in volume and ultimately

the reduced water supply coupled with high temperature would pose serious threats to the natural forests of the Himalayan ranges as well as agricultural and horticultural activities of the Gangetic plain.

2. The phytogeographical boundaries will be shifted with shifting of isothermal lines.
3. The Himalayas are said to be the home of 3000 endemic plant species. Due to the disappearance of so many rare species of orchids, rhododendrons, Saussureas, Primulus, Impatiens etc., may become totally extinct.
4. Some of the animal species, like yak, ibex, snow leopard, etc. cannot survive at high temperature. When yaks are brought down to the plain they develop a strange liver disease and die within a few months.
5. The average climate of the India plain would become hotter and dried which would affect the agricultural yields.
6. Rising of sea level will lead to lowering coastal area flood.
7. Increase of salt water intrusion into the aquifers of the coastal region.
8. Inundation of wetlands which are now used as brakish-water fisheries in the coastal areas.
9. It may alter climatic pattern.
10. Precipitation may increase by about 10 per cent in some areas.
11. There may be other consequences. The scientific modelling of the earth's weather systems is not sophisticated enough to predict the changes in detail.

Role of human activities in Greenhouse effect

1. The major human contribution to the green house gases is the carbon dioxide, use of fossil fuel has been increasing since indus trialization of the world.

   The annual consumption of coal is now one hundred times greater than it was in 1800. The annual consumption of oil has now increased more than two hundred folds in the twentieth century. All the activities that depend on fossil fuel release carbon dioxide into the atmosphere.

   The destruction of tropical forests has also the effect of increasing carbon dioxide level.
2. The second major source of greenhouse gases is methane. It has been produced in many ways. Methane is released from the decaying vegetation and manure which sink to the bottom of crop fields. The increasing number of domestic animals contribute to increasing methane from bacteria which all the animals have in their guts.

   The large scale increase of termites that feed on decaying wood produce methane as waste product. These combined effects have increased the amount of methane 155 per cent since 1800 A.D.
3. Emission of nitrous oxide (N_2O) coming out of nitrate fertilizers and vehicles exhausts.
4. The fourth source of greenhouse gases are chlorofluro carbons and hydrochlorofluro carbons (CFCs and HCFCs).

Control of greenhouse effect

1. Minimum use of fossil fuels may reduce the release of carbon dioxide in the atmosphere.
2. Alternative, non-conventional energy-solar energy, tidal energy, geothermal energy may be used as substitutes for fossil fuel.
3. Production and utilization of CFCs may be shortened as far as feasible.
4. Forestes should have to be conserved.
5. Aforestation is necessary so that plants can absorb the extra carbondioxide to maintain balance in environment.
6. Efficiency of engine of vehicles should be increased to minimise use of fossil fuel.
7. Greenhouse effect consciousness among people should be a programme for study in school, college and other institutions.
8. Research on greenhouse effect of air should continue and be a continuing process.
9. Agenda-21 for sustainable development should be obeyed by all countries.

DEPLETION OF OZONE LAYER

Ozone gas (O_3), a minor component of the atmosphere acts as a screen for biologically hazardous ultraviolet 'B' radiation. The column of ozone concentration in the atmosphere reaching the stratosphere is roughly equivalent to a layer of 3 mm thick when compressed at the atmospheric pressure. This thickness varies daily from 2.9 to 3.4 mm when spread out, the maximum vertical concentration of O_3 lies between 20-30 km above and reaches upto 40 km in the upper layer of the stratosphere. Buisson and Febry (1930-31) and Ladenburg (1931) first proved the existence of ozone in the upper layer of atmosphere. The reactions which establish the ozone layer are:

formation

$$O_2 + h\nu \rightarrow O + O$$

$$O + O_2 + M \rightarrow O_3 + M$$

(M = air molecule)

(hv = energy of quantum of light)

Decomposition

$$O_3 + h\nu \rightarrow O + O_2$$

$$O + O_3 \rightarrow 2O_2$$

$$O + O + M \rightarrow O_2 + M$$

The cyclic nature of these reactions seemed to convey a certain security that life on the earth should remain protected from the lethal effects of shorter wavelength UV radiations (Ozone filters our all radiations below about 290 nm).

The ozone depletion problem story began with Johnston's warning, way back in the seventies, of a possible depletion by nitric oxide exhaust from supersonic aircraft. By 1974, the spectre of ozone depleted from human release of chloroflurocarbons had become a major concern.

The stratosphere is said to be the atmospheric kitchen. The entry of various ozone depleting pollutants can cause long range harm to life on earth.

Ozone depleting agents

Ozone depleting agents are- water vapour, nitric oxide, chloroflurocarbons (CFCs) from aerosol sprays, refrigerants, N_2O from nitrogen fertilizers; NO_x from nuclear explosions and other. Of these CFCS have the most disastrous effect on the ozone layer.

Consequences of depletion of atmospheric O_3

The two potential consequences of alternation in startospheric ozone balance of atmosphere are:

1. Increased penetration of lethal solar UVB radiation. One per cent increase in UVB may lead to two per cent increase in the incidence of skin cancer and erythyma. It may also cause injury to plant systems.

TABLE

Altitude Km	10.5	13.5	16.5	19.5
Relative Chain Length	5	40	110	300

2. Alternation of stratospheric temperature structure due to changes in the distribution of stratospheric ozone with altitutde.

Chemistry of Ozone depletion

Ozone depleting pollutants can either be injected near the stratosphere by the exhaust of supersonic jet or rockets, which mainly introduce NO and initiate the NO_X cycle. The relative total chain length varies on the altitude of injection of NO,

(see the table).

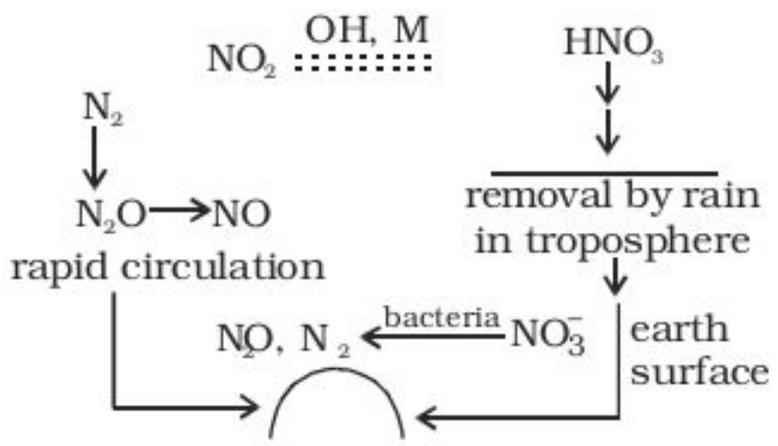
NO_X cycle-

$NO + O_3 \rightarrow NO_2 + O_2$

$NO_2 + O \rightarrow NO + O_2$

$O_3 + O \rightarrow O_2 + O_2$

Final termination of the chain occurs with the downward diffusion of NO_2 into the troposphere where it can be removed by rain etc. The effect on stratospheric ozone is cumulative one.



