Course Outcomes (CO's)

CO1. Environmental studies course will provide necessary information and knowledge about the various aspects of environment, ecosystems, and related biodiversity.

CO2. Students will be able to learn and understand about the availability and sustainable use of resources, environmental problems and their short term and long-term impacts to humans.

CO3. Course will help them to learn about environmental policies and protocols, social issues and role of human in conservation and protection of environment.

CO4. Overall course, will help students to develop skills and ability of understanding environment human relationship.

SYLLABUS

Unit 1.

Fundamentals: The multidisciplinary nature of environmental studies: Definition, components, scope and importance, need for public awareness, natural resources. Ecosystem: concept, Structure and function of an ecosystem, Types, Functional Components, Different ecosystems, biogeochemical cycle. Biodiversity: Introduction to biodiversity, biogeographical classification, India as a mega diversity nation, endangered and endemic species of India, threats to biodiversity and conservation of biodiversity. Bioprospecting and Biopiracy.

Unit 2

Environmental Pollution: (a) Air Pollution: Source, Types, effects on biosphere and Meteralogy, Air Quality Controi. (b) Water Pollution: Types and Sources. (c) Soil Pollution: Types and Control. (d) Noise Pollution: Effect, Control (e) Thermal Pollution. (f) Radiation Pollution (g) Solid waste Management, (h) Pollution Prevention, (i) Disaster Management

Pollution

- Pollution is defined as any undesirable change in composition of air, water, soil or any segment of environment against nature.
- Includes the accumulation of matter due to unknown activities in the environment; rates of flow which exceed the capacity of the ecosystem to either neutralize them below harmful levels.
- Pollution is classified, on the basis of factors causing pollution as:

Air pollution

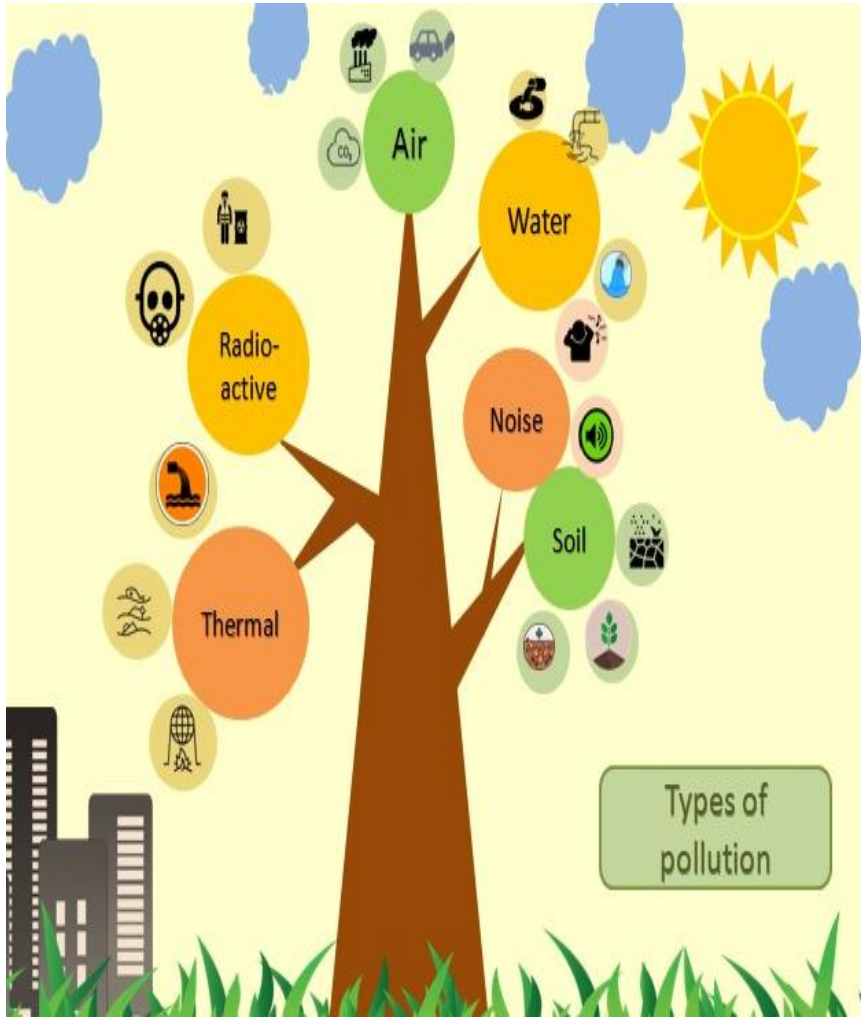
Water pollution

Soil pollution

Solid waste pollution

Hazardous waste pollution

Noise pollution



Air pollution

- It is the presence of chemicals in atmosphere in quantities and duration that are harmful to human health and environment.
- **Sources:**

1. Natural sources:

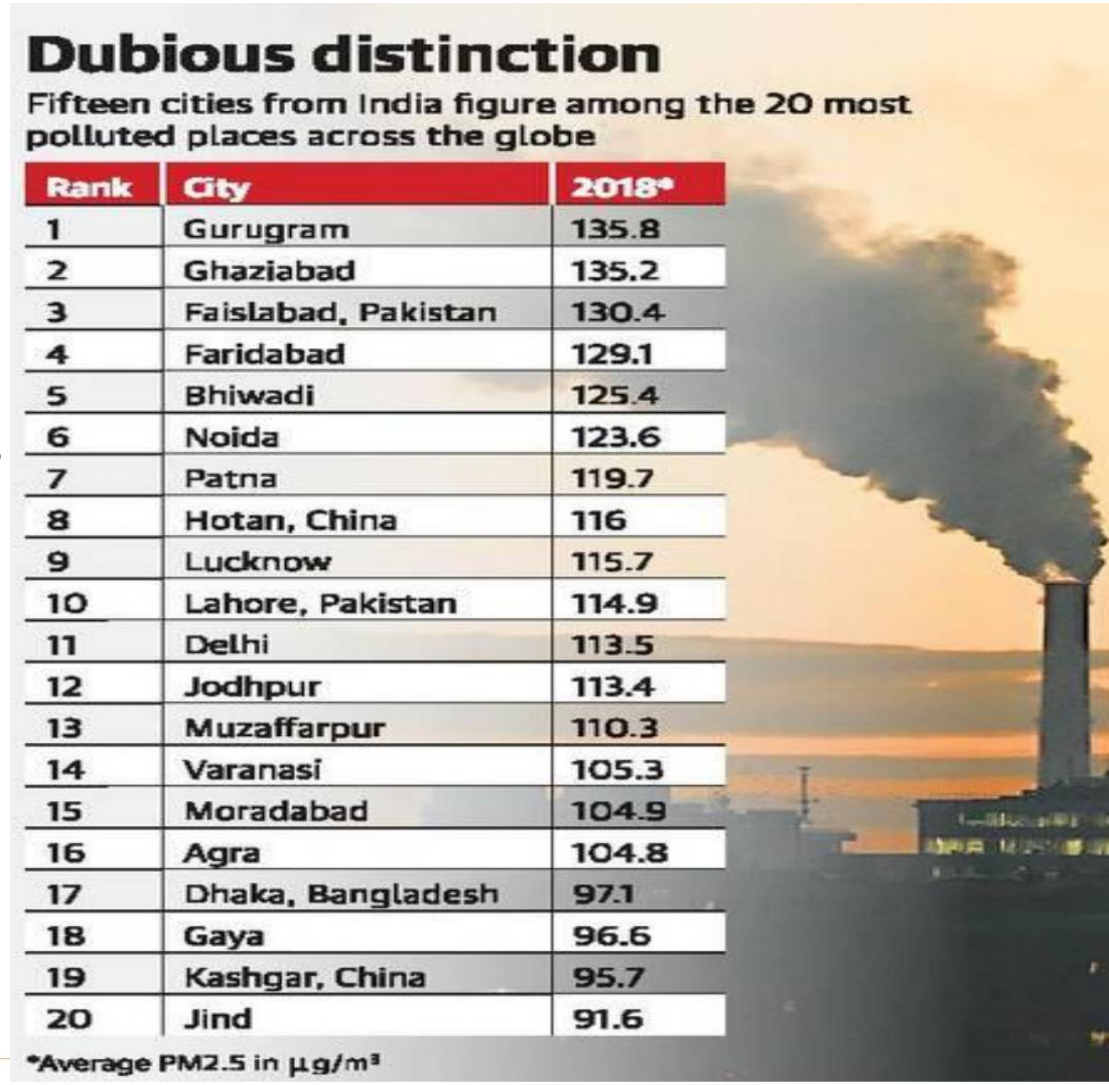
→volcanic eruptions emitting poisonous gases like SO_2, H_2S, etc.

→decay of vegetation,

→marsh gases

→pollen grains

→forest fires.



Dubious distinction

Fifteen cities from India figure among the 20 most polluted places across the globe

Rank	City	2018*
1	Gurugram	135.8
2	Ghaziabad	135.2
3	Faislabad, Pakistan	130.4
4	Faridabad	129.1
5	Bhiwadi	125.4
6	Noida	123.6
7	Patna	119.7
8	Hotan, China	116
9	Lucknow	115.7
10	Lahore, Pakistan	114.9
11	Delhi	113.5
12	Jodhpur	113.4
13	Muzaffarpur	110.3
14	Varanasi	105.3
15	Moradabad	104.9
16	Agra	104.8
17	Dhaka, Bangladesh	97.1
18	Gaya	96.6
19	Kashgar, China	95.7
20	Jind	91.6

*Average PM2.5 in µg/m³

- **Man made sources:**
- **Population Explosion:** Increase in population will create global warming and the emission of Greenhouse gases.

→ also cause an increase in demand for food followed by the need for more land for cultivation thus causing destruction and loss of forest cover and wildlife.

- **Vehicular Discharges**
- **Burning of fossil fuels and fires**
- **Rapid Industrialization**
- **Agricultural Activities:** Pesticides and fertilizers
- **Modern Warfare**
- **Smoking**

Air Pollution
A Major Health Risk

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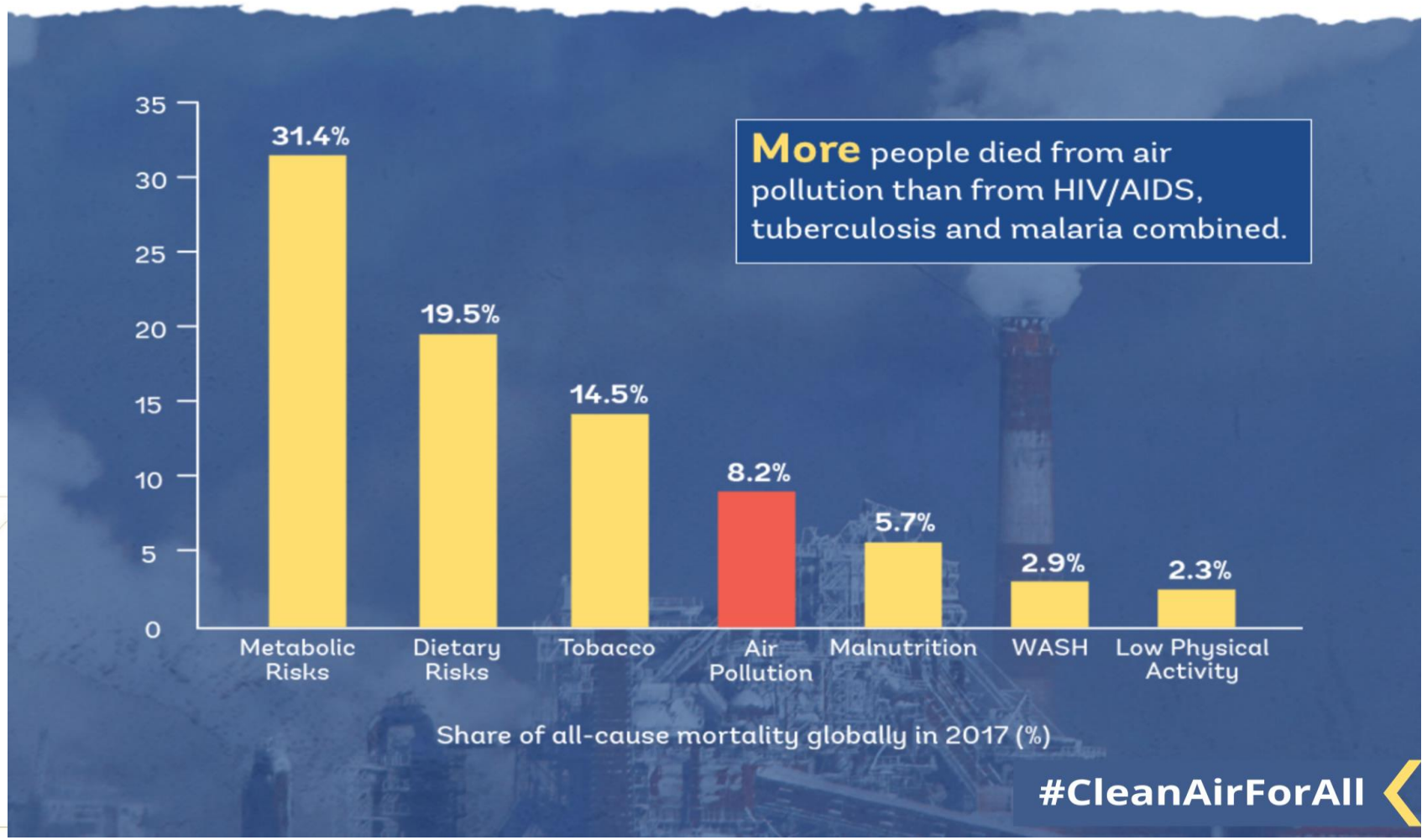
SCHOOL OF ENGINEERING AND TECHNOLOGY

In 2017 as many as **5.39 million** people died prematurely from exposure to air pollution globally.

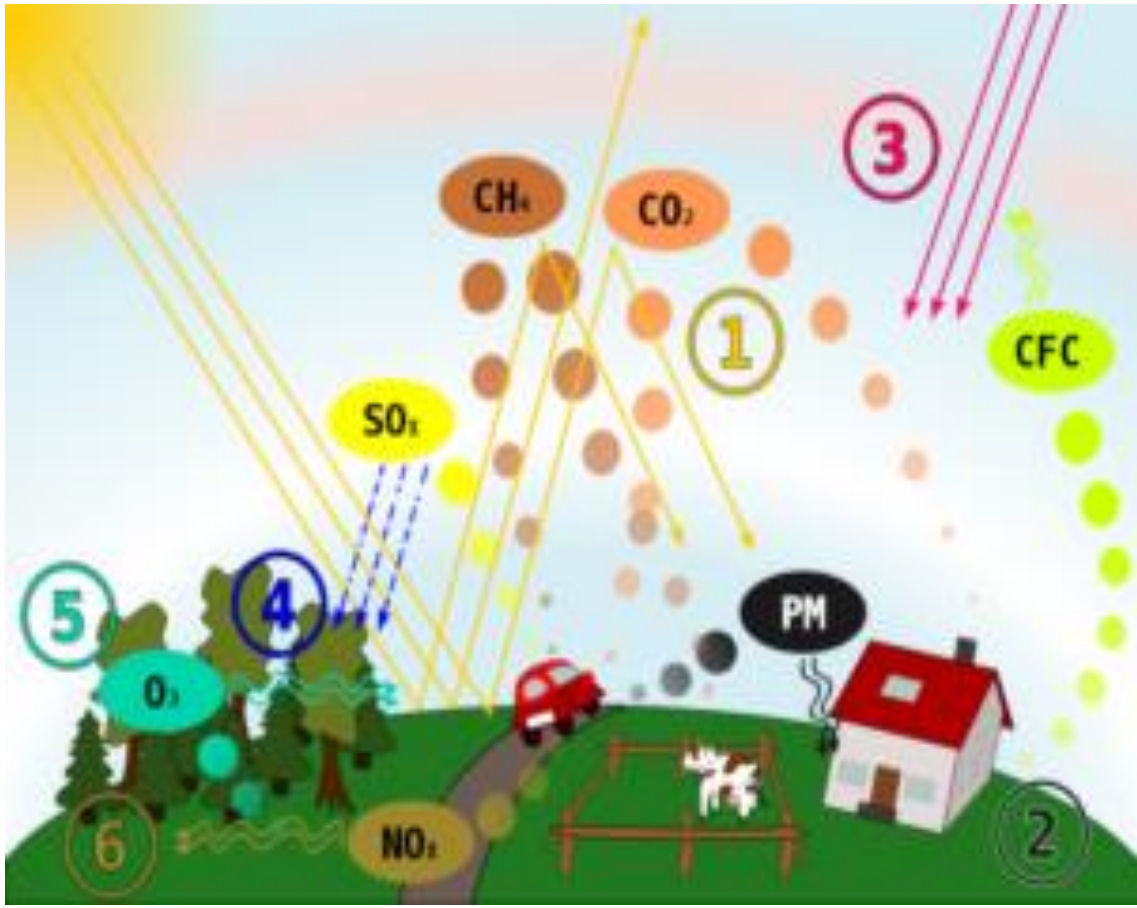


Types of Air Pollutants

On basis of physical state:

1. Gaseous pollutants: gases which mix with air without settling down. Example- CO, NO_2 , SO_2 , SO_3 etc

2. Particulate pollutants: finely divided solids or liquids. Example- dust, smoke, smog, lead, mercury, etc.



PRIMARY POLLUTANTS: It can be defined as a harmful chemical that directly enters the air as a result of either natural or man-made activities.

Oxides of carbon:

Carbon monoxide: →It is a colourless, odourless, non-irritating but very poisonous gas.

→It is a product of incomplete combustion of fuel such as natural gas, coal or wood. Vehicular exhaust is a major source of carbon monoxide.

