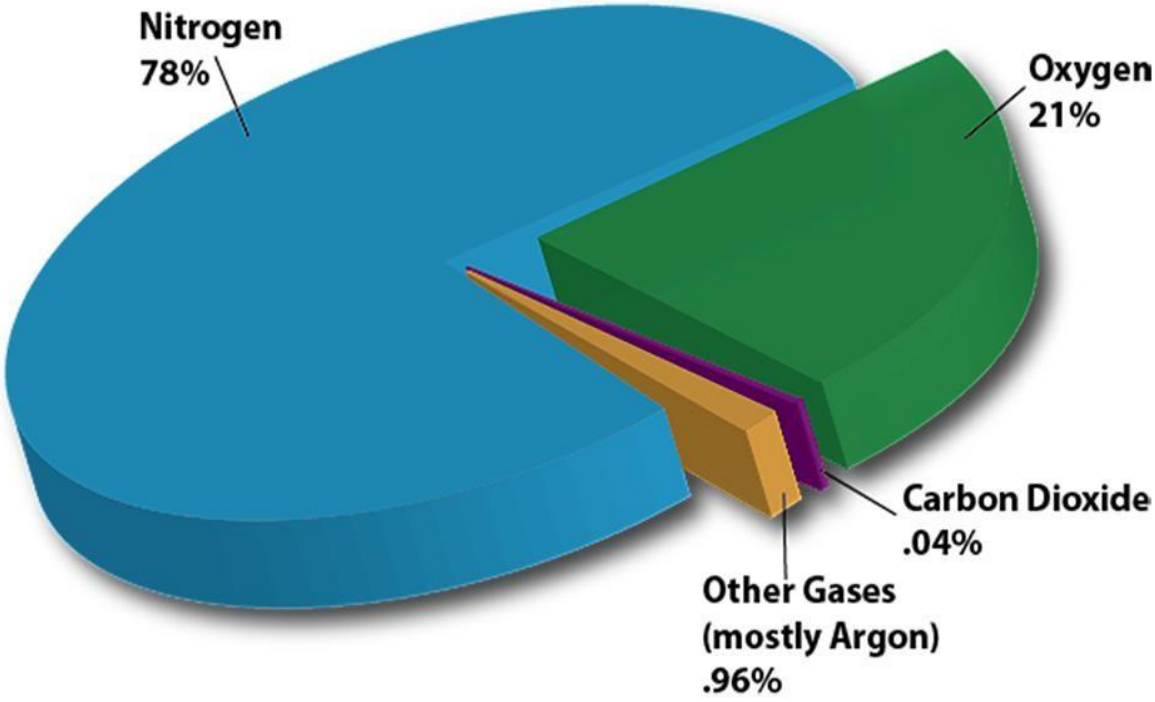
Environmental Chemistry

Composition and Segments of Atmosphere

Earth's atmosphere is made up of layers of gases and is composed of the following composition:



The atmosphere of earth is composed of about 78% nitrogen,21% oxygen,0.04% carbon dioxide,0.96% argon and trace amounts of neon, helium, methane, krypton and hydrogen, as well as water vapour.

Nitrogen : It is the most plentiful gas in the air. It is one of the primary nutrients critical for the survival of all living organisms.