CFCs enter atmosphere from below and in stratosphere they become reactive towards ozone.

Important CFCs react in Following manner;

$CCl_2F_2 + hv\ (\lambda\ 220\ nm) \rightarrow \cdot CClF_2 + \cdot Cl$

$CCl_3F + hv\ (\lambda\ 230\ nm) \rightarrow \cdot CCl_2F + Cl$

These reactions can then initiate the ClO_X cycle for the catalytic destruction of ozone.

$\cdot Cl + O_3 \rightarrow \cdot ClO + O_2$

$\cdot ClO + O \rightarrow \cdot Cl + O_2$

$O_3 + O \rightarrow 2O_2$

ACID RAIN

Acid rain means rain (or snow) which contains a higher level of acid than normal - PH Collin 1990. The term "acid rain is commonly used to mean deposition of acidic compounds in rain, snow fog, dew, or dry particles, The more accurate term is - "acid precipitation". Distilled water, which contains no carbondioxide, has a neural pH of 7. Liquids with a pH less than 7 are acid and those with a pH greater than 7 are alkaline (or basic). "Clean" or unpolluted rain has a slightly acidic pH of 5.6, because carbon dioxide and water in the air react together to form carbonic acid, a weak acid.

WATER POLLUTION

INTRODUCTION

The general survey reveals that the total surface area of the earth is 51 crore square kilometres out of which 36.1 crore square kilometres is covered by sea. In addition to this, we get water from ranks, rivers, lakes and snow on hills. About 15 crore cubic kilometres of water is also found on the average layers of the earth. Although it is surprising but true that in spite of such aboundance there is shortage of fresh water in the world.

WHAT IS WATER POLLUTION ?

Water pollution is–any change in physical, chemical or biological properties of water or discharge of any sewage or industrial waste which may be harmful to public health or safety or animal life or to domestic, commercial, industrial, agricultural or other legitimate uses.

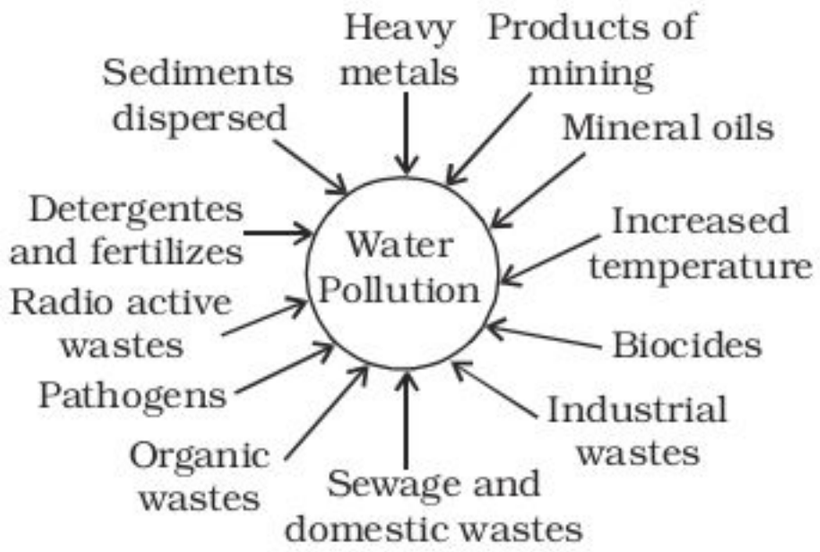
Water pollution may also be defined as-the Average change in the composition or condition of the water such that it becomes less suitable for the purposes which it would be suitable in its natural state. The changes include, physical changes, chemical changes and biological changes.

Water pollution now-a-days is considered not only in terms of public health but also in terms of conservation, aesthetic and preservation of natural beauty and resources.

WATER POLLUTING AGENTS OR WATER POLLUTANTS

The undesirable substances which cause water pollution are known as water pollutants. Water pollutants may be of following types :

1. **Physical**-Waste heat from industries.



Hypothetical representation of some important pollutants causing water pollution

2. **Chemical**
   (a) Inorganic – Phosphates, nitrates, sulphates, chlorides, fluorides, etc.
   (b) Organic - Phenols, dyes, paints, plastics, chloro compounds, etc.
   (c) Heavy metals - Water soluble heavy metallic ions like Hg, Cu, Cr, Ni, Cd and their organometallic compounds.
3. Biological-Pathogenic viruses, bacteria. protozoa, helminths, etc.

On the basis of degradation water pollutants may be categorised into two types:

1. Non-degradable pollutants
2. Bio-dcgradable pollutants.

1. **Non-degradable pollutants:** Those stable substances which can not be broken down easily into simpler components and may form toxic material in combination with other compounds are known as non-degradable pollutants, e.g., mercuric salts, phenolic compounds, DDT, radio active elements, pesticides, etc.
2. **Bio-degradable pollutants :** Those unstable substances which may be broken down by bacteria and can easily decamped are known as bio-degradable pollutants.

SOURCES OF WATER POLLUTION

The sources of water pollution are numerous. There do occur natural sources of water pollution, such as mineral ores from sedimentary rocks, chemical agents from mines and gaseous substances from the atmosphere. Here we will discuss about those sources which are man made.

1. Domestic sewage: Generally cities with large population are situated on the bank of big rivers and coast of oceans. These cities discharge their domestic sewage in the nearby rivers or oceans through sewarage system. Domestic sewage contains human and animal excreta, food residues and various types of cleaning wastes. These are rich in nitrogen, phosphorous compounds and organic matter. Decomposition of these bio-degradable pollutants depletes oxygen content of water which makes the survival of aquatic organisms difficult. Degradation of these pollutants has been found to increase the productivity of the river if these are discharged in moderate amount.

   Recent surveys indicate that only about 15% of our cities and only 8% of the towns have full sewage and full treatment facilities. The drinking water from these sources contains high amount of:

   (1) Nitrite, (2) Nitrate, (3) B.O.D., (4) C.O.D. (5) Chloride, (6) Sulphate, and (7) Total dissolved solids. These effluents in high concentrations are toxic and destroy fish and plant life.