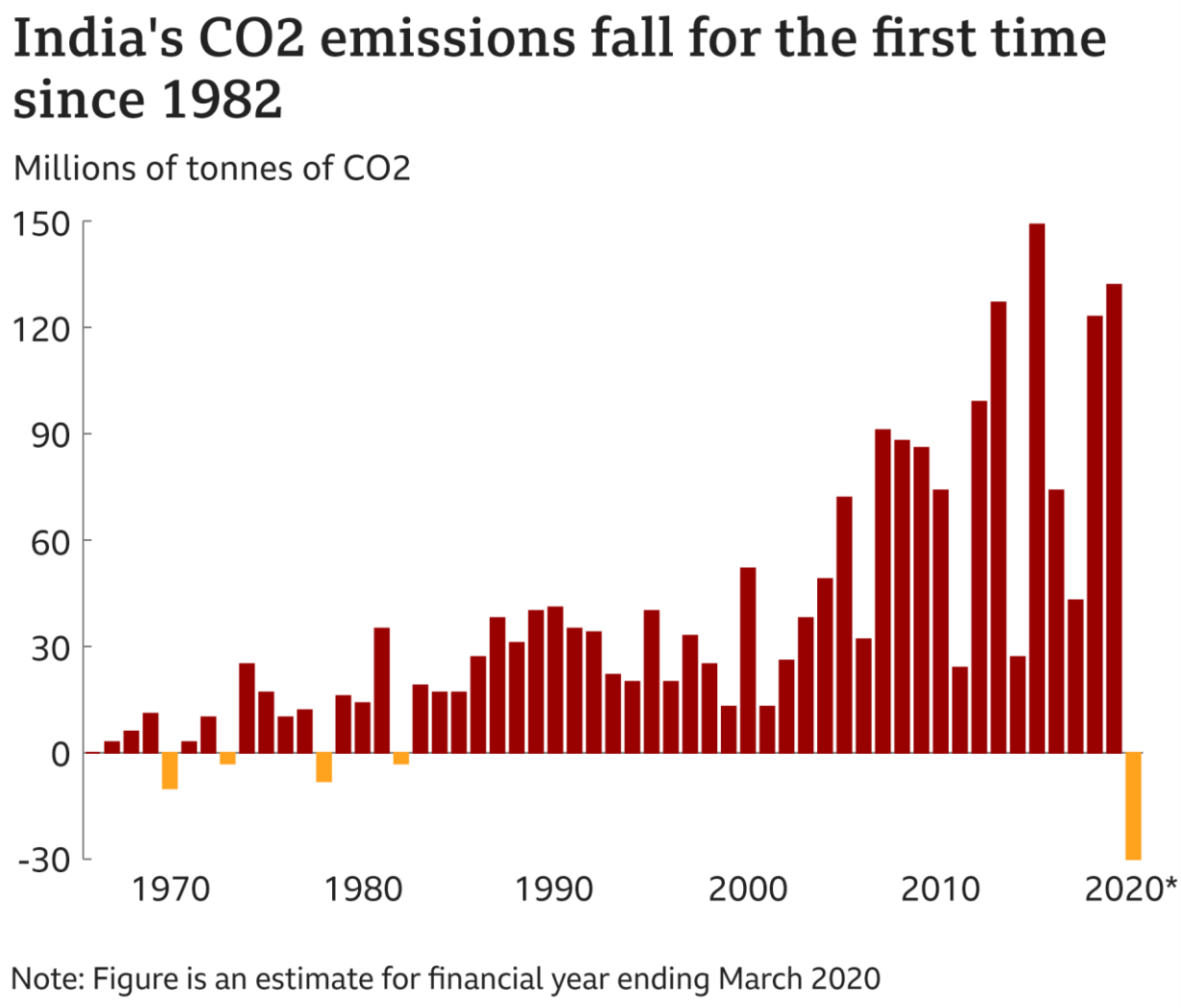
→On inhalation, CO passes into the blood stream through the lungs. Here, carbon monoxide displaces oxygen from haemoglobin to produce carboxyl haemoglobin, thus reducing the oxygen carrying capacity of blood

$$O_2Hb + CO \longrightarrow COHb + O_2$$

- **Carbon dioxide (CO_2):** → A greenhouse gas emitted from combustion but is also a gas vital to living organisms. It is natural gas in the atmosphere.

→It is the basic end-product obtained on burning fossil fuels, paper, leaves and other carbon-containing material.

→Although carbon dioxide has no direct effect on health, but with higher concentrations (above 10 per cent) it causes global warming, acid rain and Greenhouse Effect.



- **Nitrogen oxides**: →NO, N_2O, NO_2, N_2O_5 are introduced in atmosphere by natural and human activities.

→Specially nitrogen dioxide is emitted from high-temperature combustion. It is the chemical compound with the formula NO_2. It is responsible for photochemical smog, acid rain etc

→At normal temperature, oxides of nitrogen are relatively harmless but at high temperature, atmospheric nitrogen combines with oxygen to produce nitric oxide (NO) which causes asphyxiation at high concentration.

- **Sulphur oxides (SOx): →** SO_2 is produced by volcanoes and in various industrial processes.

→Since coal and petroleum often contain sulphur compounds, their combustion generates sulphur dioxide.

→Further oxidation of SO_2, usually in the presence of a catalyst such as NO_2, forms H_2SO_4, and thus acid rain.

→It corrodes limestone, metals and even clothes. It is also very injurious to the respiratory system, mainly to the lungs.

- **Particulate Matter**: → Particulates alternatively referred to as particulate matter (PM) or fine particles, are tiny particles of solid or liquid suspended in a gas.

→Sources of particulate matter can be manmade or natural. Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray.

→Human activities, such as the burning of fossil fuels in vehicles, power plants and various industrial processes also generate significant amounts of PM.

→Suspended particulate matter of smaller sizes can penetrate deep into the lungs, damaging lung tissue

→These particles also get deposited on plant leaves and block the stomata of the plant, thereby decreasing the rate of transpiration, respiration and photosynthesis causing the vegetation to perish.

- **Hydrocarbon:** → VOCs are an important outdoor air pollutant.

→They are often divided into the separate categories of methane (CH_4) and non-methane (NMVOCs). Methane is an extremely efficient greenhouse gas that contributes to enhanced global warming.

→Other hydrocarbon VOCs are also significant greenhouse gases via their role in creating ozone and in prolonging the life of methane in the atmosphere, although the effect varies depending on local air quality.

→Within the NMVOCs, the aromatic compounds benzene, toluene and xylene are suspected carcinogens and may lead to leukemia through prolonged exposure. 1, 3-butadiene is another dangerous compound which is often associated with industrial uses.

Secondary pollutants:

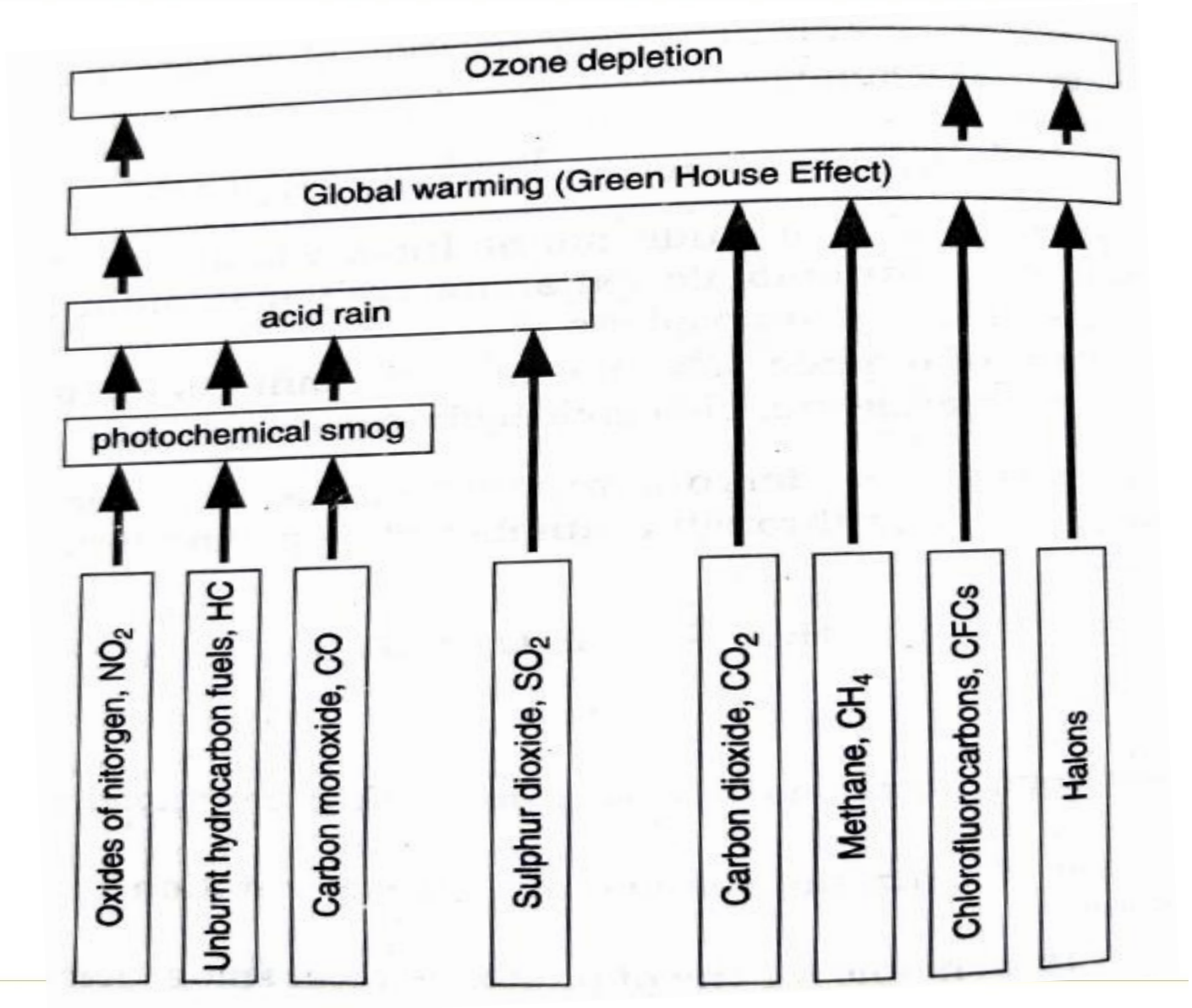
- **Secondary pollutants are formed by primary pollutants through their reaction with normal atmospheric compounds.**

- **Ozone (O_3):** Ozone is a secondary pollutant formed by photochemical reaction between primary pollutants and natural atmospheric gas near the earth's surface. The tropospheric ozone is bad ozone as it contributes to photochemical smog and global warming. Ozone also affects the respiratory and nervous system.
- **Sulfuric acid and nitric acid** (component of acid rain): Acid rain forms when water in the air combines with nitrogen oxides and sulfur dioxide (two types of PRIMARY pollutants) and then falls down the surface of the Earth. It has many damaging effects on vegetation, lakes, fish, buildings and other structures.
- **Smog**: When ultraviolet light from the sun reacts with nitrogen oxides in the atmosphere, photochemical smog is produced.
- **Peroxyacyl nitrates (PANs):** It is produced in the atmosphere when oxidized volatile organic compounds combine with nitrogen oxide. It is a component of photochemical smog.

FORMATION OF SECONDARY POLLUTANTS

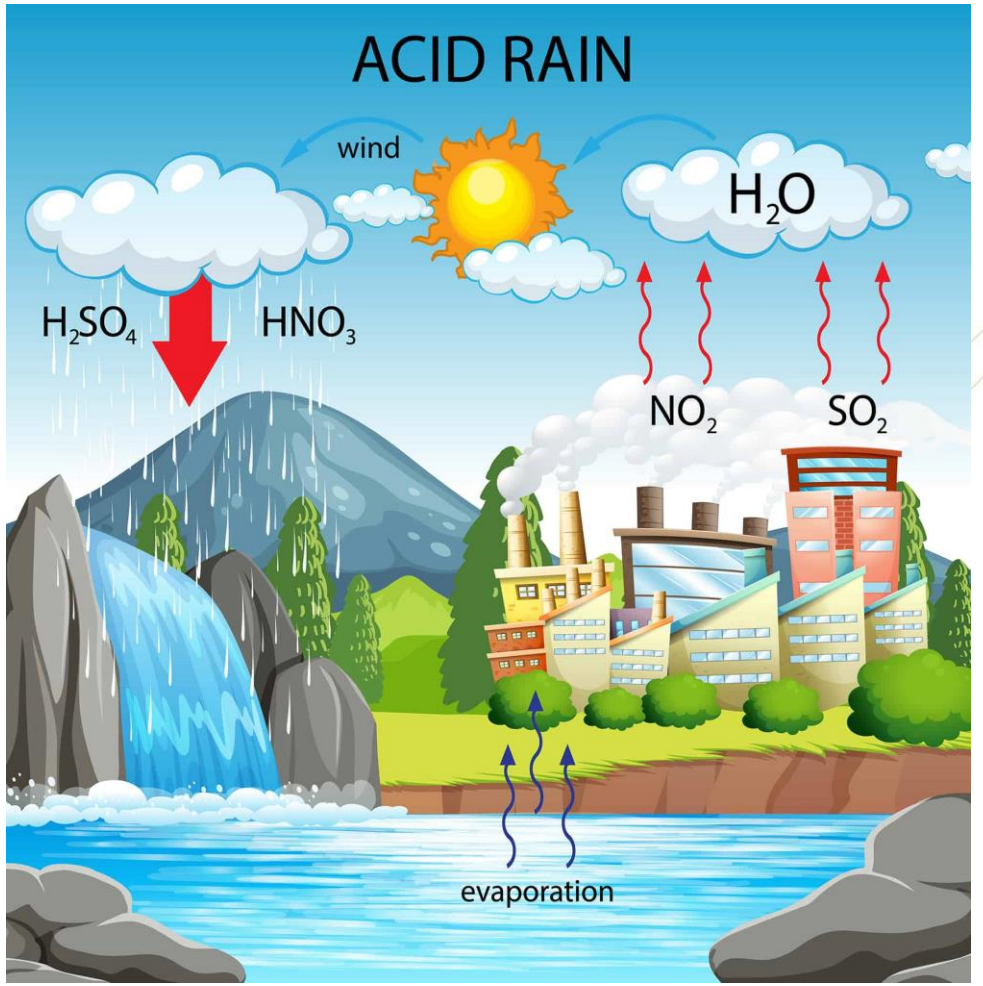
Primary pollutant	Reactions	Secondary pollutant
CO_2	$\xrightarrow{H_2O}$	H_2CO_3
H_2S	$\xrightarrow{2O_2}$	H_2SO_4
SO_3	$\xrightarrow[(O_2)]{H_2O}$	H_2SO_4
NO_2	$\xrightarrow{H_2O}$	HNO_3, HNO_2, N_2O
$HF_{(g)}$	$\xrightarrow{H_2O}$	$HF_{(l)}$
SiF_4	$\xrightarrow{H_2O}$	H_2SiF_6

Environmental effects of air pollution



Environmental effects of air pollution

- **Acid Rain**- In polluted environments, the rain passes through an atmosphere polluted with oxides of sulphur (SO_x) and nitrogen (NO_x). The falling rain water reacts with these oxides to form mixture of sulphuric acid and nitric acid and water. This is known as acid rain.



- **Effects of Acid rain-**

1. Acidification of lakes and streams.
2. Damage to the vegetation
3. Damage to buildings
4. Toxic metals like mercury and cadmium are released due to acidification of soil. These toxic metals end up in drinking water, crops and fishes.

- .

- **Greenhouse effect-** It is the rise in temperature of the earth because certain gases absorb heat from the sun.

➢ Natural greenhouse effect is responsible for life on earth. But enhanced green house effect, due to industrialisation, is responsible for global warming

➢ **Greenhouse gases:** carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), Chlorofluorocarbons (CFC's)

➢ **Effects**

→Computer model suggest that doubling of CO_2 may rise the temperature between 1 and 3°C

→Increased temperature may melt ice caps and glaciers, causing sea levels to rise, resulting in floods

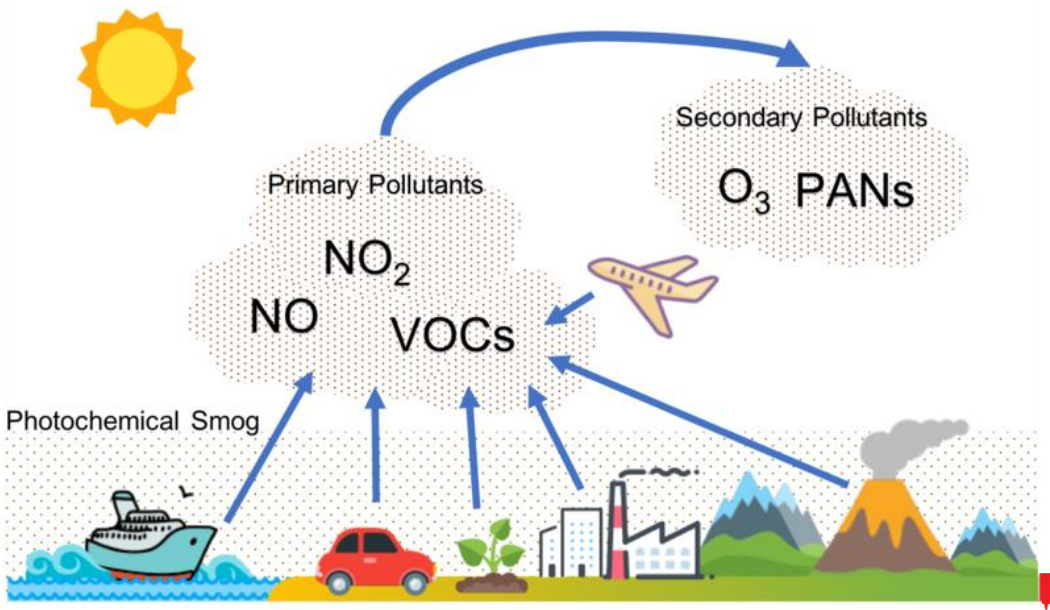
→Changing regional climates could alter forests, crop yields and water supplies

- **Photochemical smog**

➢ Volatile hydrocarbons and nitrogen dioxide in the presence of sunlight undergo a photochemical reaction. The products are peroxyacetyl nitrates (PANs) and ozone.

$$\text{Hydrocarbons} + NO_x + \text{Sunlight} \longrightarrow \text{Photochemical smog}$$

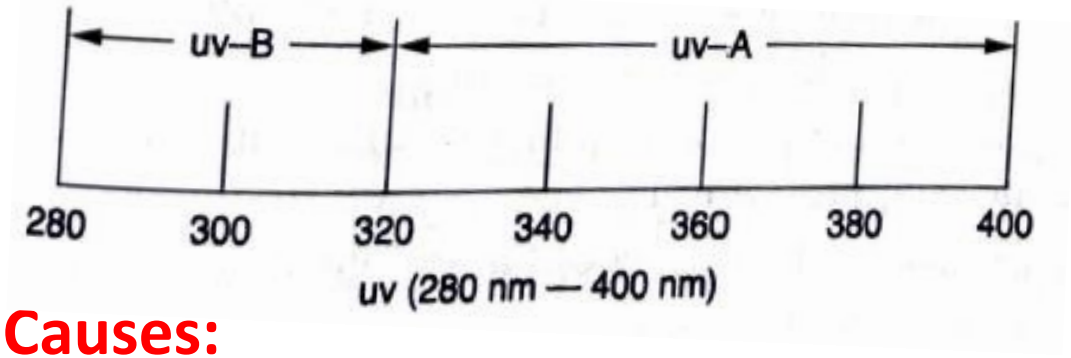
➢ O_3, PAN and NO constitute photochemical smog