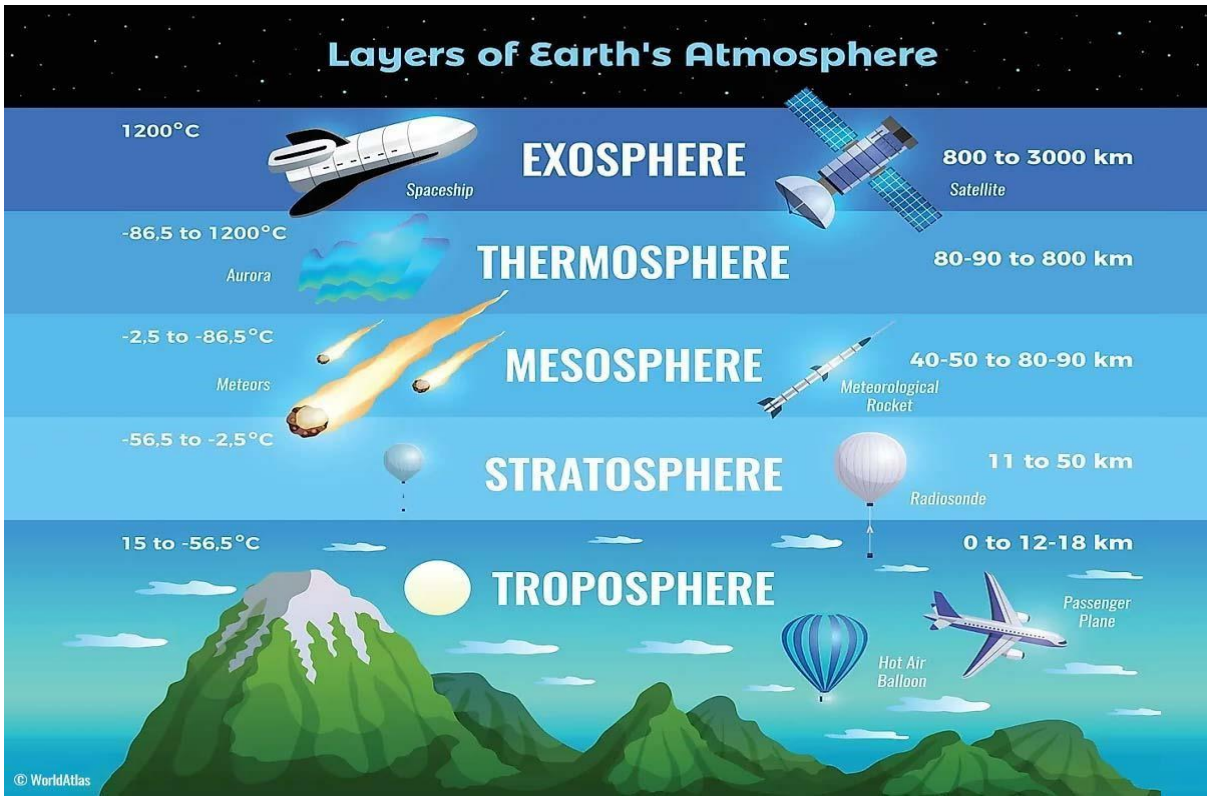
Oxygen: Oxygen is required for the survival of life. Green plants produce oxygen during photosynthesis. In this way oxygen content in the air remains constant.

Carbon dioxide : It is an important heat-trapping gas, or greenhouse gas, that comes from the extraction and burning of fossil fuels**.**

It is the most important raw material which plant utilized during photosynthesis process

Segments of Atmosphere:

The vertical structure of atmosphere consists of several layers which are separated from one another by change in slope of the graph of temperature vs altitude.



1. Troposphere:

1. The lowest layer of atmosphere in which living organisms operate is called troposphere.
2. **It extends up to 10km**
3. It is the region of strong air movements and cloud formation
4. Water vapour and dust occurred in troposphere in extremely variable concentration **5. All the climatic and weather changes take place in this layer of the atmosphere.**
6. The temperature ranges from **14^0C to -56^0C** in troposphere
7. **Tropopause** is a zone that separates the troposphere from the stratosphere.
8. The changes in temperature with height is known as **lapse rate**
9. The decrease of temperature with increasing altitude in troposphere is called **Positive lapse rate**

2. Stratosphere:

1. The region above the tropopause is known as stratosphere about 50 km above the surface of earth.
2. Temperature ranges from -56^0C to-2^0C
3. In this zone the temperature-altitude curve shows warming trend with increasing altitude
4. The increase of temperature with increasing altitude in this layer shows **Negative lapse rate.**
5. Heat is produced in the process of the formation of Ozone, and this heat is responsible for **temperature increase.**

6. **Ozone** in atmosphere acts as a protective shield (Umbrella) for life on earth from injurious effects of sun's ultraviolet rays.
7. The region above the stratosphere is known as **stratopause**
8. Weather-related phenomena are absent in this layer of the atmosphere, that is why aeroplanes fly in the stratosphere for a smooth ride**.**

3. Mesosphere:

1. Located between about 50 and 80 kilometres above Earth's surface
2. **It is known as a coolest layer of atmosphere**
3. Temperature ranges from -2^0C to -92^0C
4. The decrease of temperature with increasing altitude in this layer shows **Positive Lapse rate**
5. **Most meteors burn up in this atmospheric layer. Sounding rockets and rocketpowered aircraft can reach the mesosphere**.
6. The region above the mesosphere is known as menopause

4. Thermosphere/Ionosphere

1. It is located between about 80 and 700 kilometres above Earth's surface, whose lowest part contains the **ionosphere.**
2. **Temperature ranges from -92^0C to 1200^0C as it is much closer to the sun.**
4. It shows Negative lapse rate as temperature increases with height.
5. The gases present in this layer absorb solar radiation and undergo ionization
6. The ionosphere is the atmospheric layer, which is mostly used for communication purpose. due to electrical conductivity.
8. **Ionosphere helps in radio communication.**
9. **The International Space Station (ISS) orbits in the thermosphere.**