2. Industrial wastes: The custom to drain our industrial wastes in the nearby rivers, lakes, ponds, streams and oceans causes contamination of water. The composition of industrial wastes is of variable nature depending on the different types of industries. Depending upon the categories of industries, their waste may contain zinc, lead, mercury, cyanide, arsenic, chlorine, phenol and many other organic as well as inorganic pollutants. Important industries causing water pollution are:
   (a) Paper and pulp
   (b) Distillery
   (c) Potassic fertiliser
   (d) Electroplating plant
   (e) Asbestos
   (f) Silt
   (g) Alcohol
   (h) Detergents
   (i) Steel
   (j) Tanning
   (k) Cane sugar
   (l) Oils
   (m) Pesticides and herbicides
   (n) Radioactive wastes.

   The lignin from paper and pulp industries completely destroys the fauna and flora. The distillery wastes are highly organic in nature and because of its high biochemical oxygen demand (BOD), quickly removes the oxygen from the water.

   The potassic fertiliser contains 37% K_2O rest being silica, calcium, iron and some sodium is the end product of the process. Discharges from electroplating plants contain harmful heavy metals and cyanides which cause excessive acidity or alkalinity in waters of rivers.

   Asbestos occurs in four forms: (a) chrysolitc (b) crocidolite (c) Tremolite and (d) Amosite. As the size of asbestos fibres in water supply is very small (less than 0.1 mm in diameter), usually not detected by light microscope. It can create cancer

of intestine, lungs and stomach.

The silt particles generally choke irrigation canal and disturb aquatic life.

In the alcohol industries besides alcohol wc get glycerine, succinic acid, acetaldehyde, allyl alcohol, acetic acid and 'Fuse oil' as by products.

The detergents cause serious pollution in water resources as they contain phosphates. The phosphates are responsible for the growth of alga which deplete the dissolved oxygen. Phosphates are also responsible for hyper-eutrophication.

Discharges from steel industries contain high concentration of phenol which gives bad taste in drinking water. Tanning industrial discharge also make warer with bad taste and smell.

Effluent from cane sugar industries contain high degree of organic pollutants. If effluent stagnates in an area for a few hours, biological action starts and septic condition gives H_2S gas imparting black colour to the effluent. More over the oxygen is also exhausted giving death of fishes and other aquatic life. The water is extremely harmful to the plants.

Oils are very toxic substances which affect the living organisms in water. Sources of oil pollution are tanker diasters, ballast water and bilge washing. However, the effect of oil pollution can be seen on beaches in the form of deposits of tar-like resiue. The oil tanker route in the Bay of Bengal is relatively more polluted than that of the Arabian Sea (Sur. of Env. 1991). Dissolved and dispersed petroleum hydro-carbons causes severe damage to coral-reef and mangroove ecosystems.

Pesticides and herbicides usually used in the crop fields contain compounds like D.D.T., B.H.C., endrin, heptachlor and toxaphene are also washed down with rain water and find their way to sea through streams and rivers. In the aquatic ecosystems these compounds accumulate in the bodies of animals and plants.

In the atomic age, radioactive substances are used for power industry, heating the home, preserving food, fueling transport and as medicines. The wastes from atomic reactors, hospitals, etc., are most dangerous because their radioactivity can not be destroyed at man's will. These wastes destroy the aquatic plants and animals to a great extent. The generally cause gene mutation, ionization of body fluids and chromosomal mutations.

3. **Thermal pollution:** Water is utilized in cooling electric power plants particularly in coal oil fired generators and nuclear power stations. This discharged hot water cause calefaction i.e., warming of lake, stream or river water. A rise in temperature causes an increase in metabolic rate which ultimately accelerates the respiration of micro-organisms. Some of the organisms are directly affected by hot water and killed.

4. **Mine washeries :** Waters from mine washeries carry various pollutants like chloride, sulphates, hydrogen sulphide, sulphuric acid and various metals.

5. **Deforestation and soil erosion:** Deforestation for extensive farming and mining provides increased opportunity to cause erosion of soil during heavy rains and flood. The eroded soil is carried to the lakes and rivers with overflowing water and takes part in the formation of suspended particles (Ecology 31) in water. These soil particles decrease the productivity of water by decreasing the depth of light penetration.

Ecology of Water Pollution

Effects of water pollution: Water pollution is an age old problem. In the past the effects of water pollution were felt mainly locally. But man by his activities like sewage disposal, nuclear weapon testing, trade wastes disposal, population increase, etc., has polluted most of his water resources.

Natural waters such as the ponds, lakes, river or oceans form well balanced ecosystems, they constitute a media with well balanced concentrations of oxygen, carbon dioxide, temperature stratification and nutrients thus forming an environment on which the biological part takes its growth. With the huge discharge of pollutants the water body loses its self sustaining property and only under such circumstances the aquatic pollution becomes hazardous. The effects of water pollution are maniflod. Some important effects are as follows:

1. Effects on aquatic bodies
2. Effects on aquatic organisms
3. Effects on man

1. Effects on aquatic bodies: Water pollution leads to changes in the physical and chemical conditions of the water, which creates an unfavourable impact on the flora and fauna.

(a) Decrease in oxygen content: Sewage decomposition depletes the level of oxygen content of water, because aerobic decomposition of the organic matters tends to exhaust the oxygen present in the water body. Under extreme conditions, dissolved oxygen content drops below 4 $mg.l^{-1}$ or even to zero. Such a situation causes massive destruction of the aquatic bodies. Such water resources which lack dissolved oxygen in water are said to be 'dead'. Lake Erie is an example of dead lake.

(b) Biological Oxygen Demand: Indiscriminate discharge of raw sewage into river, lakes, and other aquatic bodies create Biological Oxygen Demand (BOD). BOD is a measure of the amount of oxygen required to oxidize organic compounds in the water body. BOD is directly

proportional not only to the organic waste load, but also to inorganic pollutants like phosphates. Types of microorganisms, pH, presence of toxin, some reduced mineral matter, and nitrification process are the important factors influencing the BOD. BOD values should not be used as equivalent to the organic load regardless of the presence of non-dcgradable organic matter, presence of toxin and local changes in populations of micro-organisms.