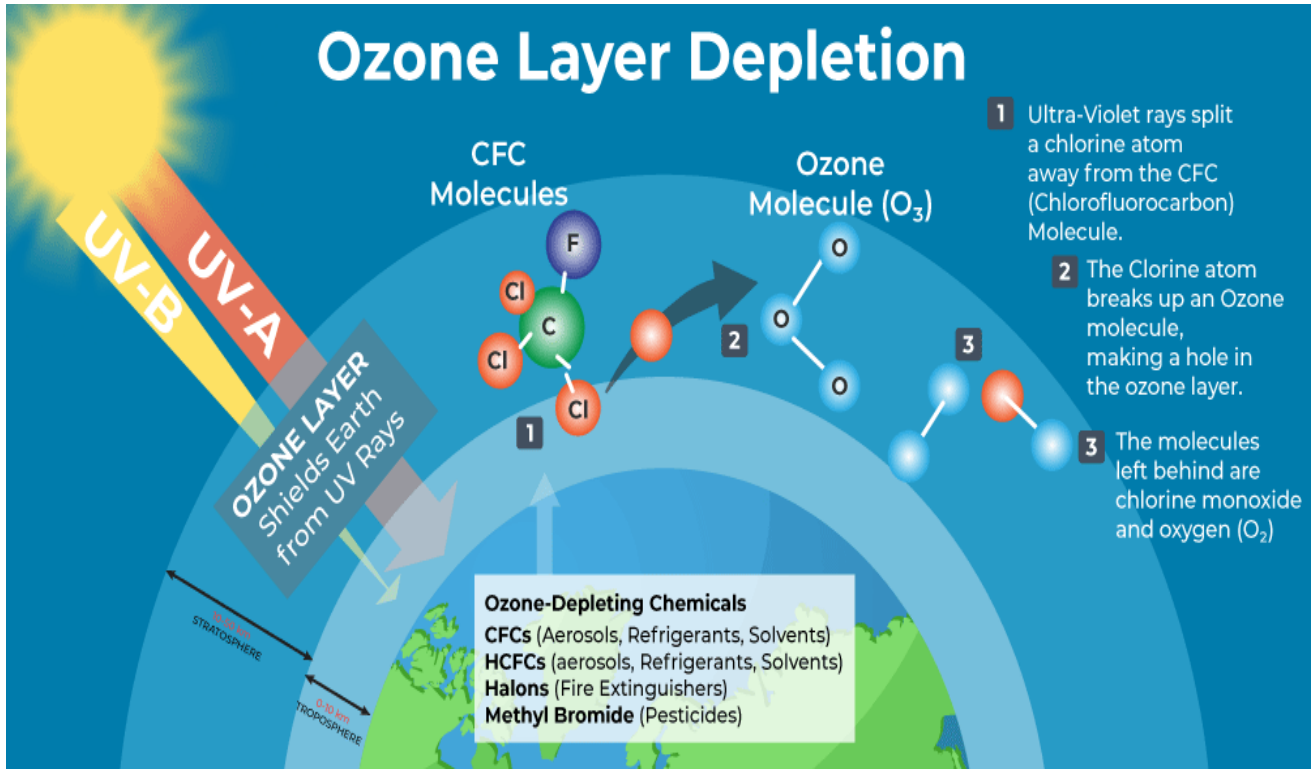


Toxic Chemical	Source	Environmental effects
Nitrogen oxides (NO and NO_2)	• combustion of oil, coal, gas in both automobiles and industry • bacterial action in soil • forest fires • volcanic action • lightning	• decreased visibility due to yellowish colour of NO_2 • NO_2 contributes to heart and lung problems • NO_2 can supress plant growth • decreased resistance to infection • may encourage the spread of cancer
Volatile organic compounds (VOCs)	• evaporation of solvents • evaporation of fuels • incomplete combustion of fossil fuels • naturally occurring compounds like terpenes from trees	• eye irritation • respiratory irritation • some are carcinogenic • decreased visibility to due to blue-brown haze
Ozone (O_3)	• formed from photolysis of NO_2 • sometimes results from stratospheric ozone intrusions	• bronchial construction • coughing wheezing • respiratory irritation • eye irritation • decreased crop yields • retards plant growth • damages plastics • break down rubber • harsh odour
Peroxyacetyl Nitrates (PAN)	• formed by the reaction of NO_2 with VOCs (can be formed naturally in some environments)	• eye irritation • high toxicity to plants respiratory • damaging to proteinsirri-tation

- **Ozone layer depletion-**

➢Ozone resides in the stratosphere and shields us from sun's ultraviolet radiation (UV-B)





- **Causes:**
- Chlorofluoro carbons (CFCs) also known as freons,
- nitric oxide
- reactive hydroxy radicals,
- atomic oxygen

- **Effects of ozone layer depletion**
- The existing ozone layer screens out more than 99% of incoming UV radiations. The small fraction that gets through is known to cause sunburn, skin cancer, and various kinds of damage
- The genetic material DNA has the capacity to absorb UV radiations which may cause various disruptive effects
- Increased UV radiations impairs the growth of certain crop plants and adversely affects a wide variety of organisms
- Exposure to UV radiations damages the cornea and lens of eye causing blindness.

Air pollution and biosphere

- Atmospheric pollutants are mainly present in troposphere and lower stratosphere.
- The first layer till 100m from the ground is highly polluted specially in industrial and urban areas. The next layer from 100-200 m contains lesser pollutants. Turbulent air currents, rain, drizzle, etc dilute the concentration of pollutants.
- From 200 m to troposphere, water droplets dissolve some pollutants and bring them back to earth as rain.
- Secondary pollutants formed affect the soil, vegetation, air quality, water quality, animals and human beings.

Effect of air pollution on meteorology

- It can be defined as the study of behaviour of atmospheric variation that determines the extent of air pollution
- Factors like wind, whose speed and direction of flow directly determine the extent of dispersion and dilution of air pollutants are called primary meteorology factor
- Precipitation, humidity, and solar radiation that control the dispersion of the pollutants indirectly are called secondary meterological factors

Wind speed and direction

- When high pollutant concentrations occur at a monitoring station, wind data records can determine the general direction and area of the emissions. Identifying the sources helps planning to reduce the impacts on air quality
- An instrument called an anemometer measures wind speed. At monitoring stations, the type of anemometer used is a sonic anemometer
- A sonic anemometer operates on the principle that the speed of wind affects the time it takes for sound to travel from one point to another. Sound travelling with the wind will take less time than sound travelling against the wind. By measuring sound wave speeds in 2 different directions at the same time, sonic anemometers can measure both wind speed and direction

- **Temperature**

Measuring temperature supports air quality assessment, air quality modeling, and forecasting activities. Temperature and sunlight (solar radiation) play an important role in the chemical reactions that occur in the atmosphere to form photochemical smog from other pollutants.

The most common way of measuring temperature is to use a material with a resistance that changes with temperature, such as platinum wire. A sensor measures this change and converts it into a temperature reading

- **Humidity**

Like temperature and solar radiation, water vapor plays an important role in many thermal and photochemical reactions in the atmosphere. As water molecules are small and highly polar, they can bind strongly to many substances If attached to particles suspended in the air they can significantly increase the amount of light scattered by the particles affecting visibility. If the water molecules attach to corrosive gases, such as sulfur dioxide, the gas will dissolve in the water and form an acid solution that can damage health and property

Air pollution control

Main routes to cutting pollutant emissions are:

1. Reducing consumption of fossil fuels
2. Industries should be allowed in places where the effects of pollutants can be minimized naturally and easily. This can be achieved through consideration of topography and wind direction of the area.
3. Better raw materials that will cause less pollution can be used.
4. Better designing of equipment to control emissions
5. Treating the flue gases through scrubbers, dry and wet collectors to remove the pollutants, followed by discharging the treated gases (discharges) using higher stacks.
6. SO_2 pollution can be controlled by extracting sulphur from the fuel before use
7. National Ambient Air Quality monitoring should be practised strictly by the State and Central Pollution Control Board.

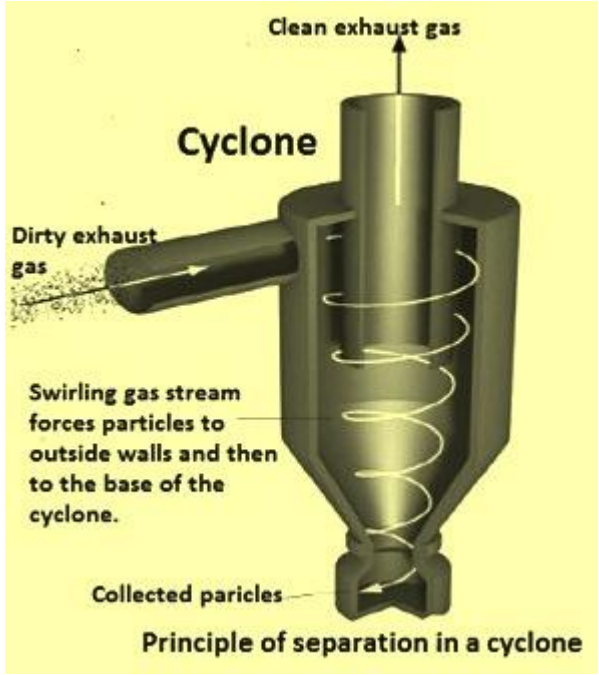
Air pollution control devices-

- **Depending on pollutant type (gaseous or particulate)**
- For Particulate pollutants, devices use one of following techniques-

(i) **Settling chambers:** They are simple devices for collecting dust particles bigger than 100 mm.

(ii) **Cyclones/multiclones:** It works on the principle of dust separation by a centrifugal force. Particle laden air enters the cyclone and swirls in it. Dust particles up to 10 microns get thrown on the periphery and clean air escapes from the centre of the cyclone.

(iii) **Electrostatic Precipitation (ESP):** ESP works on the principle of charging dust by a high voltage current to settle the particles down. The ESPs are simple in operation, cost-effective in longer sizes and very common in thermal power plants and industries.



Principle of separation in a cyclone

(iv) **Filters:** As the name implies, these consist of filter bags through which dust-laden air is passed. The dust gets filtered and clean air escapes. These bags are removed periodically to clean the dust collected.

(v) **Scrubbers:** →The process consists of absorbing the gaseous pollutants or particulate matter in appropriate liquid by scrubbing to bring the pollutants from the gaseous phase to liquid or solid phase.

→It is further treated before its disposal. Scrubbing consumes a large quantity of water and power.

→There are different types of scrubbers: venturi, spray and impingement scrubbers.

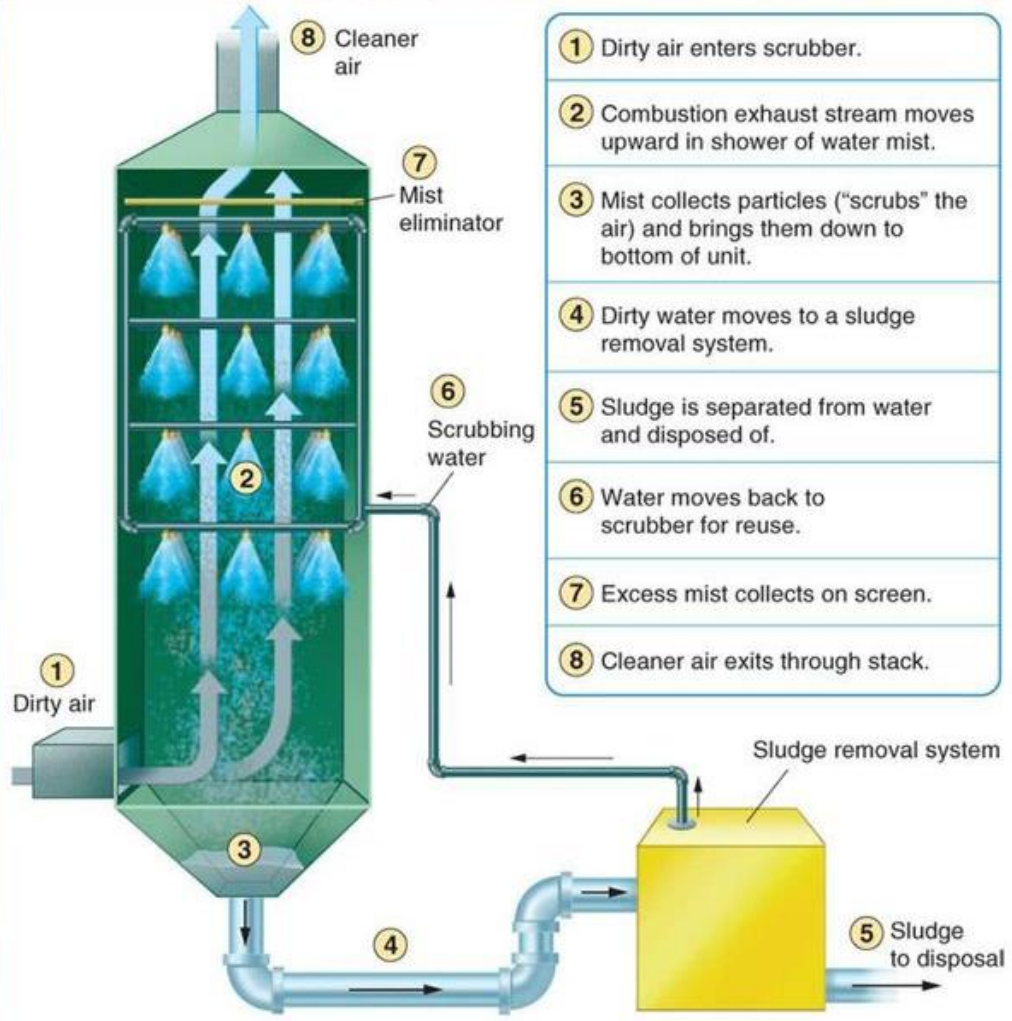


Figure 48.1
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For **gaseous pollutants** some techniques are-

1. **Combustion:** → Many organic pollutants can be decomposed into CO_2 and H_2O at high temperatures directly or indirectly or in the presence of catalysts such as Cu, Ni, V and Zn compounds for decomposition of pollutants at a lower temperature.

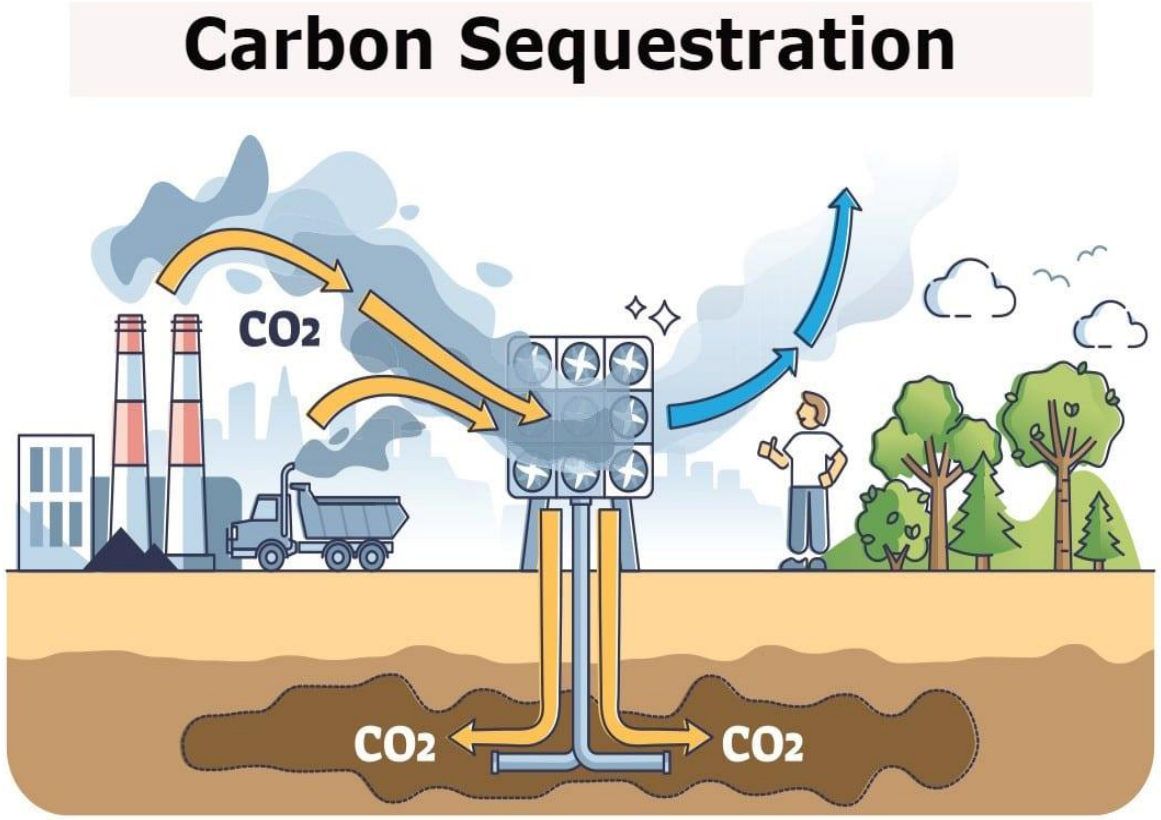
→ Catalytic converters installed in vehicles of advanced design use the same principle to convert nitrogen oxides into N_2 before emission

2. **Adsorption:** → In this process, gases, vapours or liquids concentrated on a solid surface due to surface or chemical forces are termed physical adsorption or chemisorption, respectively.

→ Bauxite, silica gel, activated aluminium or carbon, molecular sieves are mostly used as adsorbents in industries.

CARBON DIOXIDE SEQUESTRATION

- **The practice of removing carbon from the atmosphere and storing it in terrestrial biosphere, underground or oceans**. This is done by maintaining or enhancing natural processes, or development of new techniques to dispose off carbon. It is one of the many approaches being taken to tackle climate change.