5. Exosphere:

1. It is located between about 700 and 10,000 kilometres above Earth's surface,
2. The exosphere is the highest layer of Earth's atmosphere and, at its top, merges with the solar wind.
3. **Molecules found here are of extremely low density, so this layer doesn't behave like a gas, and particles here escape into space.**
4. While there's no weather in the exosphere.
5. **Most Earth satellites orbit in this layer.**

Note: Atmosphere absorbs most of the cosmic rays from outer space and protects living things from their harmful effects. it also maintains the heat balance of the earth. It serves as insulation from heat loss at the earth's surface and stabilises weather and climate owing to the heat capacity of the air

Unit-III

Air pollution

1.Introduction:

Air is one of the five essentials for almost all the life forms on biosphere. Even though the air is abundantly available over the surface of earth, but it contains a lot of impurities due to natural and manmade activities.

Air pollution is broad term applied to any chemical, physical or biological agent that modifies the natural characteristics of atmosphere

OR

Exposure of pollutants affects the actual quality of Air is known as Air pollution

2.Sources of Air pollutants:

Stationary Sources	Point Sources	These are large stationary sources such as industries, power plants, Municipal incinerations etc.
	Area Sources	These are small stationary sources and mobile sources with indefinite routes such as residential heating, commercial and institutional heating, open burning, city traffic etc..
Mobile Sources	Line Sources	These are highways, railway tracks, navigation routes, etc.

	Area Sources	These are ports, Aircrafts, mobile vehicles etc

3.Major Air Pollutants of Air Pollution:

Pollutant	Common sources	Maximum acceptable concentration in the atmosphere	Environmental risks	Human health risks
Carbon monoxide	Automobile emissions, fires, industrial processes	35 ppm (1-hour period); 9 ppm (8-hour period)	contributes to smog formation	exacerbates symptoms of heart disease, such as chest pain; may cause vision problems and reduce physical and mental capabilities in healthy people
Nitrogen oxides (NO and NO_2)	Automobile emissions, electricity generation, industrial processes	0.053 ppm (1-year period)	damage to foliage; contributes to smog formation	inflammation and irritation of breathing passages
Sulfur dioxide (SO_2)	Electricity generation, fossil-fuel combustion, industrial processes, automobile emissions	0.03 ppm (1-year period); 0.14 ppm (24-hour period)	major cause of haze; contributes to acid rain formation, which subsequently damages foliage, buildings, and monuments; reacts to form particulate matter	breathing difficulties, particularly for people with asthma and heart disease
Ozone(O_3)	Nitrogen oxides (NO_x) and	0.075 ppm (8-hour	interferes with the	reduced lung

	volatile organic compounds (VOCs) from industrial and automobile emissions, gasoline vapours, chemical solvents, and electrical utilities	period)	ability of certain plants to respire, leading to increased susceptibility to other environmental stressors (e.g., disease, harsh weather)	function; irritation and inflammation of breathing passages
Particulate matter	Sources of primary particles include fires, smokestacks, construction sites, and unpaved roads; sources of secondary particles include reactions between gaseous chemicals emitted by power plants and automobiles	150 $\mu g/m^3$ (24-hour period for particles <10 μm); 35 $\mu g/m^3$ (24-hour period for particles <2.5 μm)	contributes to formation of haze as well as acid rain, which changes the pH balance of waterways and damages foliage, buildings, and monuments	Irritation of breathing passages, aggravation of asthma, irregular heartbeat
Lead (Pb)	Metal processing, waste incineration, fossil-fuel combustion	0.15 $\mu g/m^3$ (rolling three-month average); 1.5 $\mu g/m^3$ (quarterly average)	Loss of biodiversity, decreased reproduction, neurological problems in vertebrates	Adverse effects upon multiple bodily systems; may contribute to learning disabilities when young children are exposed; cardiovascular effects in adults

Carbon monoxide:

Carbon monoxide is an odorless, invisible gas formed as a result of incomplete combustion. Nearly 50 percent of all CO emission originates from automobiles. It is also present in cigarette smoke.**it is highly poisonous and reduce the oxygen carrying capacity in blood**

Sulfur dioxide:e

A colorless gas with a sharp, choking odour, sulfur dioxide is formed during the combustion of coal or oil that contains sulfur as an impurity. Most sulfur dioxide emissions come from power-generating plants; very little comes from mobile sources. This pungent gas can cause eye and throat irritation and harm lung tissue when inhaled.**Sulfur dioxide also reacts with oxygen and water vapor in the air, forming a mist of sulfuric acid that reaches the ground as a component of acid rain. Acid rain is believed to have harmed or destroyed fish and plant life in many thousands of lakes and streams it also causes corrosion of metals and deterioration of the exposed surfaces of buildings and public monuments**. **eg:Tajmahal**