(c) **Eutrophication :** Huge discharge of sewage and agricultural run-off containing inorganic salts like nitrates, phosphates and sulphates results in a steady increase in nutrient inputs in the water body. The consequence is essentially reflected in an increase in algal productivity, a process known as eutrophication. Heavy eutrophication often results in the shift of algal flora to blue-green algae. Most of these blue-green algae are not consumed by fishes. Therefore, they get accumulated to form scums and algal blooms. Decomposition of these algae depletes the dissolved oxygen further. Finally, anaerobic bacteria take over the charge and release methane as well as other gases. The Dal Lake of Kashmir provides an example of heavy eutrophication principally due ro sewage discharge leading to extensive vegetation growth and choking at certain sites.

(d) Contamination: Domestic sewage showes as a good source of pathogenic viruses, bacteria, protozoans and worms. Contaminated water spreads epidemic diseases like cholera, typhoid, dysentery, diarrhoea, jaundice and many others water bron diseases.

2. **Effects on aquatic organisms:** Water pollution may affect the organisms directly or indirectly. The toxic pollutants like metals, biocides and a number of chemicals affect the aquatic flora and fauna directly.

The non-toxic pollutants such as, saw dust, wood fibres and some fibrous textiles wastes are deoxygenators. Simmonds (1952) reported that in Spanish river, U.S.A. wood fibre deposits became matted with fungus and a few algae; they then entrapped gases, presumably methane caused by anaerobic decomposition in their lower layers, and floated off, extending their influence even further downstream.

In the case of deoxygenators such as iron the next effect after eliminating oxygen is to produce the symptoms of pollution by inert suspended solids. If the inert solids are very fine they donot settle readily but they make the river water opaque to light and so render all plant and algal growth impossible. There seems to be little evidence of any direct effect of suspended matter on animals.

The another effect of inert solids occurs when they settle out of the water on the stream bed, which happens when the particles are large or heavy or when current is slack. The deposits smother all algal growth, kill rooted plants and mosses and alter the nature of substratum.

Destruction of spawning ground: Suspended solids in even small quantities may have a serious effect on the spawning sites of salmon and trout. At the spawning site water carries oxygen to the eggs. Silt deposition block water movement and the eggs are asphyxiated.

Bioaccumulation: The non-bio degradable water pollutants like organochlorine pesticides, methylmercury and some others tend to accumulate in plants and animals for a long period-a phenomenon called bioaccumulation. These non-biodegradable toxic substances, following bioaccumulation, move into other trophic levels through the food chain. In case of DDT, for instance, 0.01 ppm concentration of the insecticide in a lake may find a bird at a magnified concentration of as much as, 1000 ppm in the following way:

Water body	Plankton	Fish	Bird
(0.01 ppm)	(2.50 ppm)	(200-250 ppm)	(1.000 ppm)

while the non toxic pollutants may become responsible to eliminate some species indirectly by depleting dissolved oxygen concentration.

The most important toxic materials arc Cu^{++}, Pb, As, Vanadium, Phenol, nitrate, chlorine, thiocyanates, cyanides, cresols, akyl suphonate, detergents, H_2S, etc. However some of these react between themselves to form more virulent toxins such as that between chlorine and thiocyanates to form cyanogen chloride.

$$KCNS + 4Cl_2 + 4H_2O \rightarrow \underset{\text{cyanogen chloride}}{CNCl} + KCl + H_2SO_4 + 6HCl$$

Generally speaking, the individuals of each species of animals or plant can stand a certain amount of a particular toxin, and if more is in the medium, they die.

The toxicity of most pollutants is also affected by the environment. The most important factors involved are temperature, oxygen content, pH, dissolved salts. Ammonia is much more toxic in alkaline than acid waters.

This gradual but steady increase in the concentration of toxic substances in the food chain at successively higher trophic levels is known as Biological magnification or Bio-magnification or Bioamplification.

Calefaction: Thermal pollution causes warming of water which increases the rate of exchange of salts in organisms. In such a situation organisms also become more succeptible to the effect of toxins. It also affects the diurnal and seasonal behaviour of aquatic organisms.

3. **Effect on man**

(a) Compounds of mercury, arsenic and lead contained in industrial wastes are poisonous. Inorganic salts of mercury are reduced into volatile and water soluble dimethyl mercury in presence of hydrocarbons. It enters into the fish through food chain and ultimately into the man and causes deformation of human body. It is recognized as a disease known as minamata.

(b) Persistent pesticide like DDT when gets entry into the food chain, accumulates in the carnivores. Through food chain in man DDT causes fatal diseases like leukemia and cancer.

(c) Ingestion of fluoride contaminated water for a long period causes gastric intestinal -troubles, allergies along with dental, neuromuscular as well as skeletal disorders. It may cause crippling of people. These symptoms are characterised as a disease known as fluorosis.

(d) When nitrates, used as fertilizers, these become able to contaminate drinking water by seepage. These pass into the intestine with ingested contaminated water. Intestinal bacteria convert these nitrates into nitrites. These nitrites reach into blood circulation due to more affinity of haemoglobin for nitrites even than oxygen. Combination of nitrites with haemoglobin decreases the oxygen carrying capacity of blood. This is recognised as a disease known as methemoglobinema.

(e) Cadmium is another metal effecting man. In Japan, consumption of rice affected with cadmium, caused a disease, named ltai-itai. The rice fields were irrigated with effluents released by zinc smelters. It is a painful bone disease and results in liver and lung cancer. Cadmium, inflact, gets accumulated in liver, kidneys and pancreas and interferes with the activities of some enzymes.

(f) Pesticide which are non-degradable may cause endemic familial arthritis in man. This has been reported in Andhra Pradesh,

(g) Arsenic accumulates with age in human tissues such as spleen, aorta and hair. As toxicity it creates vomiting, diarrhoea, nausea, severe irritation of nose and throat, abdominal pain, skin eruptions, inflammation and even death.

(h) Selenium toxicity is due to interference with sulphur metabolism and function. It also effects enzyme systems of man. Its toxicity also causes loss of nails and hair.

(i) Metal toxicity at cellular level causes deranged reproduction, maturation and differentiation. Some metals effect the permeability of cell membrane and disturb energy metabolism, others decrease the stability of lysosomal membrane, making disruption of cell functions.

MARINE POLLUTION

Like ponds, lakes, rivers our seas and oceans suffer from pollution. The main reason why mixing of any pollutant in the sea is limited because of physical constrains. Due to thermocline the pollutant mixing takes place, on an average, only in the top hundred metres.