- **Main natural sinks are**:

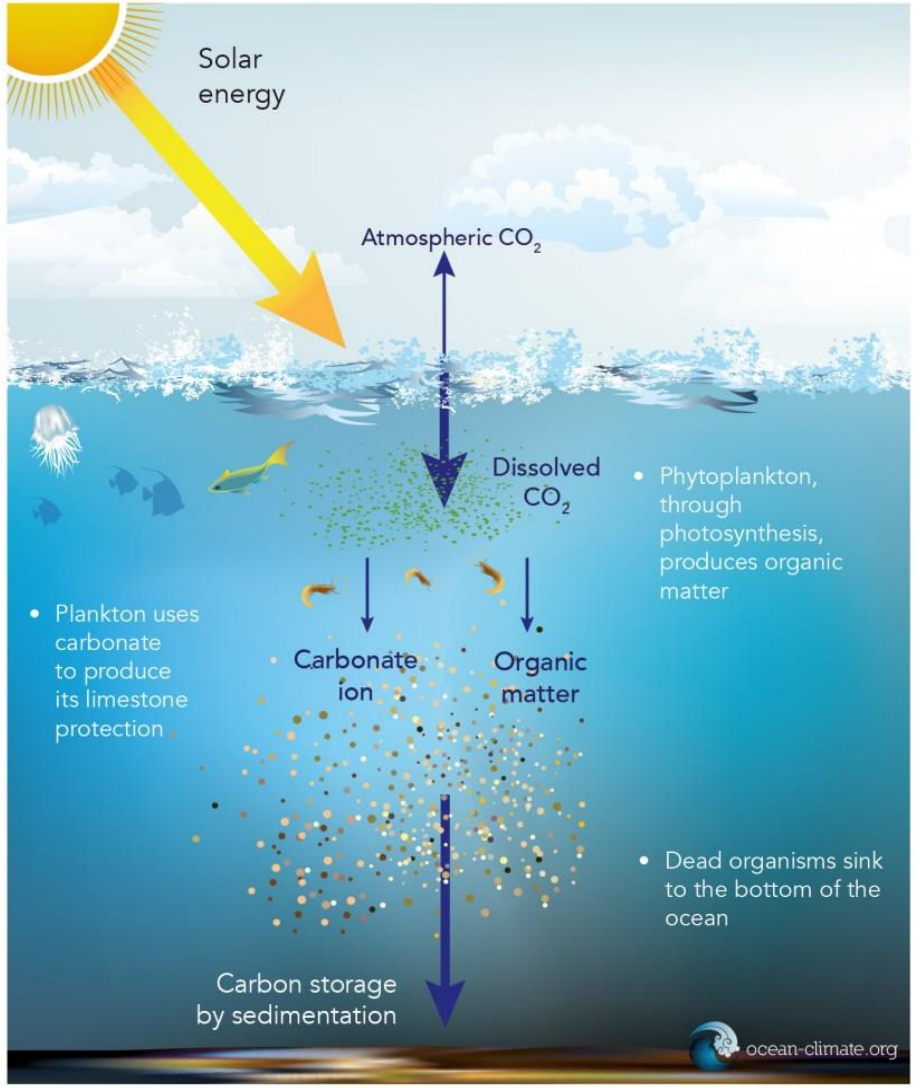
➢ **Oceans** which take up one third of anthropogenic emissions of CO_2

➢ **Plants** which use CO_2 for photosynthesis

➢ Organic carbon in **soil**

Enhancing Natural Sequestration:

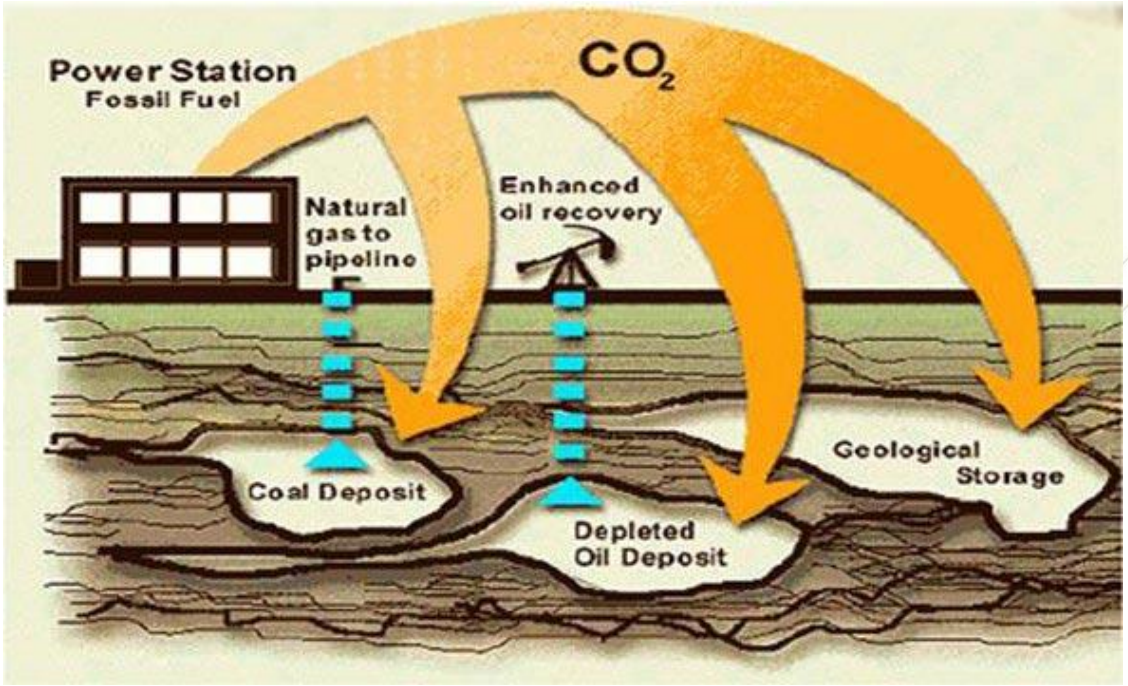
- Reforestation can increase capacity of forests to act as sink.
- The addition of iron particles in ocean water stimulate the growth of phytoplankton, which in turn remove a lot of CO_2 by photosynthesis.
- In soil, no-till farming, cover cropping, crop rotation methods are used to significantly enhance carbon sequestration.
- Conversion to pastureland, with proper grazing in management, can also enhance carbon sequestration.



Biological carbon pump

Artificial Sequestration:

- For this, carbon must first be captured, or the re-release of carbon must be significantly delayed or reduced.
- In oceans, CO_2 is pumped into water at depths where it forms lakes of liquid CO_2. However, this is dangerous method as it can lead to forming of carbonic acid.
- **Geo- Sequestration or geological storage**: injecting carbon dioxide directly into underground geological formations like declining oil fields, unminable coal mines, etc.
- **Biosequestration** involves planting biodiesel crops like switch grass, algal species, etc.



Air Quality Index

The Central Pollution Control Board (CPCB) initiated its own National Ambient Air Quality Monitoring (NAAQM) program in 1985

Ambient air quality standards in India developed by the Central Pollution Control Board

Area Category	SPM µg/m3	SO2 µg/m3	Co µg/m3	NOx µg/m3
Industrial and mixed use	500	120	5000	120
Residential and rural	200	80	2000	80
Sensitive	100	3	1000	30

Water Pollution

- When toxic substance enters lake , streams , river and other water bodies, it result it deterioration of physical, chemical and biological properties of water .
- Pollutant can be in suspended or dissolved form.
- **Sources of water pollution:**

1. **Natural Sources-** decomposed vegetable, animal and weathered products
2. **Human Activities-** domestic and industrial pollution

Classification of water pollutants

- Oxygen demanding wastes
- Pathogens
- Synthetic organic compounds
- Plant nutrients
- Inorganic chemicals and minerals
- Sediments
- Radioactive substances
- Thermal discharge
- Oil

- **Oxygen demanding wastes**
- These pollutants which are rich in carbonaceous organic material are oxidized by micro-organisms to carbon dioxide and water.

$$C + O_2 \longrightarrow CO_2$$

- The amount of dissolved oxygen (DO) in water is reduced because of oxygen demanding wastes. These substances produce undesirable odour, taste and reduce acceptability of water for domestic use.
- In case of strong sewage and when dissolved oxygen in water is less, the waste cannot be removed through biodegradation and ends up polluting the river.

Measures of oxygen demand used:

BOD→ Biological Oxygen Demand

COD →Chemical Oxygen Demand

- **Biological Oxygen Demand**

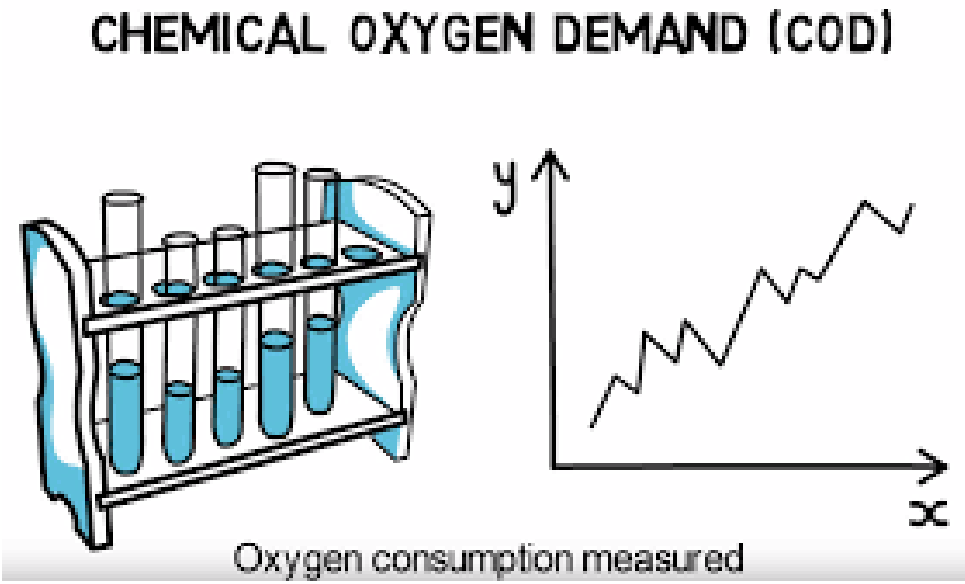
➢ The respiratory demand for oxygen by aerobic organisms for the metabolism of organic waste and nutrients is known as Biological or Biochemical Oxygen Demand. **Hence, it gives a measure of sewage strength.**

➢ BOD of a water body is measured by monitoring the decomposition of a known quantity of organic matter in a definite amount of water at 20°C for five days.

$$\text{BOD} = \frac{\text{Volume of } O_2 \text{ required}}{\text{Volume of sample used}} = \text{parts of } O_2 \text{ in ppm}$$

Type of water	BOD Level (ppm)
Municipal sewage	100–400
Dairy industry	2,000–15,000
Food processing industry	5,000–10,000
Pulp sewage	10,000–15,000

- **Chemical Oxygen Demand**
- In this method, a water sample, after dilution to an appropriate level, is mixed with a measured amount of chemical oxidizing agent, such as potassium dichromate in concentrated sulphuric acid, and kept under reflux for two hours.
- After the completion of oxidation, the amount of unused potassium dichromate is estimated by titrating against ferrous ammonium sulphate.
- The difference in the values gives the amount of oxidants used, hence the amount of oxidizable organic material present in the sample.



- **Pathogens**
- Pathogens are disease causing microorganisms. Contaminated water due to poor sanitation can cause water borne and water contact diseases.
- **Water borne diseases-** caused by ingestion of pathogens by drinking, washing food, utensils and hands with contaminated water.

Examples of pathogens- viruses, bacteria, protozoa.

- **Water contact diseases-** Just contact with contaminated water may cause the disease.

Example: Schistosomiasis caused by swimming larva called cerceria

- According to WHO, 80% of sickness in world is due to contaminated water.
- E. Coli is a bacteria found in human faeces. A large concentration of E. Coli indicated contamination by faecal matter and presence of pathogens (Indicator of hygienic quality of water)

- **Synthetic organic compounds**

They are non biodegradable and persist for long period.

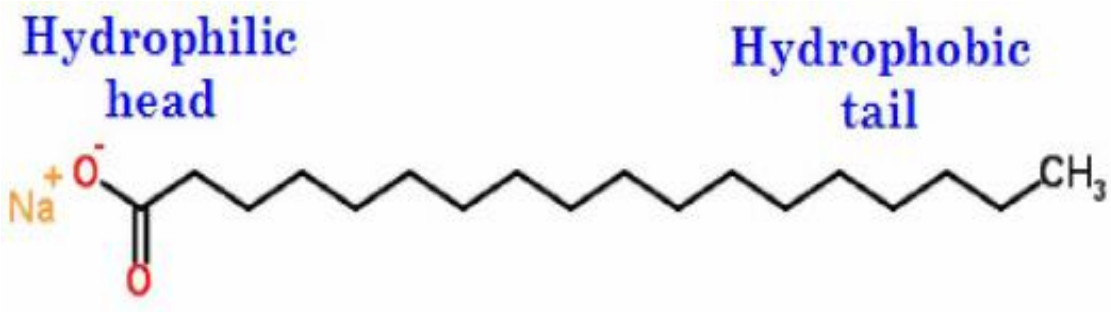
1. pesticides- three types:

Pesticide	Effects
1. **Chlorinated hydrocarbons** – DDT (Dichloro diphenyl trichloro ethane) Chlordane Heptachlor Aldrin Dieldrin Kepone Chlorophenoxy compounds (2,4,5,T, 2 – 4 D)	• Very persistent (last a long time in the environment) • Soluble in lipids and hence can accumulate in fatty tissues • Affect the calcium metabolism in predatory birds, resulting in birds, laying eggs with thin shells and consequent reproductive failure. • Tends to become more concentrated from one trophic level to another due to the process of *biological magnification. • Produce lives cancers • Cause birth defects • Severe neurological damage. • Contains the impurity dioxin, one of the most potent toxins known.

Pesticide	Effects
2. Organophosphorus compounds Parathion Malathion Diazinon	• Non-persistent but damage nervous system Acute exposure result in slurred speech, muscle twitching and convulsions.
3. Carbonate Pesticides Propoxur Carbaryl Aldicarb	• Acute exposure results in nausea, vomiting, blurred vision and convulsions.

2. Detergents:

- Detergents comprise of 10-30% surfactant and remaining builder (polysulphate salts)
- Both the surfactant and builder creates serious water pollution problems.
- The presence of detergents gives an off taste to drinking water and reduce rate of oxygen absorption in water.
- The polyphosphate detergent builder acts as plant nutrients and lead to extensive algae growth. This consumes most of the oxygen dissolved in water.



Surfactant- Sodium Stearate

- **Plant nutrients (Sewage and Agricultural Runoff):**
- When nutrients are present in excess in water bodies, it leads to excessive growth of aquatic plants, particularly algae.
- When these algae dies, it gives undesirable taste and odour to water. Further, the decaying organic matter oxidises and leads to reduced DO.
- Eutrophication is the process by which an entire body of water, or parts of it, becomes progressively enriched with minerals and nutrients, particularly nitrogen and phosphorus
- A green slimy layer if formed which prevents sunlight to penetrate and reoxygenation of lake water. Eutrophic lake eventually turns into marsh or bog.

- High nitrogen content when found in drinking water poses a great threat to human health. Certain bacteria convert nitrate to NO_2 (Nitrite) which is toxic.
- Nitrites have greater affinity for haemoglobin than oxygen.
- It decreases oxygen carrying capacity of haemoglobin and leads to methaemoglobin anaemia or blue baby syndrome.
- Nitrates can be converted to nitrosoamines in the body leading to gastric cancer.

- **Inorganic chemicals and minerals:**
- It includes mineral acids, inorganic salts, metals and their compounds, trace elements, cyanides, etc. They enter the water bodies through municipal and industrial waste and mine runoff. Most of these are highly toxic. Some of these pollutants are-

1. **Acid Mine Drainage:** Coal mines discharge contain iron sulphide which leads to sulphuric acid and ferrous hydroxide (reaction between air, water and iron sulphide)
2. **Soluble salts:** → These salts includes cations like sodium, calcium, magnesium, and anions like chlorides, sulphates and bicarbonates.

→**Salinity is measured in form of Total dissolved salts (TDS).**

→Water with less than 500 mg/L TDS is considered safe for drinking.

→ Salts cause hardening of water leading to scales and sludges.

- **Heavy metals:** these are toxic metals. These have a range of adverse effect on kidney, nervous system, lungs, etc.

Pollutant	Source	Effect
Lead	Automobile emissions, paints, storage batteries, lead piping, effluents from printing and dyeing industries	• Impairment of intellectual development and cognitive functioning • Absorbed through gastointestinal and respira tory tract and cause liver and kidney damage. • Permissible limit in drinking water 0.05 mg/L
Cadmium	Effluents from textile, electro plating and chemical plants, Fertilizer industry cadmium nickel Satteries (Nicad)	• Inhalation of vapours causes kidney damage, bronchitis • Once absorbed by the organism remains resident for many years in the body. • High dose has been linked to lung cancers. • May produce bone defects. • Permissible limits in drinking water is 0.01mg/L
Chromium	Metallurgical and chemical industries, pigments for paints cement, paper, ceramic and glass industry.	• Low level exposure can irritate the skin and cause ulceration • Accumulates in the body of fish and adds to the health effects of eating the fish exposed to high levels of chromium. • Permissible limit in water 0.0.5mg/L

Pollutant	Source	Effect
Mercury	Various industrial efflments such as those from paint and paper manufacturing units. Highly prevalent in medical waste, lamps, thermometers, used in dentistry as amalgum for fillings.	• Builds up in the tissues of fish and other creatures living in contaminated water and may be carried up the food chain to humans. • It is proved to be the most toxic aquatic pollutant because of its rapid methylation in aquatic environment by some bacteria. Monomethyl mercury and dimethyl mercury and dimethyl mercury are highlytoxic and cause neurotoxicological disorders.
Arsenic	Introduced as a by-product of fossil fuel combustion, irrigation water containing pesticides, chemical wastes	• Carcinogenic • Can cause mild bronchitis • Attack — SH group of enzymes and can coagulate proteins.
Silver	Electroplating and photographic industries	• Fish and lower organisms are susceptible to silver poisoning • It is cumulative poison and chronic injestion can cause permanent discolouration. Permissible limit in drinking water is 0.05 mg/L.

- **Sediments:** Includes soil, sand and minerals enter through storm and floods.
- **Effects:**

1. Increase the cost of water treatment for culinary purpose
2. It enters pumping equipment and turbines and increase turbidity.
3. Thickening of fish gills
4. Block sunlight and decrease photosynthesis

- **Radioactive waste: T**hey enter by mining and processing of ores, from nuclear power plants and industrial use of radioactive materials, use of radio isotopes in medicines, industry, agriculture and research.

These cause genetic mutations, cancer, leukaemia and eye cataract.

- **Thermal discharge:** → Coolant water is directly discharged in water bodies causing increase in temperature.

→An increase in temperature can reduce DO and increase toxicity of certain chemical pollutants.

→ Fishes are killed due to effect of heat on nervous system and inactivation of enzymes.

- **Oil:** → Oil wastes are added as effluents from industries, oil refineries, storage tanks, petrochemical waste, etc.

→Oil floats as a thin layer on water. It may stick to feathers of the birds and effect their insulation and buoyancy. Birds can experience difficulty in floating and flying. They may ingest oil and die.

→The oil layer formed on the surface prevents diffusion of oxygen causing reduced DO.

- **Volatile Organic Compounds:** → Most commonly found contaminants in water.

→Since they are volatile, their concentration is low. But in ground water, their concentration is higher. They are toxic and can cause tumours, effect liver, nervous system, respiratory system, etc.

Vinyl Chloride	Production of polyvinyl chloride resins	Carcinogenic
Trichloroethylene	Used as a solvent, heat transfer medium, manufacture of CFCs.	Causes tumours in animals.
Trichloroethylene	Solvent, used to clean electronic parts	Carcinogenic
1,2 Dichloroethane	Metal degreaser, used in manufacture of vinyl chloride, varnish removers and soap compounds.	Cause injury to central nervous system liver and kidneys
Carbon tetrachloride	Common household cleaning agent, used in fire extinguisher, solvent	very toxic, only a few millilitres can result in to death

Water treatment

- The purpose of waste water treatment is to remove the contaminants from water so that the treated water is of acceptable quality.
- The waste water is often termed as sewage. It is the liquid water which includes human and domestic wastes, industrial wastes, ground wastes and street washings.

- **Depending of the nature of sewage, it can be grouped:**

1. **Domestic waste-** it includes human excreta, discharge from kitchens, baths, washrooms etc from public and private buildings.
2. **Industrial sewage-** liquid waste in which industrial waste is present
3. **Storm water-** rain water which flows as runoff from streets, open yards, etc.
4. **Combines sewage-** combination of domestic sewage, industrial sewage and storm water

Strength of sewage

It is measured in following categories:

1. **Dissolved oxygen (DO)- Measured by two ways:**

- **Biochemical oxygen demand:** The amount of oxygen absorbed by a sample of sewage during a specified period (generally 5 days) at a specified temperature (usually 20° C) for aerobic digestion. Sewage with a BOD value of 300 mg/L (or 300 ppm) or above is termed as strong BOD is used to test the strength of untreated and treated municipal and biodegradable industrial waste waters
- **Chemical oxygen demand:** The amount of oxygen required to oxidize the organic matter by use of dichromate in an acid solution and to convert it to carbon dioxide and water
- The value of COD is always higher than the BOD.