Nitrogen dioxide:

Of the several forms of nitrogen oxides, nitrogen dioxide—a pungent, irritating gas—is of most concern. It is known to cause pulmonary edema, an accumulation of excessive fluid in the lungs. Nitrogen dioxide also reacts in the **atmosphere** to form **nitric acid,contributing to the problem of acid rain**. In addition, nitrogen dioxide plays a role in the formation of photochemical **smog**, a reddish brown **haze** that often is seen in many urban areas and that is created by sunlight-promoted reactions in the lower atmosphere.

Ozone:

A key component of photochemical **smog, ozone** is formed by a complex reaction between **nitrogen dioxide** and hydrocarbons in the presence of **sunlight**.it is considered as pollutant in lower atmosphere as and contribute in global warming and green house effect.

Lead:

Inhaled **lead particulates** in the form of fumes and dusts are particularly harmful to children, in whom even slightly elevated levels of lead in the blood can cause **learning disabilities,** seizures, or even death

(*see* **lead poisoning**). Sources of airborne lead particulates include **oil refining, smelting**, and other industrial activities.

4.Effects of Air Pollution on Human Health:

The air we breathe has not only life sustaining properties but also life damaging properties.The impurities in the inhaled air can affect human health in a number of ways depending upon the nature and concentration of pollutants,duration of exposure and age group of receptor. The various health effects are as under:

- Eye irritation can be caused by many air pollutants such as NOx,O3,smog and particulates
- Estimated 0.62 million mortalities occur annually in India that could be attributed to PM2.5 pollution in 2010. **TERI projected the mortalities to increase to 1.1 million in 2031 and 1.8 million in 2051, in a business-as-usual scenario.**
- Hydrogen fluoride can cause fluorosis and mottling of teeth
- Exposure of radioactive isotopes like iodine 131,phosphorous 32 etc can cause **anemia,leukaemia,cancer and genetic defects**
- Other than outdoor pollution, biomass used in rural regions and urban slums for cooking and kerosene for lighting is associated indoor air pollution and with a variety of health diseases such as Chronic Obstructive Pulmonary Disease, tuberculosis, cataract and adverse pregnancy outcomes

Effects of Air Pollution on Materials:

Direct damage to structural metals, surface coating fabrics and other materials of commerce is a frequent and widespread effects of air pollution. This destruction is related to many types of pollutants but chiefly attributed to acid acid mists, oxidants of various kinds, H_2S and particulate matters of combustion and industrial processing.

Effecton Metals: Corrosion of surface with eventual loss of materials from the surface and alteration in electrical properties of metals eg: Zinc is often used a protective coating on iron to form galvanized iron.

Effect on Stones: Soiling and deterioration of limestone,marble stone etc.eg:Carbon dioxide in presence of moisture forms carbonic acid.which is responsible for deterioration

Effects on Paints: H_2S reacts with lead base pigments to blackened it.

Effects of Air Pollution on Vegetation:

The primary factor that govers the gas absorption by the plant leaves is the degree of opening of stomata.There are m,any effects of air pollution vegetation is listed below:

) Reduced Photosynthesis and Growth

Photosynthesis, the very cornerstone of plant life, ensures growth and nourishment. This process is imperilled by particulate matter, ozone, **sulphur dioxide**, and nitrogen oxides. **These agents often hamper the chlorophyll's absorption capability,**derailing the natural process of converting light to chemical energy.

.**2) Damage to Leaf Structure and Function:**Air pollutants' insidious nature means they can settle onto the leaf surfaces, initiating a sequence of deleterious effects. **The visible symptoms are manifold, from necrotic spots and premature leaf drop to yellowing and stippling.**These damages disrupt essential functions like transpiration, making plants vulnerable to heat stress, nutrient deficiencies, and subsequent illnesses.