The definition of marine pollution, as given by the Oceanographic Commission of UNESCO, states- "Introduction by man, directly or indirectly, of substances into the marine environment resulting in such deleterious effects as harm to living resources, hazards to human health, or hindrance to marine activities." The definition fails to include the impact of natural phenomena, such as oil naturally seeping out of the sea bed, excessive run off of fresh water after heavy rains, or volcanic eruptions with the resultant ash settling on the sea bottom and smothering the life there. A better definition of marine pollution would be; "any impaitment of its quality that adversely or unreasonably affects the subsequent uses of seawater."

Causes of marine pollution: Major sources of marine pollution are:

1. Sewage sludge
2. Industrial effluents
3. Oil spills and discharge from marine vassels
4. Toxic wastes in sealed containers

Organic pollution causes the excessive multiplicaton of harmful organisms, such as dinoflagellates, which sometimes give the water a red tinge.

The toxicity of fuel oil no. 1 is 20 ppm for fish and 0.4 to 0.6 ppm for other marine forms. The rates for degradation by natural means vary from 36 to 360 $\mu g/m^2/yr$. The isoperenoids, alicyclic and aromatic components of crude oil can be detected even two years after an oil spill.

Although radioactive wastes are diluted before releasing into sea, many living organisms selectively absorb them. Thus the radioisotopes of cesium, zinc and cobalt are accumulated in the soft tissues, while those of radium, strontium and calcium are found in the bones. Sea weeds concentrate cobalt and iodine. Even the bottom sediments accumulate plutonium by a concentration factor of 10^4-10^5.

With the heating of seawater by discharged coolant water, the enhanced temperature leads to the replacement of diatoms and green algac by blue-green algae, which therefore, are indicators of thermal pollution.

Control of Water Pollution

The International Institute of Applied Systems Analysis in Australia has warned that water pollution will be India's major problem in 25 years unless, sewerage and sanitation facilities are improved. It said that accumulated human wastes could mix with open water resources resulting in epidemics. Out government has also adopted many methods to clean up rivers and lakes as well as to check the further pollution of rivers and lakes. Some of the important suggestions and steps taken to minimize the pollution are as follows:

1. Raw sewage should be treated properly in the sewage treatment plant to such an extent that discharged products must become harmless. Sewage treatment involves the grounding up of solid materials and solids are allowed to sediment. The effluent is then well aeriated to induce bacterial decomposition of organic compound and again for removing bacteria it is chlorinated. Finally nitrates and phosphates are removed and treated water is discharged into the rivers.
2. Industrial effluent contain various kinds of toxic compounds. These should be treated chemically before releasing into the rivers and lakes.
3. Utilization of wastes such as excreta of man and cattles in preparing biogas and gobar gas is also helpful in controlling water pollution.
4. Legal restrictions should be imposed on releasing wastes into the rivers and other water resources without proper water treatment or processing.

SOIL POLLUTION

Introduction: The land is usually known as solid part of the earth's surface. A major global concern has been weather, at the present rate of population growth, there will be, at the turn of the present century, enough land to meet the long-term worldwide demands for food, fibre, fuel and shelter at reasonable costs.

The addition of any substances to soil which ultimately changes the physical, chemical and biological properties of land is known as land or soil pollution.

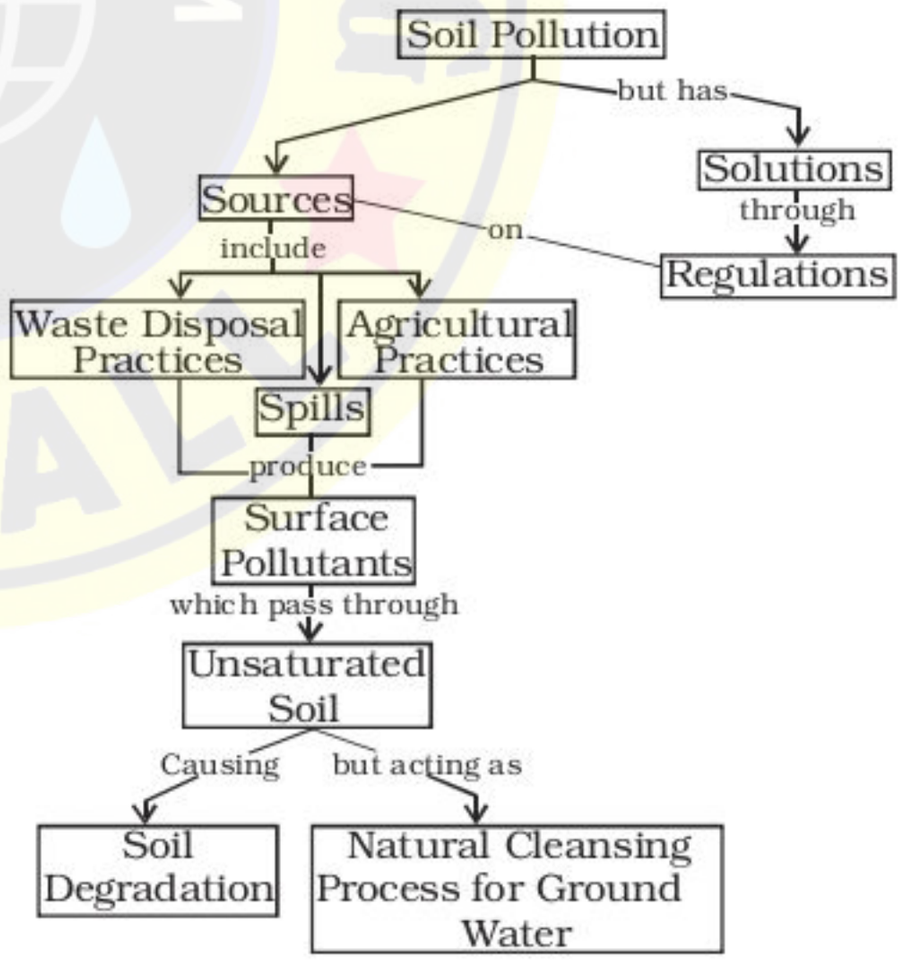
Sources of Land (Soil) Pollution

Various factors or agents causing land pollution are known as land pollutants. Land pollutants may be of various types, such as:

1. Municipal wastes
2. Industrial wastes
3. Agricultural activities
4. Commercial activities
5. Hazardous solid wastes

A brief description of about some important land pollutants is given below :

1. **Household wastes:** The common practice of disposing solid house hold and office wastes such as discarded food, garbage, papers, cartoons, containers, clothes, polythene bags, damaged furnitures, etc. in most careless manner affects the quality of land and its soil.
2. **Industrial wastes :** Industrial wastes discharged in the form of flyash, rubbish, pulp etc., also cause land pollution. Industrial pollutants are increasing in quantity with the advancement of industry and technology and causing more and more problems.
3. **Agricultural activities:** Measures adopted for extensive farming have also an increasing effect in changing the basic characters of our land. Water used for irrigation in crop fields brings various soluble salts with itself in huge quantity. It becomes accumulated on the soil surface and increases the alkalinity of soil which ultimately lowers down the fertility of land. Salts present in the lower layers of land' also cause alkalinity because during summer or drought these move up by capillary action and form a white crust on the surface of land. Use of chemical fertilizers also add chemical soil pollutants in the land, such as compounds of nitrate, phosphate, sulphate etc.