2. Dissolved CO_2

CO_2 can be picked up from atmosphere or generated at the bottom of lake due to decay of organic matter. Rivers receiving acid wastes may also show high CO_2 content (Titration with Na_2CO_3)

3. Free chlorine: It can be added as a by product of disinfectants. Chlorine determination is necessary in those water samples which have been treated with chlorine or hypochlorites. (Iodometric titration)

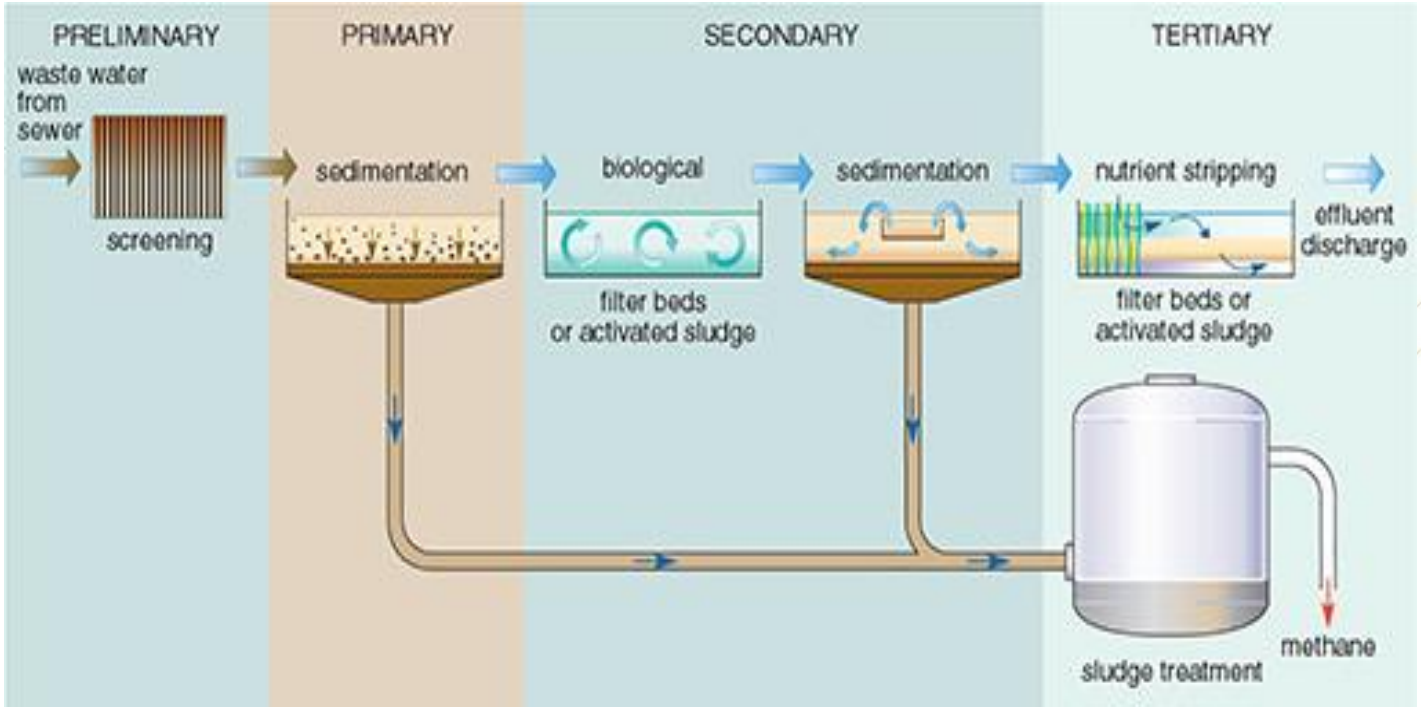
4.**Dissolved chloride:** present due to discharges from industries, irrigation drainage, marine sedimentary deposits, etc. (Titration with $AgNO_3$)

5. **TDS:** denote various kinds of minerals present (Residue left behind after evaporation of filtered sample)

Waste water management

Waste water treatment processes can be classified as:

1. Physical processes
2. Chemical processes
3. Biological processes



The waste water treatment processes are generally grouped according to water quality they are expected to produce. These are:

1. Primary treatment
2. Secondary treatment
3. Tertiary or advanced treatment

- **Primary treatment-** It uses physical processes like screening or sedimentation to remove pollutants that will settle or float or are too large to pass through screening devices. It involves pre treatment and sedimentation
- **Pre treatment** → it consist of screening and grit removal. Screening removes large floating objects and suspended solids.

→ The raw sewage is passed through bar-screens with openings of 8 to 10 cm between the bars placed across the inflow channels

→**Grit removal-** Combined sewerage systems carry grit from roads or other debris. The sewage is allowed to flow in a channel at a controlled velocity of about 30 cm/s

→ The grit is removed periodically, washed free of organic matter and used for land filling road making and sludge drying bed

- **Sedimentation→** The velocity of water is reduced to allow settling of suspended particles by gravity.

→ The sewage is retained in sedimentation tanks for 4 to 12 hours. An efficient sedimentation tank removes 80-90% suspended solids and 40% organic matter. The settled solids are called primary sludge

→**Mechanical Flocculation:** → When finely divided particles are difficult to remove using simple sedimentation, mechanical flocculation is used.

→Slow moving paddles are used for flocculation of solids The process removes 50 - 60 % of the suspended solids and about 40 percent of the BOD of the sewage. The settled sludge is removed either continuously or at frequent intervals to prevent it from becoming septic

→ **Chemical Coagulation:** Chemical treatment by the addition of coagulants may be used to assist sedimentation. The coagulants react with colloidal matter in the sewage to form floc. The floc entraps the finely suspended matter and eventually settle down as sludge. Common coagulants used are $Al_2(SO_4)_3.18\ H_2O$, $FeSO_4.7H_2O$ etc

- In **industrial waste water** the primary treatment sometimes included equalization and neutralisation
- **Equalisation:** To get homogenous and equalized effluent, the waste water generated from different industries are held in big tank for a certain period of time
- **Neutralization:** Acidic waste water is neutralized with lime stone and basic waste water are neutralized by treatment with CO_2 or conc H_2SO_4 Mutual neutralization of acidic and basic waste water can also be done

SEDIMENTATION TANK

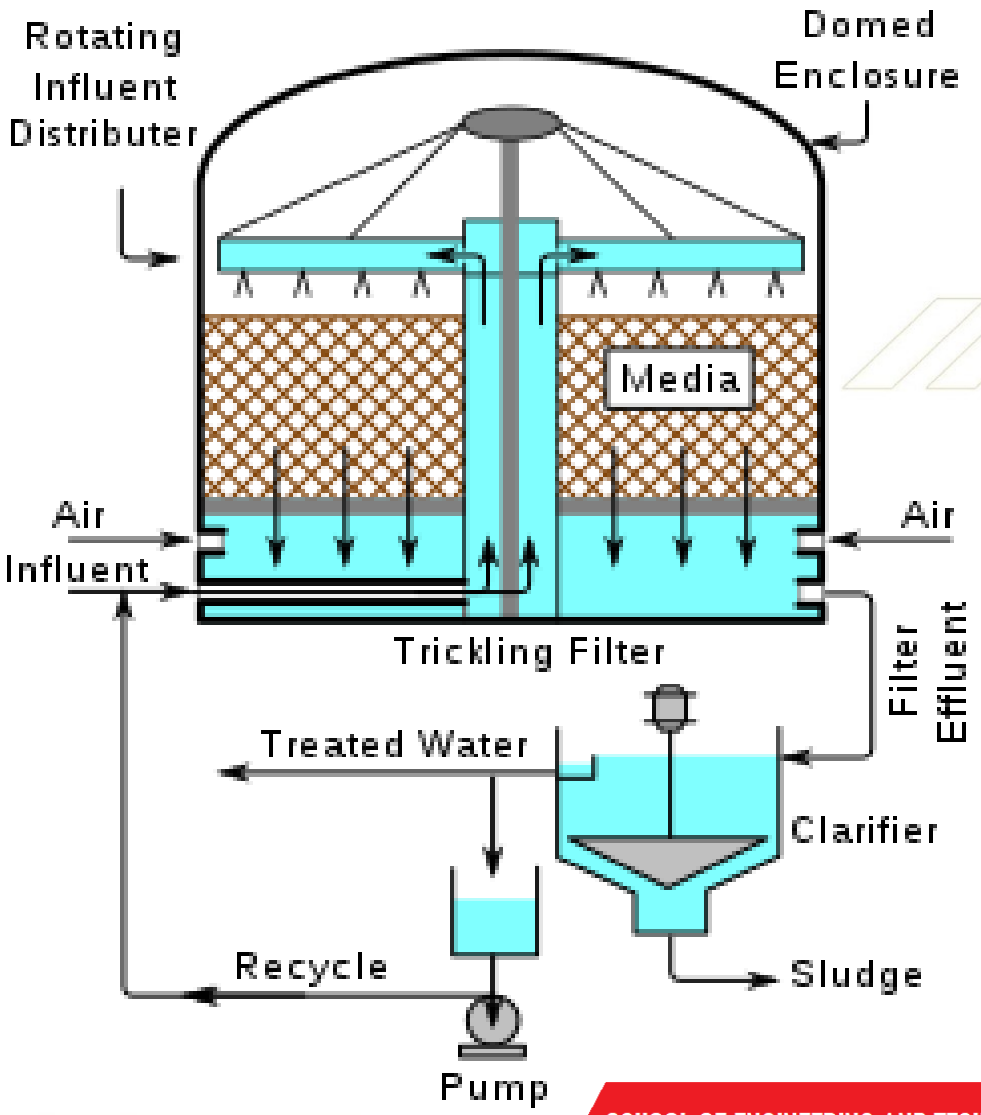
Secondary treatment

- The secondary or biological treatment of sewage essentially involves the oxidation of suspended and dissolved organic matter by aerobic bacteria
- Carbonaceous matter is converted to carbon dioxide and water
- Nitrogenous material is converted to ammonia, nitrites, and nitrates
- Fungi, algae, protozoa, insects and worms supplement the bacterial digestion
- Anaerobic digestion of sludge takes place
- Secondary treatment removes 85 to 95 percent of BOD and TDS and minor portions of nitrogen, phosphorus, and heavy metals

- **The main processes employed for biological treatment are as follows:**

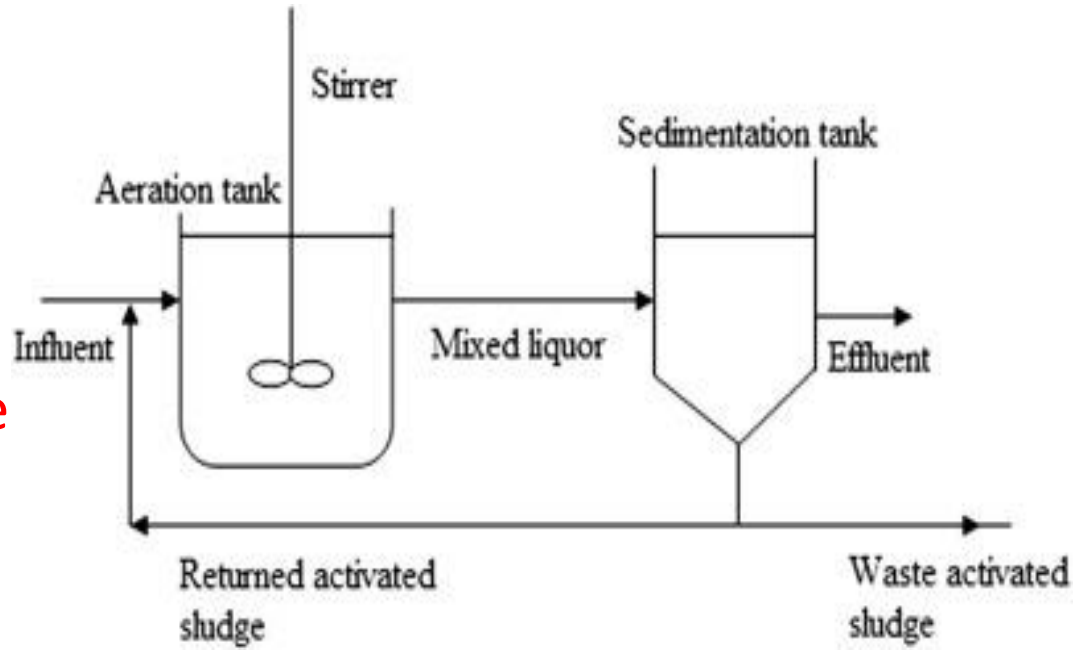
- **<u>TRICKLING FILTER</u>**

- Thickness of slime layer increases and it get detached from the surface of stones. It is carried with the effluent and settle down in the form of humus. This humus is pumped into sludge digestion unit
- Percolation is followed by final settling into secondary sedimentation or humus tanks to remove the slimy layer
- It is simple to operate doesn't require much monitoring and can produce BOD removal from 65 to 85%
- Used for treatment of industrial waste water from Dairy brewery, food pharmaceutical industries



Activated sludge process

- Activated sludge is obtained by settling the sewage in excess of oxygen.
- In this method mixture of waste water and activated sludge is agitated and aerated
- .The activated sludge is biologically active because it is heavily loaded with microorganisms which are in active state of growth.
- **Principle :** The principle is to add sufficient quantity of sludge obtained from the final sedimentation tank to sewage that is to be treated .Activated sludge contains active aerobic bacteria vital for decomposition of sewage.
- The process requires air supply and thorough mixing which brings about an intimate contact of the organic solids with oxygen and aerobic bacteria



Activated sludge method

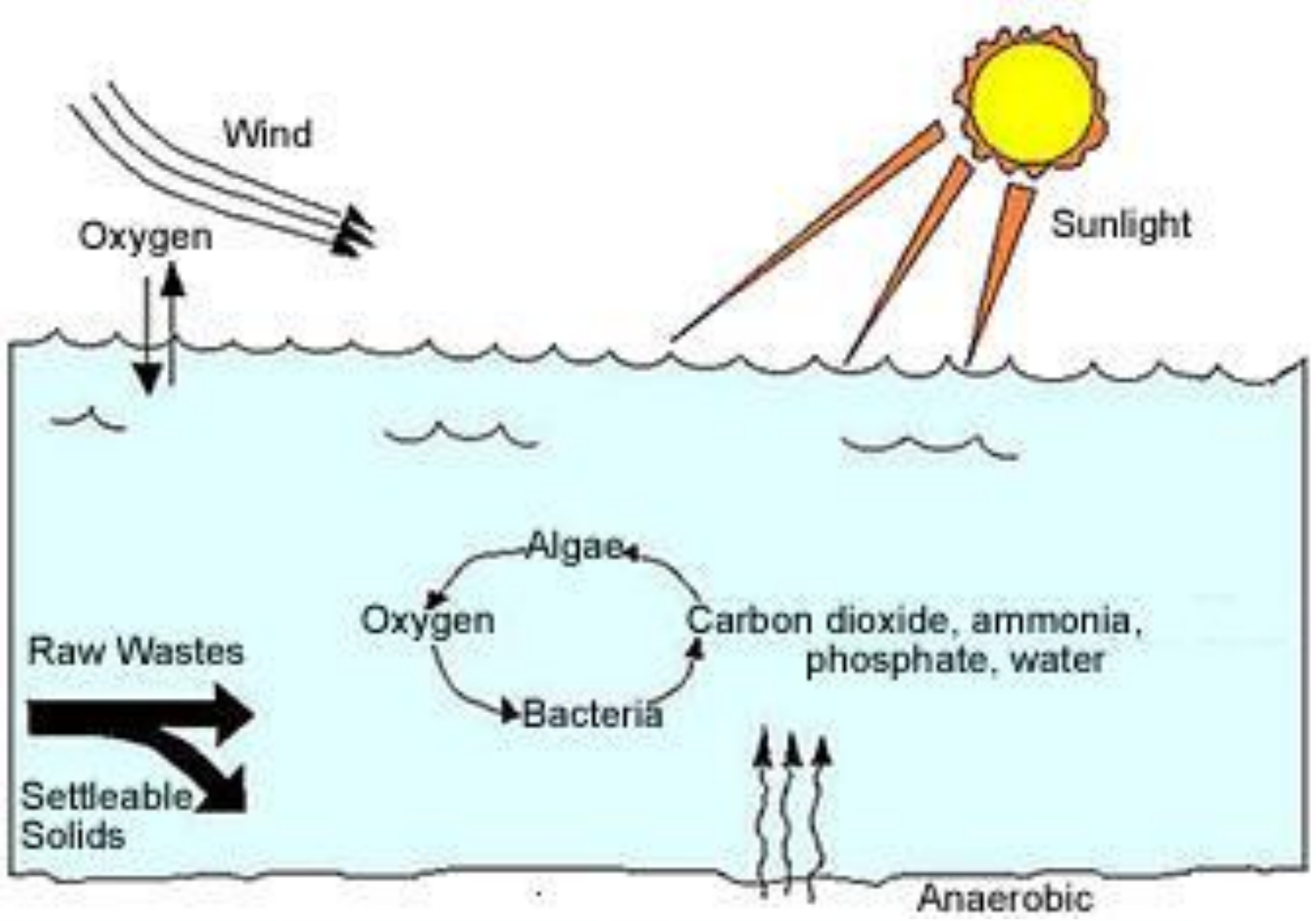
- **PROCESS**

- First the effluent from the primary sedimentation tank is mixed for an hour or two with the activated sludge to form the ‘mixed liquor’.
- Oxygenation of this mixed liquor is carried out for 4 to 6 hours by passing compressed air to aeration chamber to break up the sewage into fine spray.
- The aeration is followed by settling in tanks.
- The sludge is removed and the clear purified final effluent flows out for safe discharge.
- Most of this activated sludge is returned to be mixed with the sewage from the primary settling tanks.
- Thus there is a continuous circulation of activated sludge within the system.

Oxidation pond or “Redox Pond or Sewage Lagoon or Waste Stabilization Pond” :

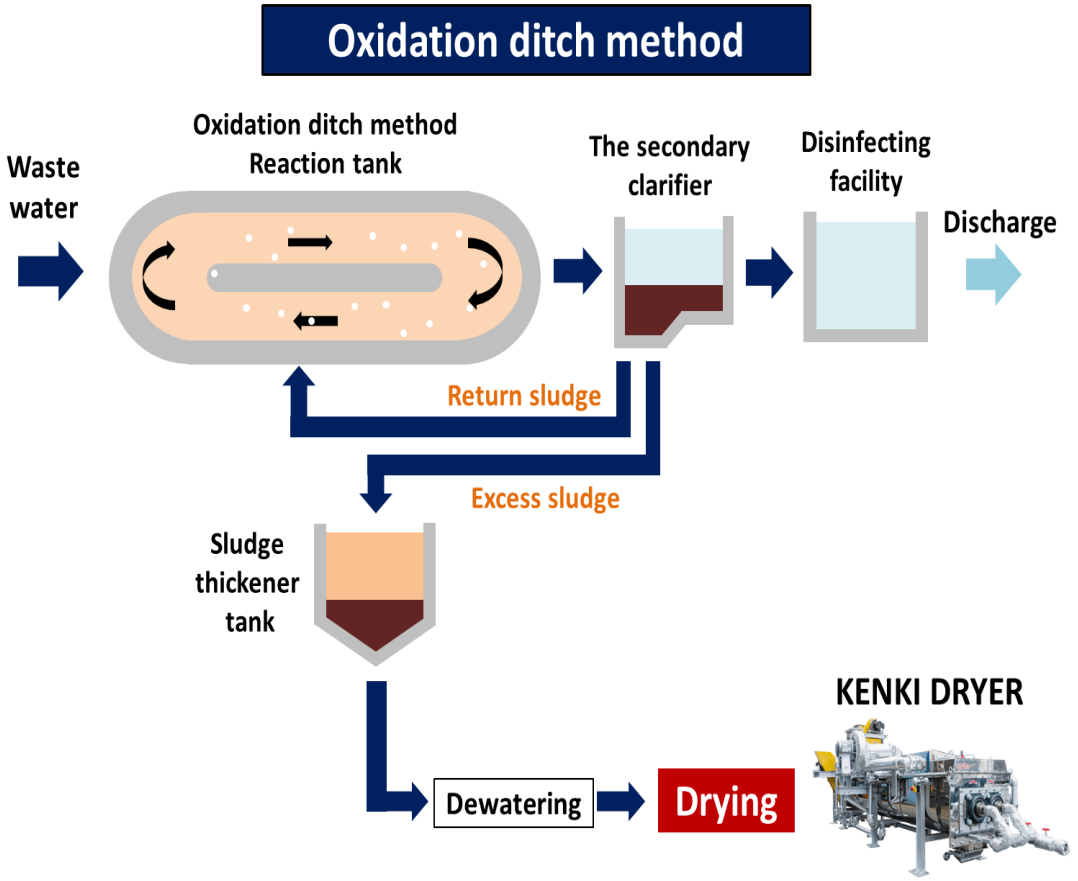
- It is one of the cheapest method of satisfactory sewage disposal . It is an open shallow pool up to 5 feet deep with an inlet and outlet. The presence of algae, bacteria decompose organic matter in presence of sunlight .Bacteria oxidize sewage to carbon dioxide, ammonia and water.
- The algae, with the help of sunlight utilize carbon dioxide, water and other organic substances for its growth.
- Algae releases oxygen during photosynthesis, which is used by bacteria.
- So the pond works as an aerobic system during the sunlight hours, and anaerobically during the dark (night) hours, especially in the lower layers.
- The effluent can be used for farming or can be discharged into rivers after suitable treatment.