3) Changes in Reproductive Success

From the larger perspective of an ecosystem's vitality, air pollution's effect on plant reproduction is severely unsettling. **Pollutants can distort the structural integrity of pollens, debilitating their function. With compromised pollen health, plants face daunting challenges in reproduction**

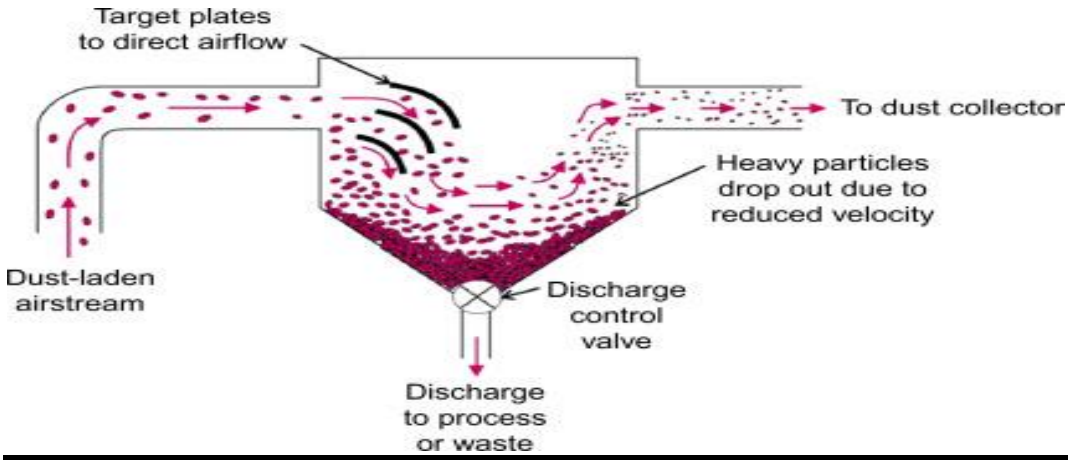
5.Strategies for Control of Air Pollution:

- Drive less: Drive fewer miles by walking, biking, carpooling, or using public transportation.
- Use less energy: Use less electricity and reduce your energy consumption.
- Recycle and reuse: Reduce waste by recycling and reusing items.
- Avoid plastic bags: Plastic bags take a long time to decompose and are harmful to the environment.
- Use fans instead of air conditioners: Air conditioners use a lot of energy and emit a lot of heat.
- Avoid burning garbage: Don't burn your garbage or have backyard fires.

- Plant trees: Plant and care for trees.
- Use electric or hand-powered lawn equipment: Switch to electric or hand-powered lawn equipment.
- Keep your car in good repair: Keep your car serviced on time.

6.Air Pollution Control Devices/Equipments

(a)Gravity Settling Tank:



Gravitational settling chambers are generally used to remove large, abrasive particles (usually >50 μm) from gas stream using a combination of gravitational and inertial forces.

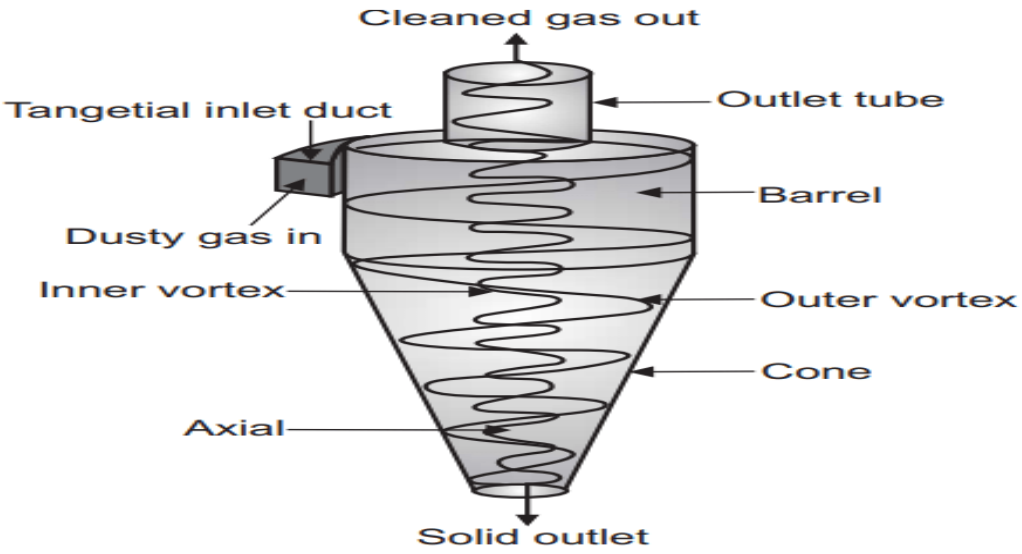
These forces move the dust to an area where the forces exerted by the gas stream are minimal which allow the dust to settle into a hopper under the effect of gravity.

Settling chambers are generally built in the form of long, horizontal, rectangular chambers with an inlet at one end and an exit at the side or top of the opposite end.

There are two primary types of settling chambers: the expansion chamber and the multiple-tray chamber. In the expansion chamber, the velocity of the gas stream is significantly reduced as the gas expands in a large chamber. The reduction in velocity allows larger particles to settle out of the gas stream.