Showing model of soil (land) pollution

4. **Pesticides:** Extensive farming according to modern agricultural technology has increased the utilization of various kinds of insecticides and pesticides. These vary in having their life period as toxic substances. Some pesticides and herbicides

such as organo-phosphaes are considered to be degradable as these are converted into harmless substances within short period but most of them are non-degradable and do not break down into harmless substances for many years. These remain in the soil for a long period. Mercury, lead or arsenic containing pesticides, chlorinated hydrocarbons, DDT, eldrin etc, are non degradable. These become accumulated in the soil and cause land pollution.

5. **Excavation:** Removal of upper layers of land during excavation for mining, brick making, construction of road, rail, building, etc. cause land pollution. These commercial activities are increasing through out the world.
6. **Deforestation :** Deforestation causes degradation of the soil, salt infestation, flooding of lowlands, sedimentation, nutrient stress and soil acidity. Formation of wastelands is also a type of land pollution.
7. **Radioactive fall outs :** Nuclear explosion during atomic test causes fall of radioactive dusts on the surface of earth. These dusty substances are known as radioactive fall outs. Some of the radioactive isotopes have very long half life time. These remain alive for a ????

Effects of Land Pollution

1. Land pollution causes a change in the original structure and fertility of the soil.
2. Pathogens contained in the wastes from hospitals contaminate the soil, vegetables and crops and becomes sources of causing many diseases.
3. Radioactive isotopes contained in the radioactive fall outs and toxic substances contained in the industrial wastes and pesticides when pass to man through food chain various types of fatal diseases may occur.
4. Salinity and erosion of land decrease the fertility of land.
5. Non-degradable pesticides retained in the soil increase the resistancy of many insects where as these insecticides/pesticides also eliminate some other organisms from the ecosystem creating ecological imbalance.
6. When these land pollutants reach our water resources with run off during heavy rain and flood are able to pollute our water resources.
7. Soil pollutants are also responsible for ground water pollution.
8. Various chemical pollutants inhibit processes of soil formation.

Collection and Disposal of solid waste

Waste (municipal, industrial) involves a multiphase activity consisting of collection, interim storage, transport, treatment and disposal. All these steps are technically, as well as organizationally, highly interdependent. Safe collection and transport of hazardous waste constitute a critical link in the chain between the point of its generation and place of its treatment and disposal.

Collection: In India, collection and transport of municipal and household wastes are done following three broad procedures:

1. In most of the small and class II towns, household and industrial wastes are dumped in specific sites of disposal by municipal personnel assigned for this particular job. Industrial wastes in huge quantities are collected by specialised industrial workers.
2. Recently, various municipalities throughout the country have adopted direct collection method. In this process, municipal workers collect domestic wastes from door to door and make interim storage in some specified sites, from which they are taken up and transported to the specific disposal area.
3. In advanced countries and some major Indian cities, employ a different technique for waste collection. In this process waste disposal containers or vehicles are being kept in some specific areas for a few days. The municipal staff collect the waste materials from different premises, offices or industrial establishments and dump into these containers, which are later transported to the area of disposal.

Waste Disposal: The disposal of the solid waste also requires careful planning. At present four different means of disposal are commonly practised:

1. Landfill disposal
2. Incineration
3. Dumping at sea
4. Underground disposal

1. **Landfill disposal:** Landfill disposal processes are most widely used practice. Landfill disposal methods are of two types.
   (a) Open dumping
   (b) Sanitary landfill

   (a) **Open dumping:** In this method waste materials are dumped in open lowlands for away from the city or town. Such dumping is less expensive and need not much planning but it is not environment friendly. They cause other environmental problems by ruinning the appearance of the area. Various disease producing insects like-mosquitoes, files and mice inhabit those areas. The wastes give off foul odour. Most dumps allow some burning which again creates air pollution. Furthermore rain water through these wastes create water pollution to adjacent aquatic bodies.

   (b) **Sanitary landfill:** It is more environment friendly i.e. little damage to the environment. Now-a-days, well planned highly environment friendly landfill sites are constructed with proper preventive measures against any leaching or spreading of any pollutant. In this process, the area to be filled, is lined with a

non-porous substance like clay or high-density polyethylene to prevent the wates from leaking to the surrounding areas. The wastes are packed and dumped at the site and are convered with earth daily to prevent insects and rodents from getting into the waste.

The wastes in the landfill are subjected to bacterial decomposition, resulting in the change in physical, chemical and biological features. This process also generates different gases such as, CO_2, CH_4 and little amount of H_2S and NH_3.

As the area gets filled up, it gradually becomes changed sufficiently, and this area can be used for various human activities.

2. **Incineration:** Incineration is one of the most efficient methods for waste disposal. This method is very useful for many industries and large cities which lack enough land for waste dispoal.

   This process involves burning of waste products and has been proved to be an excellent method of waste minimization, detoxification and waste disposal. But the cost of its operation is very high and thus it must be associated with the provision for reutilization of heat content of wastes. This is also a source of alternative energy. Like electricity.

3. **Dumping at sea:** The radioactive wastes are now-a-days disposed to the bottom of the deep sea. In this process radioacative wastes are separated in the form of solids and they are dumped at the deep sea in the container or vaults made of lead. Thousands of such containers have already been dumped into the sea by the developed countries, with a notion that deep sea is better equiped than the land for digesting wastes. Tragically enough, these containers leak sooner or later or even break off, causing serious effects on the marine ecosystem.

4. **Underground disposal:** Dumping of radio f active wastes under the ground is a very common practice, this is because underground disposal is an environmentally and economically viable option. The underground disposal of such wastes is acceptable only in inactive or partially active mines that meet specific geological and technical eriteria. Salt mines are often used for radioactive waste disposal, because unique properties of salt deposits prevent the interaction of wastes with other geological formations.