- **OXIDATION POND**



Oxidation Ditch/Aerated Lagoon

- The process used in oxidation ditch or aerated lagoon utilizes mechanical rotors for extended aeration and thus minimizes the requirement of land area.
- By giving certain level of flow speed to whole water channel, oxygen demanded for aeration process is supplied as sewage and activated sludge are being mixed and circulated.
- Activated sludge is prevented to be settled down by being mixed and agitated with wastewater in the water channel.
- The land requirement in this method is barely one tenth of oxidation pond .
- On stabilization with a 30-day retention, coliforms reduce to 99 - 99.9%.



Sludge Treatment and Disposal

- The sludge from primary or final sedimentation tanks contains 90 to 95 % water. This high water content needs to be reduced for converting the sludge to a solid condition in which it may be used or disposed off harmlessly.
- Anaerobic digestion is the most preferred sludge treatment method. The sludge is pumped daily into enclosed digestion tanks.
- With anaerobic fermentation a gas comprising of about 70 % methane and 30 % carbon dioxide is produced.
- Sewage sludge contains useful nitrogen and phosphorus, and although rather deficient in potassium, it forms a moderately good fertilizer.
- Undigested primary sludge are easier to apply to land, and their humus content improves the soil.
- In suitable circumstances sewage sludge may be composted with municipal refuse. Where sludge cannot be used either as a fertilizer or for composting, or, in a few cases, for recovery of by-products, it is usually tipped for land reclamation, dumped at sea, or incinerated.

Tertiary water treatment

- The purpose of tertiary treatment is to provide a final treatment stage to raise the effluent quality before it is discharged to the receiving environment such as sea, river, lake, ground, etc., or to raise the treated water quality to such a level to make it suitable for intended reuse.
- This step removes different types of pollutants such as organic matter, nutrients, pathogens, and heavy metals that secondary treatment is not able to remove
- Tertiary treatment is the final cleaning process that improves wastewater quality before it is reused, recycled or discharged to the environment. The treatment removes remaining inorganic compounds, and substances, such as the nitrogen and phosphorus.
- Depending upon the required quality of final effluent , a number of techniques can be used- microstraining, adsorption, ion exchange, solvent extraction, chemical precipitation, etc .

Ways to conserve water

- Prevent groundwater contamination
- Greatly reduce nonpoint runoff
- Reuse treated wastewater for irrigation
- Find substitutes for toxic pollutants
- Work with nature to treat sewage
- Practice four R's of resource use (refuse, reduce, recycle, reuse)
- Reduce resource waste
- Reduce air pollution

SOLID WASTE

- Solid wastes originate from the human activities such as agriculture, industry, domestic activities.
- Wastes are the material that are not needed and are not usable .
- Solid waste can pollute air, water and soil, and have various environmental impacts, and cause health hazard, due to improper handling and transportation. These adverse effects are seen on health and environment.

Solid waste management

- Solid waste management is defined as the discipline associated with control of generation, storage, collection, transport or transfer, processing and disposal of solid waste material.
- The primary goal of solid waste management is reducing and eliminating adverse impacts of waste materials on human health and the environment to support economic development and superior quality of life.

Classification of solid waste

- **Garbage:** Garbage is organic waste produced during the preparation, storage of food, vegetables, fruits, meat etc. It is biodegradable and highly putrescible with moisture content of 70 % and heating value of 6×10^6 J/kg.
- **Rubbish:** Rubbish is mostly dry material and non putrescible with 25 % or lesser moisture content and heating value of 15×10^6 J/kg. It can be combustible or non combustible.
- **Pathological waste:** It includes hospital waste like syringes, swabs, body fluids, etc. It also constitutes dead animals, humans, etc. It has moisture content of 85 % and heating value of 2.5×10^6 J/kg.

- **Industrial waste:** includes waste from industries. Example- waste from coal or ore mines, electroplating works, textile industries, dairies, oil refineries, etc. It contains organic and inorganic pollutants which might be soluble or insoluble.
- **Agriculture waste:** includes animal manure, crop residues, herbicides, fungicides, etc.
- **Ashes:** these are residue of combustion of solid fuels.
- **Urban:** sometimes domestic and commercial wastes are considered as urban waste. It amounts between 0.3-0.5 kg per person.

TREATMENT AND DISPOSAL METHOD

- Since the composition of solid waste is not same everywhere, so selection of a suitable disposal method is complicated.
- Several disposal methods are being used and most common are:

1. Dumping
2. Sanitary land fill
3. Incineration
4. Composting
5. Recycling and reuse

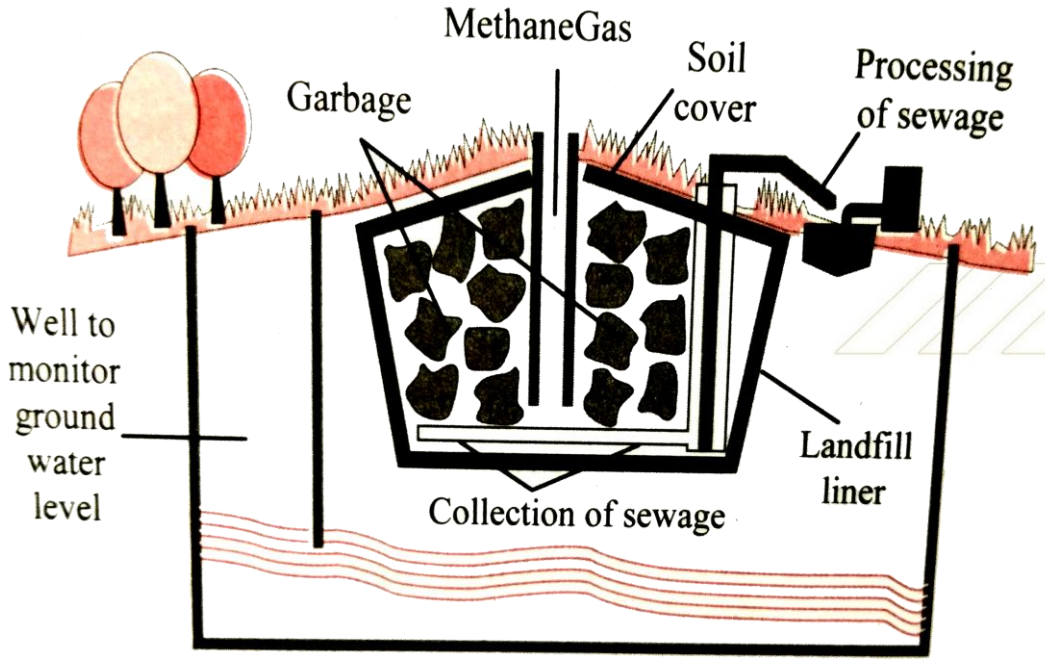
Disposal Methods

1. Dumping:

- It is the cheapest method as no planning required and practiced extensively in India.
- Open dumps (uncovered areas) are used to dump solid waste of all kinds. The waste is untreated, uncovered and not segregated. It becomes breeding grounds for rats, flies and other insects that act as vectors for causing disease.
- The rain water run-off from these dumps contaminates the nearby land and water bodies. This method is no longer used in some countries.

2. Landfills:

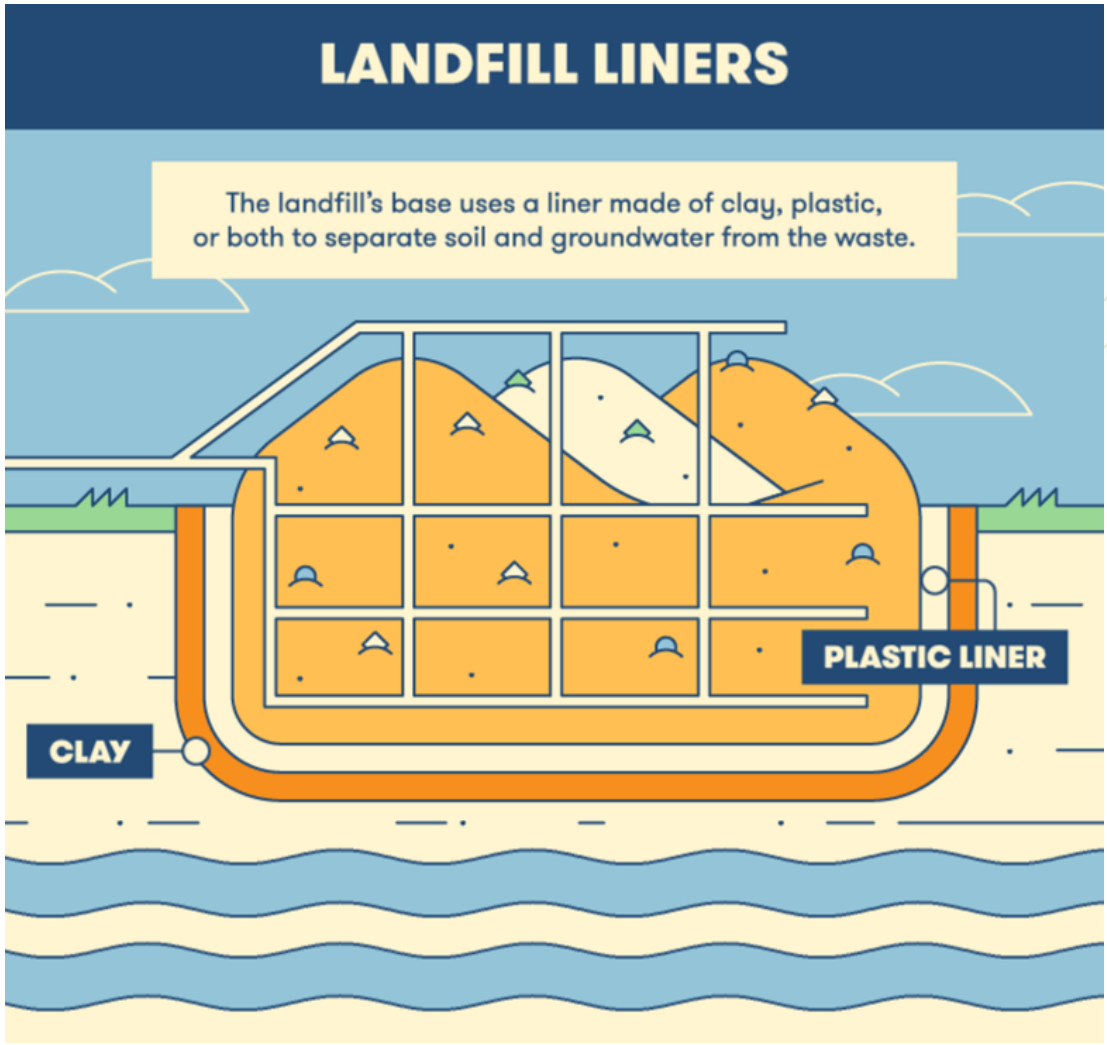
- Landfills are a method of waste disposal where the waste is buried underground in large piles.
- A controlled waste disposal method which is monitored very closely.
- A pit is dug in ground, waste is dumped and the pit is then covered. Thus, preventing breeding of rats, flies or insects.
- At the end of each day, a layer of soil is scattered on top and garbage is compressed to form a layered structure called a **cell.**



Modern landfill site

Problem with landfills is that when water seeps through them it contaminates the nearby ground water and soil. This is called ***leaching.***

- An alternative to landfill is **sanitary landfill** which is more hygienic and built methodically. These are lined with impermeable material like plastic or clay (known as liners) and built over impermeable soil.
- Daily collected waste is spread evenly across the depression and covered with a layer of soil.
- Drainage system are set around and beneath the liners to prevent leaching and contamination.
- Collected liquids are treated to make environment safe.



Landfill method is essentially a biologic treatment method and it occurs in following steps:

1. In first phase aerobic bacteria deplete the available oxygen as a result of aerobic respiration.
2. In second phase, anaerobic conditions exist and H_2 and CO_2 are evolved.
3. In third and forth phase, methane forming bacteria decompose waste to methane and CO_2. Therefore, escape vents for gases are provided in landfills
4. In fifth phase, methanogenic activity decreases indicating depletion of organic matter and aerobic conditions are restored.

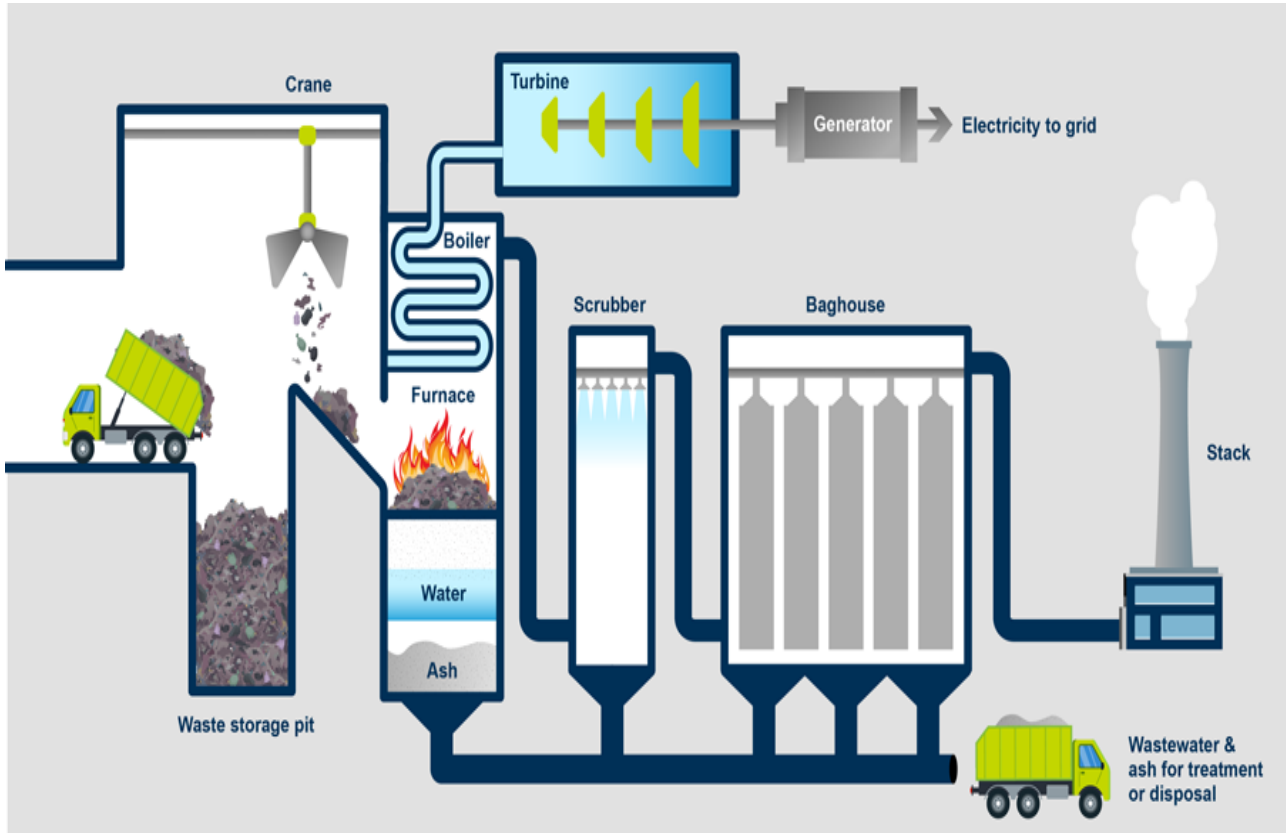
- **Problems of Sanitary landfills:**
- construction is costly
- the plastic liner develops cracks when various chemical solvents react with it.
- Rate of decomposition is variable
- Some biodegradable materials do not decompose in landfills

- **Advantages:**
- Infectious diseases are minimised due to covered pits
- No air pollution from burning
- Fire hazards are minimal

3. Incineration:

- In this, the recyclable material is segregated and rest of the material is burnt. At the end of the process, only ash is left.
- During the process, some ash floats out with hot air. This is known as **fly ash.**
- Dry ash and ash left behind in the furnace after burning contains toxins like heavy metals, dioxins etc. in high concentration. Disposing of this ash is a problem.
- The ash that is buried at the landfills cause severe contamination due to leaching.
- Incineration is kept as a last resort because of release of toxic ash that pollutes air and water. It is only used for treating infectious waste.

- The process can be made more effective with the use of filters and scrubbers.
- **Scrubbers** use liquid spray for reducing the acidic content of the gases, while the **filters** remove the tiny ash particles from smoke and prevent the burning ash from entering the atmosphere.
- If properly equipped, an incinerator is also capable of converting water into steam, which, in turn, can be used to generate power.
- Burning waste at high temperatures can also destroy harmful chemicals and disease causing bacteria



- **Disadvantages of incineration:**
  - Burning trash releases dioxin, lead, and mercury (in many areas, incinerators are the largest sources of these pollutants.) The products of incineration also includes carbon dioxide, and oxides of sulfur and nitrogen.
  - Cost of incinerators is high

- **Advantages:**
- Using properly equipped incinerators can help in recovering useful materials and energy.
- Huge solid wastes are reduced to small volumes of ash which can be handled.

4. Composting:

- It is a biological process in which micro organisms mainly bacteria and fungi, decompose the organic waste into the humus or compost like formation.
- It helps in disposal of solid waste and production of valuable manure for crops.
- In contrast to sanitary landfills, composting is an aerobic process.
- The process starts with oxidation of organic matter in the waste to produce CO_2 and heat.
- The temperature rises and thermophilic bacteria starts decomposition. After around 3 weeks compost is stabilised. The manure obtained has high nutrients content.

- Composting occurs in three steps:

1. **WASTE PREPARATION: W**aste is placed on conveyer belt and undesired materials are removed. Paper is removed by hand picking, iron material is removed by magnetic separation. Waste is then grounded to required size. A nutrient source is mixed along with water to provide 50% moisture.
2. **DIGESTION:** mixture is subjected to digestion by microorganisms for 4-6 weeks.
3. **PRODUCT UPGRADATION: T**he resulting compost is upgraded by curing, grinding, etc for selling purposes.