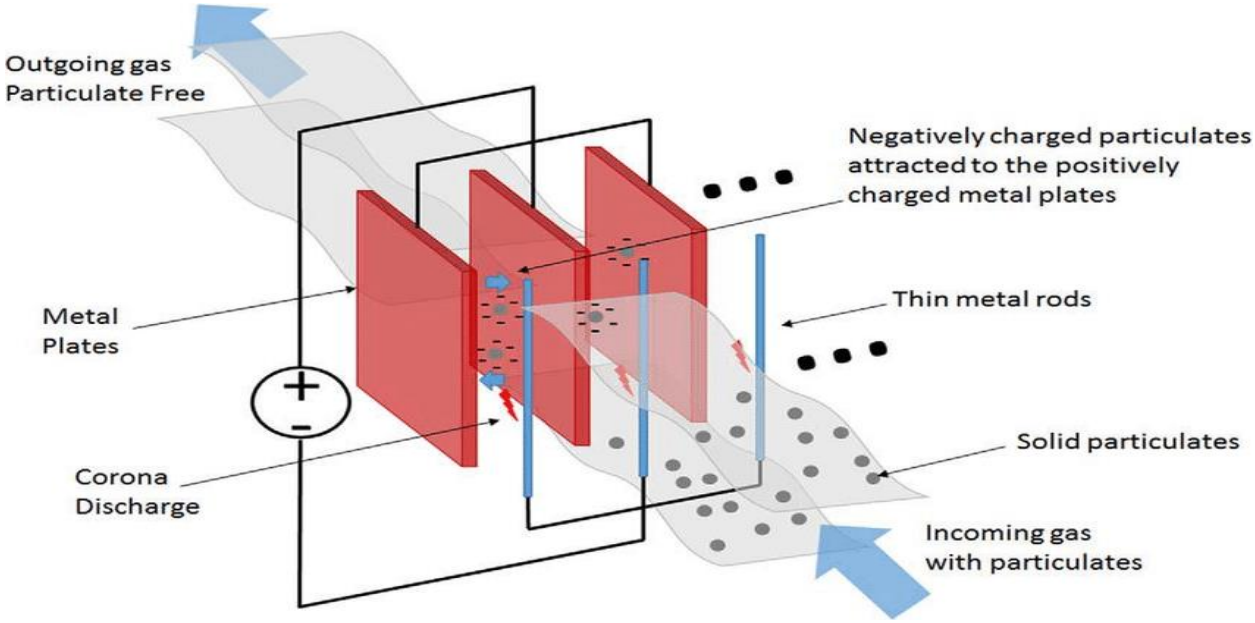
A multiple-tray settling chamber is an expansion chamber with a number of thin trays closely spaced within the chamber, which causes the gas to flow horizontally between them.

(b)Cyclone Separator



- A cyclone separator consists of a cylindrical shell, conical base, dust hopper and an inlet where the dust-laden gas enters tangentially.
- Under the influence of the centrifugal force generated by the spinning gas, the solid particles are thrown to the wall of the cyclone as the gas spirals upward at the inside of the cone. The particles slide down the walls of the cone and into the hopper. The operating efficiency of a cyclone depends on the magnitude of the centrifugal force exerted on the particles.
- The greater the centrifugal force, the greater the spreading efficiency. The magnitude of the centrifugal force generated depends on particle mass, gas velocity within the cyclone, and cyclone diameter.

(d)Electrostatic Precipitator:

- 

- SP uses an electric field on electrically charged particles to separate liquid or solid aerosols from gas stream.
- The aerosol is deliberately charged and passed through an electric field causing the particles to migrate towards an appositively charged electrode which act. The precipitator system consists of a positively charged collecting surface and a high voltage discharge electrode wire suspended from an insulator at the top and held in passion by weight the bottom.
- At a very high DC voltage, of the order of 50kV, a corona discharge occurs close to the negative electrode, setting up an electric field between the emitted and the grounded surface.
- The particle laden gas enters near the bottom and flows upward. The gas close to the negative electrode is, thus, ionized upon passing through the corona.
- As the negative ions and electrons migrate toward the grounded surface, they in turn charge the passing particles.

- The electrostatic field then draws the particles to the collector surface where they are deposited. Periodically, the collected particles must be removed from the collecting surface. This is done by rapping or vibrating the collector to dislodge the particles. The dislodged particles drop below the electrical treatment zone and are collected for ultimate disposal.