   Besides these above mentioned solid waste disposal methods, in India there are some other methods for solid waste disposals which are used in many places. They are:

   1. Composting
   2. Manure pits

1. Composting: Composting is a conventional method for the disposal of organic wastes, animal dung and human faecal matter. This process involves bacterial decomposition of organic wastes into humus, known as compost, which can be used as good fertilizer. Composting also give rise to CO_2 and heat that can be used for various purposes.

2. **Manure pits:** In rural areas there is no specific waste collection and disinfection facilities which usually cause land pollution due to indiscriminate dumping of wastes. Manure pits constitute a satisfactory solution to this problem.

   In this process, pits are digged, inside which wastes are dumped. These wastes include-organic, domestic and other materials used by the rural people. As the digs get filled up, these pits are covered with soil. After 5-6 months, the waste materials become transformed into manures and are used in agriculture.

NOISE POLLUTION

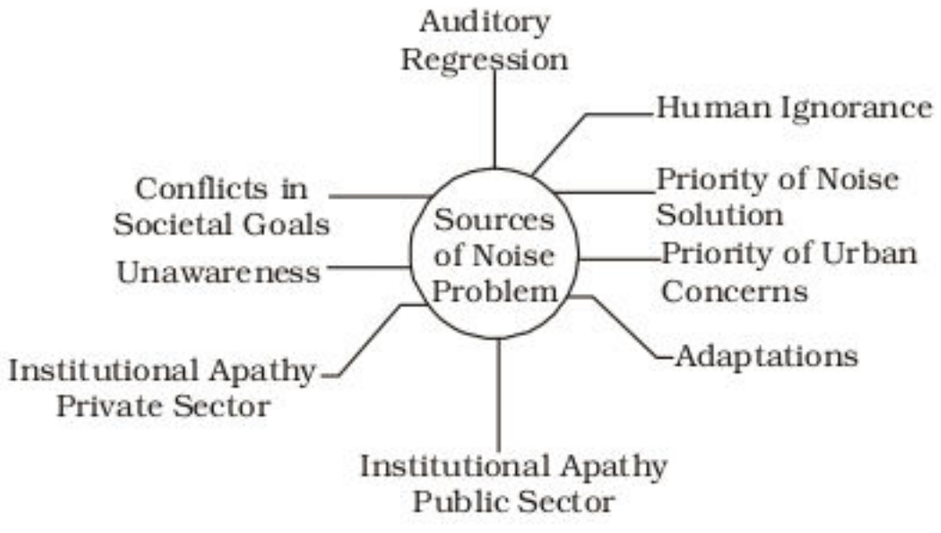
Introduction

Robert Alex Baron (1964) for the first time showed that noise, which forms an inseparable part of everyday living for many people, has damaging physiological and psychological effects. So noise pollution is yet another serious threat to man's environment. If we define noise as "unwanted sound" then noise pollution is unwanted sound "dumped" into the atmosphere without regards to the adverse effects it may have. Noise is an environmental phenomenon, it is an environmental pollutant, but it differs from other pollution in that it disappears fast.

Sources Of Noise Pollution

High intensity sound or noise pollution is caused by many machines man has invented during his technological advancement. Thus, there exists a long list of sources of noise pollution including different machines of numerous factories, industries and mills, different kind of auto and motor vehicles such as scooters, motor bikes, cars, heavy vehicles, social gathering, loud pop-music, supersonic aircrafts and others.

Noise is usually defined as unwanted sound or sound without value. The word 'noise' has been derived from Latin word 'nausea'.



Hypothetical representation of some sources of noise problems

Noise level measured in sound energy

Noise Source	Decibels
Threshold of hearing	0
Whsiper	30
Conversation	60
Domestic water pump motor	90
Heavy traffic	100
Festival pandel noise	100

Noise is measured in the unit of decibel (dB), which is a tenth of the largest unit, the bel. One decibel is equivalent to the fainest sound that can be heared by the human ear. Decibel (dB), a unit named after Sir Alfred Graham Bell.

Transport Noise

Noise from vehicular traffic, railways and airlines is the major source of pollution in urban areas. Road side rural areas are also affected seriously. A single truck may generate sound levels exceeding 90 dB. Recent use of electric and diesel engines has lowered the noise level to a great extent. The area around airport may exceed noise level beyond 150 dB.

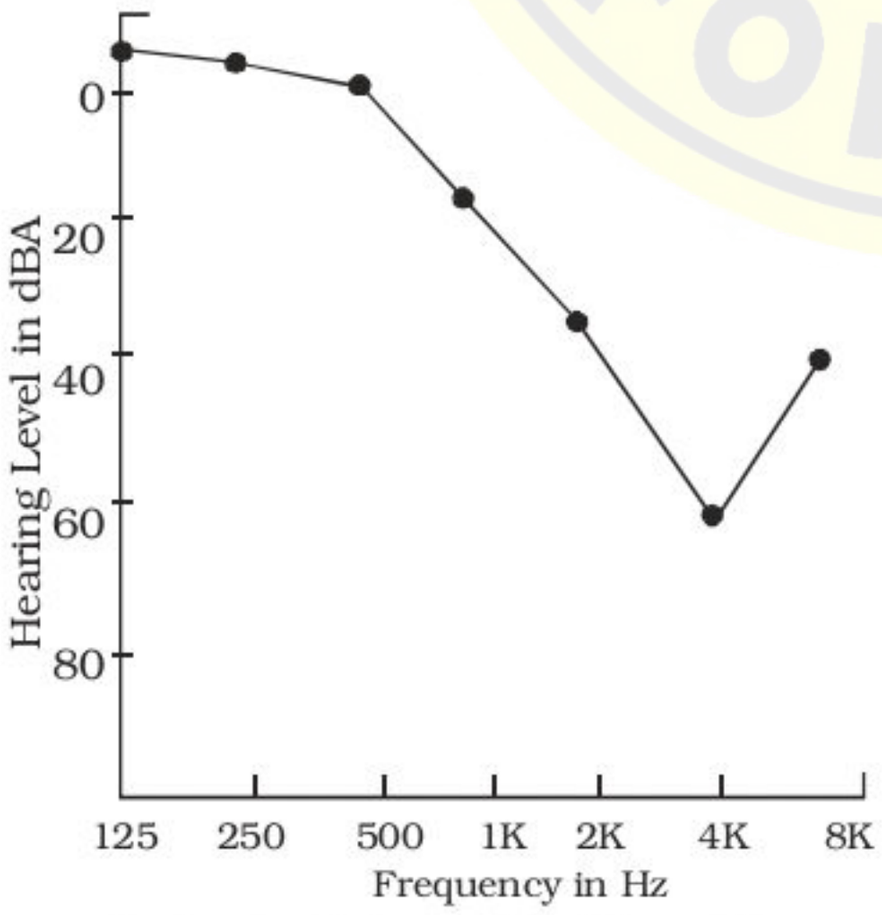
Occupational Noise

The industries and factories often generate noise of considerably high intensity. The workers are often subjected to 8-10 hours daily exposures for at least six days a week.