VERMICOMPOSTING- In this method worms are added to compost. These insects help in breaking waste and their excreta make compost rich in nutrients.

- **Advantages of composting:**
- It ensures waste produced in the kitchen is not carelessly thrown
- It recycles the nutrients and return them to soil as nutrients
- It is clean, cheap, safe method which reduces the amount of garbage.
- Manure obtained can be used as natural fertiliser
- Helps to increase soil's water holding capacity and makes soil easier to cultivate.

5. Recycling and reuse:

- Solid waste contains significant amount valuable materials like steel, aluminium, copper, etc. which can be recycled or reused.
- **Recycling** involves collecting used and discarded materials, processing these materials and making them into new products. It reduces the amount of waste generated.
- **Reuse** involves using the items which are already present and not buying new items

- Steps involved in process prior to recycling include:

1. Collection of waste from doorsteps, commercial places, etc.
2. Collection of waste from community dumps
3. Collecting/packing of waste from final disposal sites

The four R's to be followed for solid waste management are:

1. **Refuse:** refuse to buy new items
2. **Reuse:** practice of using the same things instead of buying new things
3. **Recycle:** processing the old materials into the new material
4. **Reduce:** reducing the generation of unnecessary waste.

- **Advantages of recycling waste;**

- Less consumption of raw materials
- Reduces environmental impact arising from waste treatment
- Makes surroundings cleaner and healthier
- Saves money
- Reduces amount of energy required for manufacturing new products

- **Segregation of waste**

Prior to recycling waste should be segregated. Waste can be segregated as biodegradable and non biodegradable.

→**Biodegradable waste:** it includes organic waste. Ex- kitchen waste, flowers, leaves from garden, paper, etc.

→ **Non Biodegradable waste:** can be further segregated into:

1. **Recyclable waste:** plastic, glass, metal, etc.
2. **Toxic waste:** expired medicines, paints, chemicals, bulbs, spray cans, batteries, etc.
3. **Soiled:** hospital waste soiled with blood and other body fluids

Toxic and soiled waste must be disposed of with utmost care.

Soil Pollution

- Soil is the thin layer of organic matter and inorganic matter that covers the earth crust and is vital for life. It is a weathered layer of earth's crust.
- Soil pollution is defined as contamination of soil by some chemical substances, whereby the productivity and fertility of soil decreases.

- **Composition:**

➢ **Inorganic matter:** made up of rock fragments due to their decomposition. Contains silicates of Na, K, Ca, Al, Fe. Oxides of Fe, Mn and Ti. Carbonates of Ca and Mg.

➢ **Organic matter:** constitutes 50% of soil. It is formed by the decay of plant residues, animal remains and microbial tissues.

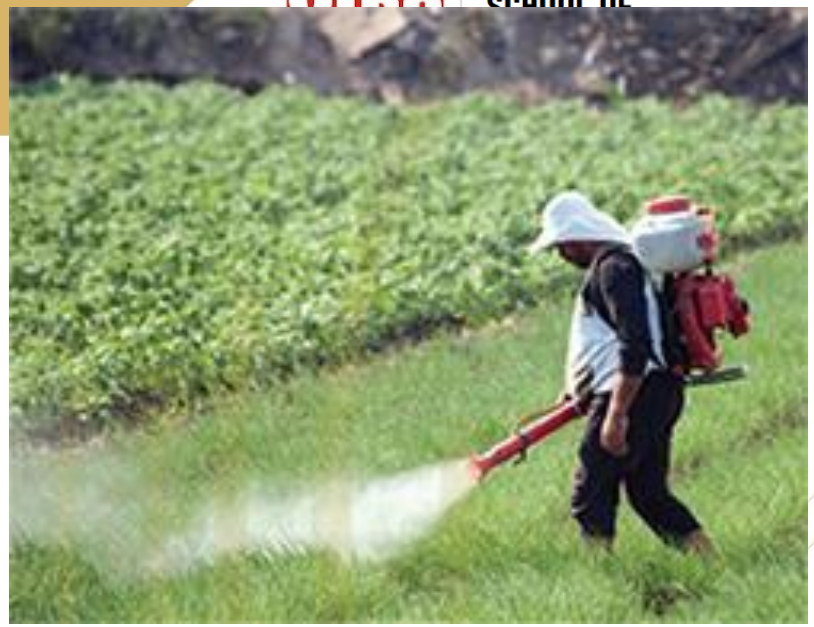
➢ **Living organisms:** bacteria, fungi, viruses, insects, protozoa.

➢ **Water & air:** They are obtained from atmosphere. Soil water and soil air fill up the spaces between soil particles.

Sources of soil pollution:

1. Industrial waste
2. Disposal of soil waste in urban areas
3. Agricultural practices
4. Biological agents
5. Soil erosion

- **Industrial waste:**
- Disposal of industrial waste pollute the soil.
- The pollutants added alter the chemical and biological properties of soil.
- Industrial sludges containing calcium salts and several toxic elements like arsenic, mercury, etc. pollute the soil.
- Air pollutants from mining and smelting industry also add to soil pollution.
- **Soil pollution by urban wastes:** Lead particulates from automobile exhaust, garbage containing plastic, glasses, metallic cans, fibres, etc constitute soil pollution.



- **Agriculture practices:**
- **E**xcessive use of fertilisers containing nitrates and phosphates can release these nutrients in soil which may leach out in nearby water bodies and cause water pollution.
- Pesticides, herbicides, etc may cause soil pollution when used in excess. They seep into the ground after they mix with water and slowly reduce the fertility of the soil.
- Plants absorb many of these pesticides, and after decomposition cause soil pollution
- Animal wastes (cow dung) contains pathogenic bacteria and viruses which enter into plan metabolism and ultimately to man

- **Biological agents:** Human, animals and bird excreta constitute of biological agents which pollute soil. Moreover, faulty sanitation, municipal garbage, waste water also add to soil pollution.

- **Soil erosion:**
- It happens when topsoil of the land is stripped off essential nutrients needed for plant and vegetative growth. Consequently, humus (partially decomposed organic matter) is removed.
- The result of soil erosion over a long period of time includes decaying of vegetation. This man-made disaster leaves large areas of land destroyed and unfit for regrowth for many years.

- **Coal based thermal plants:**
- Disposal of large quantities of fly ash and bottom ash from coal based thermal plants also contribute to soil erosion.
- This renders large areas of land unfit for cultivation. Moreover, toxic metals also leach out of soil and pollute ground water.

- **Acid rain and oil spills also cause soil pollution**

Effects of soil pollution:

1. Soil pollution caused by industrial waste adds various chemicals to the soil which are extremely toxic to human beings. These enter human beings through food chains and cause undesirable effects.
2. Metallic contaminants (Hg, Pb, As, Zn, etc) destroy beneficial microorganisms in soil. These are highly toxic to living organisms in soil.
3. Excessive use of fertilisers renders soil acidic or alkaline depending on fertiliser used. The acidic or alkaline soil is unfit for growth of many crops. Nitrates and phosphates added as fertiliser may get leached out and pollute nearby surface water and groundwater.

4. →**Use of pesticides** contaminate the soil and are persistent pollutants.

- They enter the food chain and pose serious threat to health. Some of the degraded products of these pesticides are carcinogenic.
- Examples- DDT accumulates in food chain and is not metabolised. Polychlorinated biphenyls (PCB) have half life of 25 years in soil and cause deformities in foetus, nervous system disorders, liver and stomach cancer.

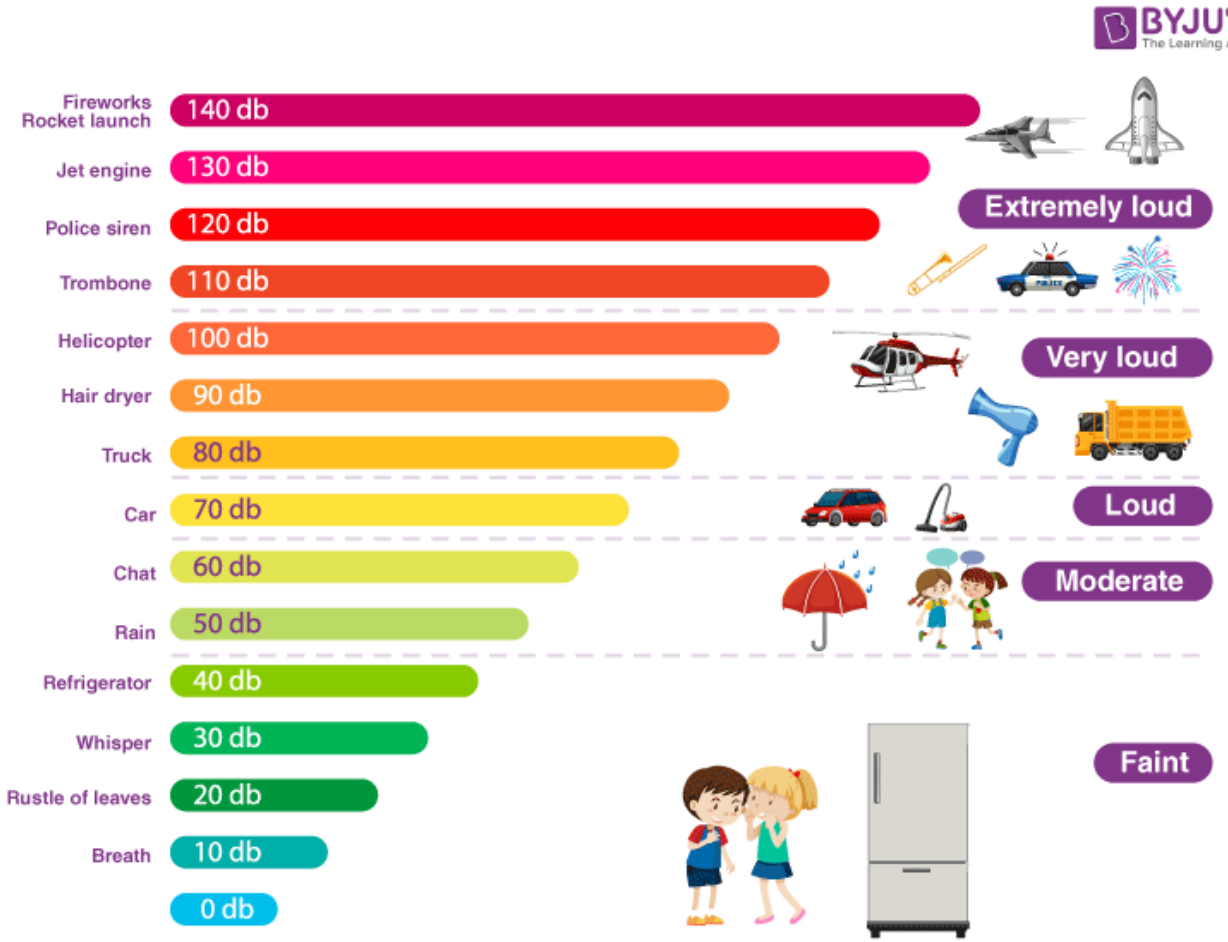
Control of soil pollution

Some of control measures are:

- **Proper dumping of solid waste:** dumping in open dumps should be discouraged. Instead, landfills should be possible disposal way.
- Highly toxic and persistent synthetic chemical pesticides should be banned
- Crop rotation should be encouraged to revive depleted soil nutrients
- High concentration of lead and cadmium can be controlled by growing a special type of grass called vetiver grass. The contaminants get concentrated in roots of this grass and get reduced in soil.
- Recycling of waste like ferrous materials, metals, glass, plastic is another method of reducing the amount of pollutants added to soil.
- Plantation of trees can help to check soil erosion.

Noise Pollution

- In addition to other pollutants, noise also plays a major role in the degradation of the environment.
- Noise can be explained as any sound that is not desired by recipient. So noise pollution is unwanted sound dumped into the atmosphere
- Our ears can hear ordinary conversation between 30-60 decibels. Modern conversation has a noise value of 60 decibels. A decibel value greater than 80 decibels causes noise pollution.



Classification of Noise

1. Transport Noise:

→Road Traffic Noise

→Aircraft Noise

→Rail Traffic Noise

2. Occupational Noise: Heavy industrial machines are a source of occupational noise. Also includes noise from domestic gadgets like vacuum cleaners, mixer-grinders and washing machines.

3. Neighbourhood noise

Effects of noise pollution

- Constant noise affects a man physically and mentally. Physical effects include blood vessels to contract, skin to become pale, muscles to constrict and rise in blood pressure leading to tension and nervousness
- High intensity sound emitted by industrial plants, bottling machines, supersonic aircrafts, when continued for long periods of time not only disturbs but also permanently damages hearing
- Offices, industries and crowded places where constant noise prevails can produce temper, tantrums, headaches, fatigue and nausea
- Loud and sudden noise affect the brain Intermittent noise leads higher incidence of psychiatric illness and also a danger to health of pregnant mothers and small infants
- Noise has harmful effects on nonliving materials too, eg cracks develop under the stress of explosive sound

Controlling noise pollution

- Limited use of loudspeakers and amplifiers
- Excursing control over noise producing vehicles
- Industrial workers should be provided with ear plugs
- Delocalization of noisy industries far away from dwelling units
- Within a radius of 10 miles of airport, no buildings or factories should be allowed
- Plants and trees should be planted all around the hospitals, libraries and schools and colleges

Thermal Pollution

- Different industries and nuclear power plants use water for cooling purposes and discharge the heated water into nearby streams or water bodies. As a result, the nearby water body is heated up and this in turn, affects aquatic life. This phenomenon is known as thermal pollution.
- Natural phenomenon such as earthquakes also cause thermal pollution.
- Random cutting down of shade-providing trees beside the water bodies.

The harmful effects of thermal pollution are:

1. **Reduction in DO:** The pollutant from various industrial plants are heated which decrease the concentration of oxygen with an increase in the temperature of water

2. **Change in water properties:** The decrease in density, viscosity, and solubility of gases in water increases the setting speed of suspended particles which seriously affect the food supplies of aquatic organism

3. **The increase in temperature will cause death of aquatic life by stopping essential biochemical reactions** (enzymes can tolerate temperature change only up to a few degrees)

Radiation Pollution

- Radiation pollution is caused by the addition of more ionizing radiation to the environment and people are exposed to more radiation than they normally experience.
- Radiation interacts with living tissues and damages them.
- Radioactive disintegration of atomic nuclei generates three types of radiation: alpha, beta and gamma which are very harmful to living systems.

Sources of Radiation

- **Natural Radioactive Sources**
- **Cosmic Radiation:** These are high-energy charged particles (mostly protons) that enter the earth's atmosphere from outer space. While travelling they produce secondary radiation by colliding with other atoms such as oxygen and nitrogen, present in the earth's atmosphere.
- **Terrestrial Radioactivity:** It originates from the deposit of radioactive minerals such as uranium, thorium, actinium and polonium.
- **Radio Isotopes:** These are the most damaging and dangerous pollutants. Some radioactive isotopes like K^{40}, Ca^{14}, Th^{232}, U^{238} are present in human body tissues, although their concentration varies with the geographical location and other factors. Radio isotopes are produced by the cosmic rays in the upper atmosphere.

- **Artificial Radioactive Sources**

→**Nuclear Power plants**

→**Constructive use of Nuclear Explosions**: nuclear explosions have begun to be used for constructive purposes such as, releasing natural gas from the underground region, harbour-building and for the construction of canals between oceans.

→**Radioactive Fallout from nuclear weapons: T**esting of a nuclear weapon in the atmosphere results in the local fallout of radioactive fission products over the immediate area for about a day, followed by worldwide troposphere fallout for a month and a worldwide stratospheric fallout which continues for many years

→**Radiation from Miscellaneous Sources:** A person can also get exposed to radiation while watching television or smoking cigarettes.

Harmful Effects of Radiation

- The harmful effects of radiation may be of the following two types:
- **Direct Effects:** Fragmentation of biologically important molecules such as DNA.
- **Indirect Effects:** Fragmentation of biologically less-vital molecules with the formation of reactive ions or free radicals that can later affect more important molecules and impair their functions
- It is felt that radiation exposure to man from artificial sources is already capable of producing serious diseases such as leukaemia, bone tumours, genetic damages and infant mortality.

Types of radiation	Effects on body
α particles Particulate in nature	Can travel in air only a few centimetres and in living tissues only 30μm (that is, can cross about three cells), generally cannot penetrate the skin. Entry to body parts such as bones and lungs cause irreparable damage.
β particles Particulate in nature	Can travel in air about 8 cm. And in tissue about 1 cm. These can penetrate the skin but do not reach underlying tissues. They can cause damage to skin, causing cancer and eye cataract.
γ radiation	Can travel about hundred meters in air and can easily penetrate the body and pass through it.
X-rays	Can travel extremely far and pass through the body tissue, except bones. Causes damage to the molecules in cells
Ultraviolet rays	Have relatively lower energy than X-rays, can cause skin cancer.

Safety Measures

- The International Commission on Radiology Protection (ICRP) formed in 1947, has recommended that the Maximum Permissible Dose (MPD) for adults and members of the public, exposed to radiation should not exceed 0.4 RAD a year and cumulative dose over a period of 30 years should not exceed five RAD.

→RAD: Radiation Absorbed Dose is defined as the quantity of radiation that leads to the absorption of 100 erg/gm of the absorbing material

- X ray examinations should be avoided as far as possible.
- Better technology and suitable waste disposal method is also essential for all nuclear power plants.
- Nuclear power plants should be located far from populated areas and should be provided with a suitable radiation absorption zone around them to check the escape of radiation.

- **Method of disposal of radioactive waste:**

It should be disposed in such a way that no hazard is caused. It can be disposed off in soil or ocean

Disposal in ground: the burial of radioactive waste is 500 m deep. Soil absorbs radioactive materials easily. The wastes are kept buried for 13 years and then finally disposed off in sea.

Vacated coal mines can be used for disposal. Salt is a powerful absorber for radioactive radiations and hence it is disposed off in heaps of salts.

Before disposing in sea, it should be ensured that radioactive waste is below harmful levels.

Hazardous Waste

- The term generally refers to the waste that could pose a threat to human health and environment if managed improperly.
- It is defined as any waste which because of its quantity, concentration or physical, chemical or infectious characteristics may cause significant hazard to human health and environment when improperly treated, stored or disposed off.
- Hazardous waste will contribute to:

1. **Increase in mortality**
2. **Increase in serious illness**
3. **Pose a substantial hazard to human health**

→ A substance is defined as hazardous if it possesses any of the following characteristics:

- **Reactivity:** if any substance is not stable at normal conditions, can cause explosive reactions or liberate toxic fumes, gases and vapours, reacts violently when mixed with water is termed as reactive.

Examples- sodium and potassium metals, cyanide, dry picric acid, etc.