7.Histrory Overview:

Bhopal Gas Tragedy:

On December 3, 1984, about 45 tons of the dangerous gas methyl isocyanate escaped from an insecticide plant that was owned by the Indian subsidiary of the American firm Union Carbide Corporation. The gas drifted over the densely populated neighborhoods around the plant, killing thousands of people immediately and creating a panic as tens of thousands of others attempted to flee Bhopal. The final death toll was estimated to be between 15,000 and 20,000. Some half a million survivors suffered respiratory problems, eye irritation or blindness, and other maladies resulting from exposure to the toxic gas; many were awarded compensation of a few hundred dollars. Investigations later established that substandard operating and safety procedures at the understaffed plant had led to the disaster. In 1998 the former factory site was turned over to the state of Madhya Pradesh

London Smog:

he Great London Smog of 1952 (also just called the Great Smog) was an environmental disaster of unprecedented severity as a result of critical air pollution. Its impact ultimately served as a turning point in enacting the first air quality legislation in the United Kingdom and paved the way for future environmentalism.**On December 5, 1952,** fog descended upon the city of London. This was not unusual, as it was winter, and the capital was known for its misty weather. However, the fog later turned into smog as a result of mixing with smoke from coal-burning factories and chimneys, and diesel-fueled automobiles and buses. London had experienced these types of smog before. They were called “pea-soupers” due to their yellowish-brown appearance. Today, pea-soupers are known as sulphurous smog or “London smog”. These result from a high concentration of sulphur oxides (SO_x) in the atmosphere from fossil fuels high in sulphur, such as coal. They are exacerbated by dampness and particulate matter (PM): water vapour would stick to the released particulates and produce thick and dark clouds that impaired visibility.

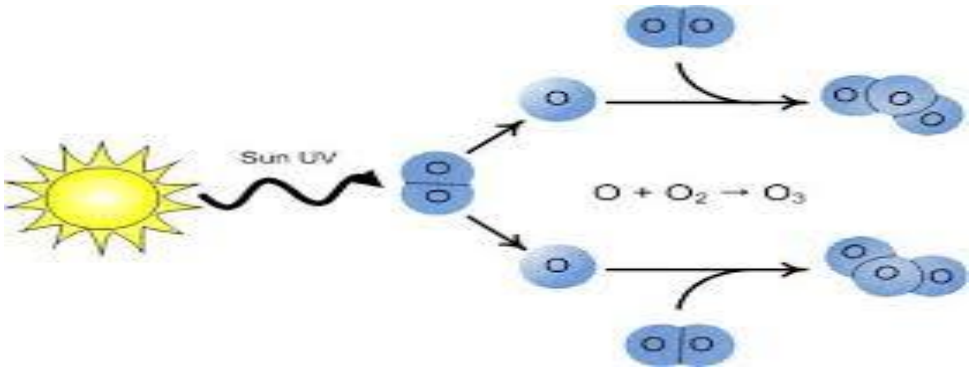
UNIT-III

Ozone layer

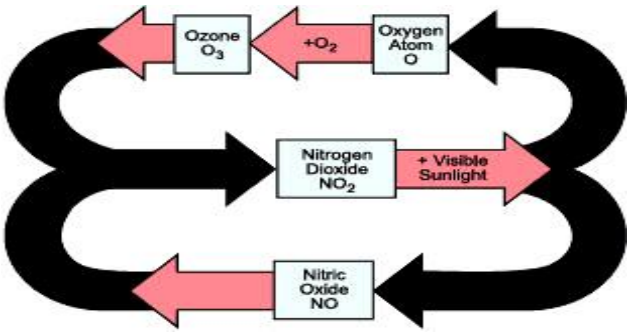
Ozone layer, region of the upper atmosphere, between roughly 15 and 35 km (9 and 22 miles) above Earth's surface, containing relatively high concentrations of ozone molecules (O_3). Approximately 90 percent of the atmosphere's ozone occurs in the stratosphere, the region extending from 10–18 km (6–11 miles) to approximately 50 km (about 30 miles) above Earth's surface. In the stratosphere the temperature of the atmosphere rises with increasing height**, a phenomenon created by the absorption of solar radiation by the ozone layer.** The ozone layer effectively blocks almost all solar radiation of wavelengths less than 290 nm from reaching Earth's surface, including certain types of ultraviolet (UV) and other forms of radiation that could injure or kill most living things.

Ozone creation :

The production of ozone in the stratosphere results primarily from the breaking of the chemical bonds within oxygen molecules (O_2) by high-energy solar photons. This process, called **photo dissociation,** results in the release of single oxygen atoms, which later join with intact oxygen molecules to form ozone.



Thus ozone is constantly created by solar radiation on earth's atmosphere and eliminated by reaction with atomic oxygen, reactive hydroxyl radicals and nitric oxide.