In our daily life, we make use of different gadgets like washing machine, vacuum cleaners, air cooler, air conditioner, pressure cooker, mixer, generators also produce considerable noise.

Neighbouring Noise

Man is greatly affected by the noise emitted from televesion, music system and high pitch conversation.



Hearing level of man with different frequency.

Social Noise

Various social, cultural and religious functions are sources of noise. Display of various fire works and crackers constitutes an integral part of our society causing noise problem.

Major nosie source in metropolitan cities is the automobile generated sound and its reverberations from the ill planned buildings on the road side.

EFFECTS OF NOISE POLLUTION

In a survey it has been observed that in a metropolitan city 8 persons out of 1,000 are week in hearing and out of 8 persons most or them are having deafness due to persistent noise called "steady state noise" due to traffic, loud speaker, loude conversation among the persons, ogans of demonstration etc. Again

ϕ "instant noise" e.g. sudden explosion of cracker or gunfire may cause deafness.

On the basis of extensive research into human response and preferences, the WHO has recommended noise assessment criteria in the form of noise exposure limits which are as follows:

Environment	Recommended Maximum Level : dBA
Industrial/occupational	
Community (Urban)	
(i) day time	55
(ii) night time	45
Indoor (domestic)	
(i) day time	45
(ii) night time	35

Standards to control urban noise pollution have also been laid down. The recommended ambient noise level limits for the various areas are as follows:

Area	Day Time (6 a.m to 9 p.m.)	Night Time (9 p.m. to 6 a.m)
	dBA	dBA
Industrial area	75	65
Commercial area	65	55
Residential area	55	45
Silence zones	50	45

Silence zones are areas up to 100 metres around hospitals, educational institutions and courrs.

Individual sensitivity to noise varies greatly from one person to another. Some effects of noise in human body are as follows:

1. One auditory system:
   (a) Partial loss of hearing and interference with understanding
   (b) Displacement of middle ear bones.
   (c) Disruption of some parts of organ of Corti.
2. Emotional disturbances: Noise may produce emotional disturbances of annoyance, irritation, quarrelsomeness, loss of attention, etc.

3. Susceptibility to infection and audiogenic stress:
   (a) Under experimental condition it has been observed that the subjects are more susceptible to the infection during exposure to noise.
   (b) Animals exposed to sound intensities about 120 dB for 3 hours of pituitary-adrenocortical axis causing increase in ACTH secretion,
4. Endocrine system :
   (a) Sound reduces the secretion of TSH from anterior pituitary depressing thyroid activity.
   (b) It has been reported that hypertension due to repeated exposure to sound have an elevation of urinary catecholamines.
5. **Digestive system :** People working in noisy areas become hypersensitive. Their digestive glands in the stomach and duodenum may develop ulcers,
6. Reproductive system: It has been proved experimentally that girls in cities who are exposed to intensive noise develop menstruation earlier. Increased weight of ovaries, rapid follicle maturation.

   Hazardous noise levels develop defects in the nervous system of foetus. Later on, its, ill effects, are reflected in the behaviour of boy or giri.
7. Psychological effects: The schizophrenics exposed to noise have high secretion of norepinephrine and are similar to psychotics during extreme aggressive episodes.
8. Cardio-vascular system: Noise may cause high blood pressure, either systolic or diastolic, or both; vasoconstriction and left ventricular hypertrophy.
9. Brain: Less pronounced oscillation in the cortex. Morphological changes in neurons.
10. Pain sensation: Noise reduces pain sensation.
11. Physical and mental health:
   (a) Victor Green, noted city planner, holds that "noise is the agent that brings death closer bit by bit".
   (b) Noisy environment-seriously curtail the total time asleep, cut down the amount of deep sleep and increases the number of waking reactions.
12. Vegetative effects: Auditory tracts are linked with the reticular activating system and alarm-sensitive structures of the brain. For this connection many of the effects of noise and the spread of a state of activation or alarm occur and may result in :
   (a) Impaired alertness
   (b) Disturbance of sleep
   (c) A feeling of stress.

   This activation affects the autonomic centres and produces the so called "vegetative effects" in the internal organs. These vegetative irritations are :
   (a) Rise in blood pressure
   (b) Acceleration of heart rate
   (c) Contraction of the blood vessels of the skin
   (d) Increase in metabolism
   (e) Slowing down of the digestive system
   (f) Increased muscular tension
   (g) Gastric ulcer
   (h) Colitis
   (i) Migraine
   (j) Various mental diseases known as "neurohumoral stress response."
13. Human performance: Noise principally affects human performance in tasks requiring communication. Recent investigations have shown that aircraft noise influences speech communication in offices in the same predicatable way as industrial noise.
14. Muscle potential: Experimental studies have shown increased energy expenditure (metabolism) when working in noise.
15. Other physiological effects:
   (a) Feeling of vibration in the head.
   (b) Loss of equilibrium.
   (c) Vibration of eyeballs may cause distubances of vision.

"You may forgive noise but your atteries never will."

– Samuel Rosen

Control of Noise Pollution

The environmental (Protection), Act, 1986, recognises noise pollution as an offence and Section 6(1)b allows the Govt, of India to make rules on the maximum limits of concentration of pollutants, including noise. Noise pollution also figures in the Indian Penal Code, the Motor Vehicles Act., 1939, and the Industries Act., 1951. Despite all this, the problem has not been tackled and it continues to inconvenience the people. The main reason for this is that the concept is vague which makes setting of standards/limits difficult. The other contributing factors are the non-availability of measuring equipment and the lack of will to handle the problem.

The Government of India created a new Department of Environment in 1980. Subsequently in 1985, Environment and Forests departments were united. In 1986 a full-fledged act was made on Environment - "Environment (Protection) Act.", 1986. Recommendations of central Pollution Control Board (1986) for controling noise pollution are as follows :

1. Banning of the use of shrill or musical horns.
2. Banning of bursting of crackers.
3. Improvement of the road condition of rhe state
4. Liberal plantation of shrubs, creepers and trees of broad-thick leaves.

□□□