- **Ignitability:** wastes which burn easily below 60°C. Example- ether, methanol, paint thinners, etc.
- **Corrosivity:** waste containing liquids with pH less than 2 or greater than 12.5. ex- sulphuric acid, drain openers, sodium hydroxide.
- **Toxicity:** substances that are harmful or fatal when absorbed. Ex- mercury, benzene containing products, rat poison, etc

Explosives

Gases

Flammable Liquids

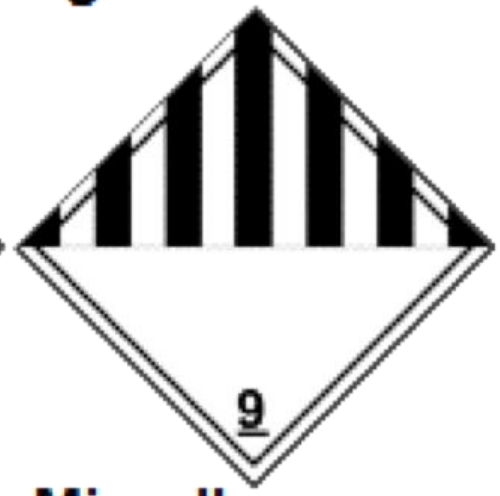
Flammable Solids

Oxidizers and Organic Peroxides

Poison and Infectious Substances

Radioactive

Corrosive



Miscellaneous

- **Hazardous waste is classified as:**

1. **Radiochemical waste**
2. **Biomedical waste**
3. **Chemical waste**

Radiochemical waste-

- Radioactivity arises from decay of some isotopes.
- All kinds of radiation (alpha, beta and gamma) are naturally part of our environment at low concentrations.
- However, Radiation pollution is caused by the addition of more ionizing radiation to the environment and people are exposed to radiation more than they normally experience. Radiation interacts with tissues and damages them.

- Sources of radioactive waste (done previously)
- Damages caused by radiation (done previously)
- Disposal of radioactive waste and disposal methods (done previously)

Biomedical Waste

- It is the waste that is generated by human or animal healthcare facilities and veterinary or medical teaching establishments. It includes-

1. Human anatomical waste
2. Animal waste like tissues, organs, body parts, etc
3. Microbiology laboratory waste like specimens, laboratory cultures
4. Needles, syringes, blades, etc

Chemical Waste: It includes effluents from various industries, solvents, etc

HAZARDOUS WASTE TREATMENT TECHNOLOGIES

- **Physical process: I**t includes sedimentation, phase separation, adsorption, reverse osmosis, ion exchange etc.
- **Chemical process:**

→**Neutralization:** discussed previously

→**Chemical Precipitation:** The pH of the wastewater is adjusted so that the solubility of the toxic metal is decreased, leading to the formation of a precipitate.

Example: $M^{2+} + Ca(OH)_2 \rightarrow M(OH)_2 + Ca^{2+}$

→**Oxidation-Reduction Process:** Converting the substance to an oxidation state which is less toxic. Eg. Cr^{6+} to Cr^{3+} using SO_2 as reducing agent

$3SO_2 + 3H_2O \rightarrow 3H_2SO_3$

$2CrO_3 + 3H_2SO_3 \rightarrow Cr_2(SO_4)_3 + 3H_2O$

- **Biological process:** in situ biodegradation of organic matter to CO_2 and water by micro-organisms
- **Incineration:** discussed previously
- **Land disposal:** discussed previously

Disaster Management

- Disaster management or emergency management is discipline of avoiding and fighting both natural and man-made disasters. Preparedness, response and recovery plans are made to decrease the impact of these disasters.
- National Disaster Management Authority (NDMA), under home ministry is responsible for disaster management in India.
- **Types:**

➢ **Natural Disasters:** floods, hurricanes, earthquake, volcanic eruptions. Immediate and secondary effects both are caused.

➢ **Environmental emergencies:** technological and industrial emergencies using hazardous materials. Ex- Bhopal Gas Tragedy

➢ **Complex emergencies:** involves breakdown of authority, wars, attacks, etc.

➢ **Pandemic emergencies :** sudden onset of contagious disease which affects health, social and economic sector.

- **Preparedness and mitigation**

❑ Disaster Preparedness includes all the activities which should be done before the event to ensure best use of available resources, relief and rehabilitation facilities.

❑ **Disaster mitigation** is ongoing effort to lessen the impact of disaster on people and property.

Floods

- It refers to huge amount of water reaching land in short span of time causing the land surface to get submerged in water which is otherwise dry.
- As per National Flood Commission report, more than 40 million hectares of land is prone to floods.
- **Types:**

❖ **Flash floods-** During heavy rainfall, in areas with steep slope, the water flows over the river bank and floods the area.

❖**Coastal flood-** it is caused by severe storm in coastal areas. The characteristic of such floods is that water rises and drops with tide. This results in build up of force by the sea and then sea floods the coast.

- **Urban flooding :** it is specific in urban areas where there is lack of drainage. Heavy rainfall can cause flooding when the city sewage system and draining canals are unable to drain away the amounts of rain that are falling.
- **Fluvial floods:** Rainfall over extended period and large areas can cause overflowing of rivers or when a dam breaks and large amount of water flows with high speed. Downstream areas are affected in such cases.
- **Pluvial floods:** this affects flat surfaces. When more rainwater enters than that can be stored, flooding occurs

• Mitigation strategy for floods:

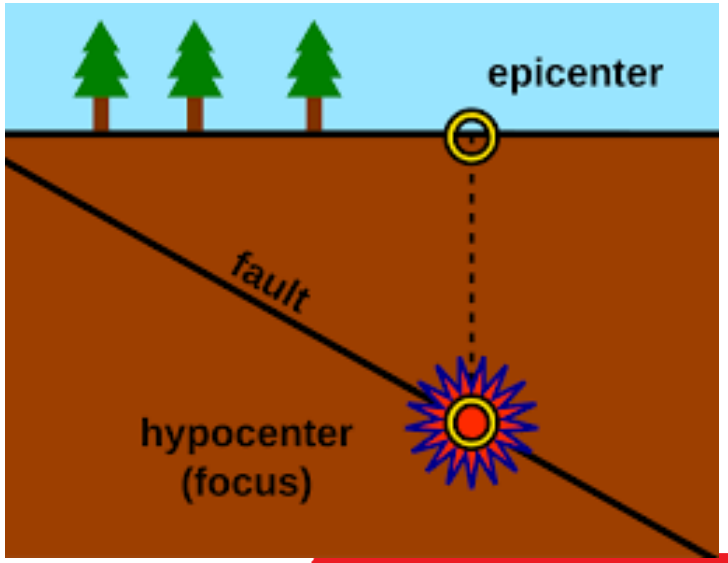
Before the Disaster	During the Disaster	After the Disaster
• Learn warning signs and community alert systems • Emergency building materials should be collected • Sewer drains should have check valves in sewer traps to prevent flood waters from collecting • Evacuation route should be chalked out. • An emergency communication plan in case of separation should be made.	• During a flood, turn on battery operated radio to get latest emergency information • Get pre-assembled emergency supplies • In case of emergency leave, the place immediately. • If outdoors: Climb to high ground and stay there. • If advised to evacuate, do so immediately to avoid flooded roads, being sure to follow recommended evacuation routes and listen to radio for evacuation instructions	• Don't return home until told by authorities • Use extreme caution when entering buildings and check for cracks or other damage to make sure that the building is not in danger of collapsing • Watch out for animals, especially poisonous snakes, which may have come into your home with flood water.

Earthquakes

- It is result of release of energy in the Earth's crust that creates seismic waves. It is always natural and can never be man made.
- The place of initial rupture of earthquake is called **hypocenter** and ground directly above it is called **epicentre.**
- Epicentre is the point on earth's surface that is directly above the focus, point where earthquake originates.

Classification of earthquakes

1. **Intensity-** it measures the effect of earthquake at different places having same epicentre.
2. **Magnitude-** based on amount of energy released of a particular earthquake.



- **Earthquake hazard-** anything associated with earthquake that may effect normal activity
- **Earthquake risk-** it is the probable damage to buildings and number of people that are expected to be hurt or killed in case if earthquake occurs.

National guidelines on earthquake risk management in India:

(a). Ensure incorporation of earthquake resistant design features in construction of new structures

(b) Facilitate selective strengthening and seismic retrofitting of existing priority and lifeline structures in earthquake-prone areas.

(c) Improve the compliance regime through appropriate regulation and enforcement.

(d) Improve the awareness and preparedness of all stakeholders.

(e) Introduce appropriate capacity development interventions for effective earthquake management (including education training, R&D, and documentation).

(f) Strengthen the emergency response capability in earthquake-prone areas.

Earthquake disaster mitigation strategies

Before the Disaster	During the Disaster	After the Disaster
• Check for hazards in the home • Identify safe places in each room • Locate safe places outdoors • Ensure all family members know how to respond after an earthquake • Teach children when and how to call 9-1-1 • Have disaster supplies on • Develop an emergency communications plan in case of separation during the earthquake • Ask an out-of-state relative or friend to serve as the family contact	• If indoors: Take cover under a piece of heavy furniture or against an inside wall and stay inside • If outdoors: Move into the open, away from buildings, street lights, and utility wires and remain there until shaking stops • If in a moving vehicle: Stop quickly, stay in vehicle, move to a clear area away from buildings, trees, overpasses, or utility wires	• Be prepared for after shocks • Help injured or trapped persons and give first aid where appropriate • Listen to a battery operated radio for emergency information • Stay out of damaged buildings and return home only when authorities say it is safe

Cyclones

- Cyclone is a whirl in atmosphere with very strong winds circulating around it. **Cyclone preparedness-**

When a cyclone warning is issued	On warning of local evacuation	After a Cyclone
• When requested by local authorities, collect children from school. • Put wooden or plastic outdoor furniture *i* with other loose items. • Pack an evacuation kit of warm clothes, essential medications, valuables, important documents. Large/ heavy valuables could be protected in a strong cupboard. • Remain indoors (with your pets). Stay tuned to your local radio/TV for further information.	• Wear strong shoes and tough clothing for protection. • Lock doors; turn off power, gas, and water. • If evacuating out side the town, take pets and leave early to avoid heavy traffic, flooding and wind hazards. • If going to a public shelter, take bedding needs and emergency kit (medicine etc.). • Leave pets protected and with food and water.	• Don't go outside until officially advised it is safe. • Check for gas leaks. Don't use electric appliances if wet. • Listen to local radio and remain indoors until advised. • Beware of damaged power lines, bridges, buildings, trees, and don't enter floodwaters. • Don't make unnecessary telephone calls.

Landslides

- It is caused by mass movement of rock, debris or earth down a slope. Himalayas and western ghats are the two regions which are most vulnerable to landslides.

Table 11.6 Main causes of landslides

Geological causes	Morphological causes	Anthropogenic causes	Physical causes	Man made Causes
• Weak or sensitive materials • Sheared, jointed, or fissured materials • Adversely oriented discontinuity (bedding, schistosity, fault, unconformity, contact, and so forth) • Contrast in permeability and/or stiffness of materials	• Tectonic or volcanic uplift·Fluvial, wave, or glacial erosion of slope toe or lateral margins • Subterranean erosion (solution, piping) • Deposition loading slope or its crest· Vegetation removal (by fire, drought) • Thawing· Freeze-and-thaw weathering • Shrink-and-swell weathering	• Excavation of slope or its toe • Loading of slope or its crest·Draw-down (of reservoirs) • Deforestation • Irrigation • Mining • Artificial vibration • Water leakage from utilities	• Prolonged precipitation • Rapid draw-down· Earthquake • Volcanic eruption·Thawing • Shrink and swell	• Excavation (particularly at the toe of slope • Loading of slope crest • Draw -down (of reservoir) • Deforestation • Irrigation • Mining • Artificial vibrations • Water impoundment and leakage from utilities

Nuclear accidents and Holocaust

- International Atomic Energy Agency has defined nuclear and radiation accident as “an event that has led to significant consequences to people, the environment or the facility.”
- In case of major nuclear accident, the reactor core gets damaged and significant amounts of radioactivity are released such as Chernobyl disaster in 1986.
- Although nuclear power is an alternative for fossil fuels but thermal waste, nuclear waste and nuclear accidents are a cause of major concern.
- Release of radioactive waste can harm the mankind for several generations. Ex- Bhopal gas tragedy, 1984

- Thermal pollution created by these nuclear plants is also a major concern as it leads to global warming, effect national and global meteorology and form dangerous fog.
- Thus solids, liquids and gaseous waste compounds releases from nuclear plants should be treated so that there is no risk for humans.
- **Well known nuclear accidents-**

Three Mile Island accident, 1979

Chernobyl, 1986

Fukushima, 2011

Case Study, Fukushima, 2011

- Fukushima Daichii power plant was severely affected by earthquake and tsunami resulting in damaging its crucial cooling system.
- As a result, a series of explosions and meltdowns occurred causing leakage of radiation.
- More than 80,000 people were evacuated with no prospect of returning back to their homes.
- Economy was also severely affected.
- Operators of the nuclear power plant had spend months to bring it in the state of cold shutdown.

Land Resources

- **India's mainland comprises four broad geographical areas:**

→**Northern Mountains:** Corresponding with the Himalayan Zone, alongwith country's northern boundaries including the Jammu and Kashmir (J&K), Himachal Pradesh (H.P.), North-West Uttar Pradeh (U.P.), Sikkim, part of Assam, and the North-Eastern States of Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura and Meghalaya.

→**The Great Plains:** Also known as the Indo-Gangetic plain is formed by the basin of three distinct river systems - the Indus, the Ganga and the Brahmaputra. The Plains extend from Rajasthan in the West to Brahmaputra valley in the East.

→**The Deccan Peninsula:** This zone covers the whole of South India which includes the States of Tamil Nadu, Karnataka, Andhra Pradesh and Kerala. The Region also covers the State of Madhya Pradesh, and parts of Bihar, Orissa, Puriliya district of West Bengal

→**The Coastal Plains and Islands:** The peninsula is flanked on either side by the Eastern Ghats and the Western Ghats. On either side of the Ghats outward to the sea lies a coastal strip

Land Utilization

- The land resources are utilised for the following purposes:

1. **Forests**

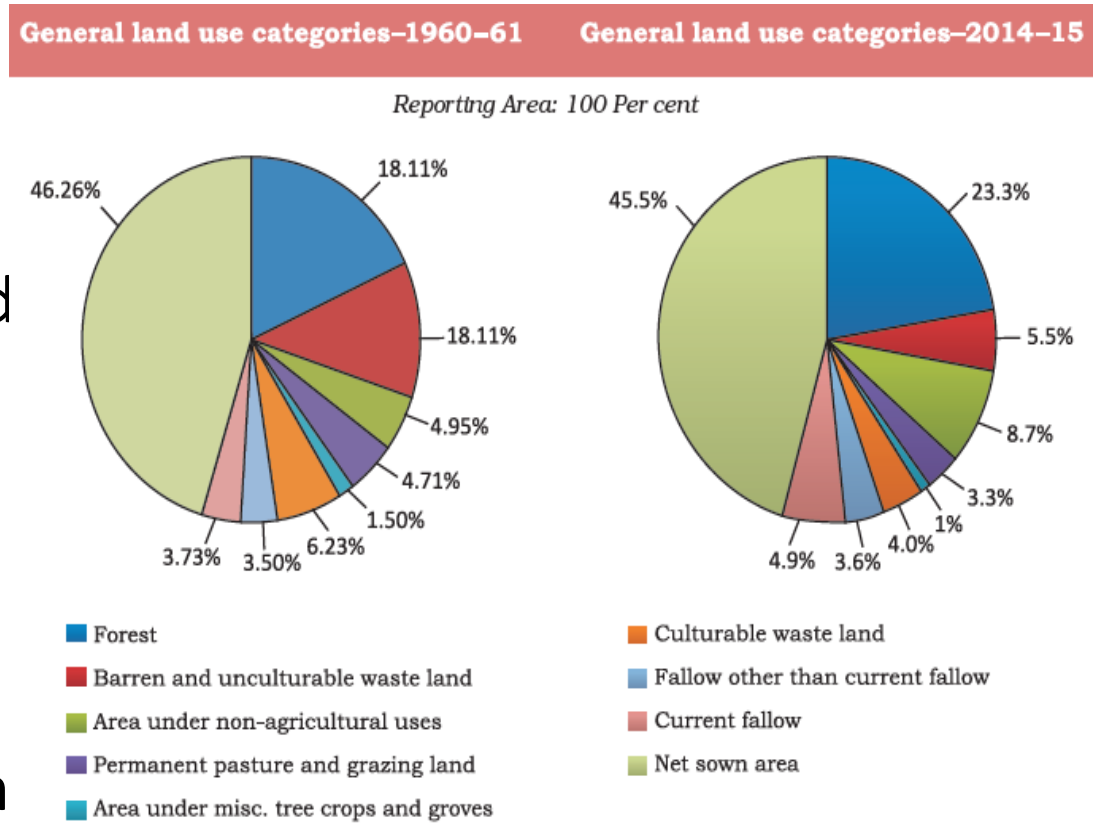
2. **Area under non-agricultural use** e.g. land occupied by buildings, roads and railways, housing, recreational purposes, industrial sites and irrigation systems.

3. **Barren and unculturable land,** are generally unsuitable for agricultural use either because of the topography or because of their inaccessibility e.g. desert areas in Rajasthan

4. **Permanent Pasture and Grazing lands.**

5. **Fallow lands** are left uncultivated from less than a year to five years or more.

6. **Cropped areas:** Area sown more than once in an agricultural Year plus the net sown area



Land Degradation

There are **four direct causes** of land degradation:

1. **Deforestation and removal of natural vegetation:** the land that is cleared is steeply sloping or has shallow or easily erodible soils, and when clearance is not followed by good management.

2. **Over-exploitation of wood cover for domestic use:** people cut forests, woodlands and shrublands to obtain timber, fuelwood and other products at a pace exceeding e rate of natural regrowth.

3. **Overgrazing:** grazing of natural pastures at stocking intensities above the livestock carrying capacity; the resulting decrease in the vegetation cover is a leading cause of wind and water erosion.

4. **Agricultural activities that can cause land degradation include**:

→shifting cultivation without adequate fallow periods

→absence of soil conservation measures,

→cultivation of fragile or marginal lands,

→unbalanced fertilizer use,

→Host of possible problems arising from faulty planning or management of irrigation.

Soil Degradation

- Soil degradation in general contribute to land degradation. Factors causing Soil Degradation are:

1. **Soil Erosion:** This is the process by which top soil is detached from land and either washed away by water, ice or sea waves or blown away by wind. Contributing Human activities:

- Deforestation
- Faulty Cultivation Methods
- Shifting Cultivation
- Overgrazing
- Lack of proper surface drainage
- Forest fires

2. **Loss of Fertility by Mismanagement:** This includes:

→Unscientific cropping practices

→Imbalancing of nutrients

→Loss of organic matter

→Soil Pollution

3. Salinity/Alkalinity of soil

→Occurs in areas of temporary water surplus and high temperatures.

→Due to over-irrigation or high rainfall, the moisture percolates down and dissolves the underground salts in it.

→During the dry period, this solution comes to the surface by capillary action. The water gets evaporated, leaving behind a crust of salts of sodium, magnesium and calcium which has a fluorescent appearance.

4. Acidity:

→It is a chemical degradation of soil including toxicity of certain metallic ions for the normal crop growth.

→Acid soils are characterised by low pH values, low base saturation and high mounts of exchangeable hydrogen and aluminium resulting from intense leaching

5. Water Logging

→Waterlogging is defined as the state whereby soil becomes saturated with water within the depth of the root zone for a period that affects yield and quality of crops.

→This happens when the water table gets saturated for various reasons over-irrigation, seepage from canals, inadequate drainage etc

6. Floods and Droughts

7. Desertification

→Formation and expansion of degraded areas of soil and vegetation cover in arid, semiarid, and seasonally dry areas, caused by climatic variation and human activities. These lands are traditionally called **drylands.**

→three major practices that expose soil to erosion and lead to desertification are:

- **Overcultivation**
- **Overgrazing**
- **Deforestation**

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