Ozone production from NO_x

Oxygen atoms freed from nitrogen dioxide by the action of sunlight attack oxygen molecules to make ozone. Nitrogen oxide can combine with ozone to reform nitrogen dioxide, and the cycle repeats.

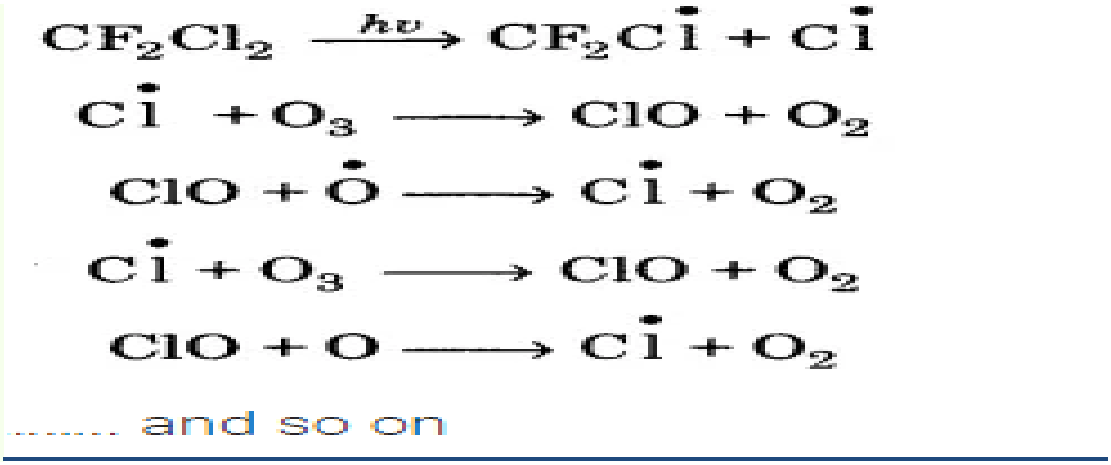
Mechanism of depletion:

Over the course of several decades, however, human activities substantially altered the ozone layer. Ozone depletion, the global decrease in stratospheric ozone observed since the 1970s, is most pronounced in Polar Regions, and it is well correlated with the increase of chlorine and bromine in the stratosphere. Those chemicals, once freed by UV radiation from the chlorofluorocarbons (CFCs) and other halocarbons (carbon-halogen compounds) that contain them, destroy ozone by stripping away single oxygen atoms from ozone molecules. **Depletion is so extensive that so-called ozone holes** (regions of severely reduced ozone coverage) form over the poles during the onset of their respective spring seasons. The largest such hole—which has spanned more than 20.7 million square km (8 million square miles) on a consistent basis since 1992—appears annually **over Antarctica between September and November**.

Causes of depletion:

The main cause of ozone depletion and ozone hole formation is called ozone depleting substances (ODS) due to industrial chemicals, especially manufactured halocarbon refrigerants, solvents, propellants and blowing agents (chlorofluorocarbons (CFCs), HCFCs, halons). These compounds are ejected from the surface and transported into the stratosphere by turbulent mixing, where the molecules mix much faster than they can settle. Upon reaching the stratosphere, they release atoms of halogen groups through photodissociation, which catalyses the breakdown of ozone (O_3) into oxygen (O_2).

Reaction involved in ozone layer depletion:



The ozone layer depletion came to the public eye after the creation of a chemical compound known as chlorofluorocarbons or CFCs (formerly used in refrigerators, aerosols, and air conditioners). It was discovered in the 1970s. These were used as refrigerants, aerosol spray propellants etc. CFCs are light and can move up in the air and reach the stratosphere. Here the chlorofluorocarbons react with the ozone layer in the presence of ultraviolet radiation and cause it to break down into oxygen molecules. The result is the depletion of the Ozone Layer. After an International Treaty was signed in 1973, the use of CFCs was lowered and subsequently banned. In the 1980s, it was observed that the ozone layer in an area of the Antarctic stratosphere had hit low levels coming at around as low as 33 percent of pre-1975 levels. This area became known as **the Ozone hole.**

Appearance of hole over Antarctica:

This is an annual phenomenon that takes place from September to early December when the westerly winds circulate all over the continent. The frigid temperature during this time, in combination with the Chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) contained in the manufactured chemicals that are emitted from the surface of the Earth, trigger ozone depletion. High altitude clouds are formed as the temperature goes down. Chlorine and bromine react within these clouds in a photochemical process and destroy the surrounding ozone layer. The following entry of ultraviolet rays increases the chances of skin cancer and blindness in humans and sun damage in animals.

The appearance of ozone hole over the Antarctic mobilized international community into signing the Montreal Protocol in 1987. Good news is that the year 2019 recorded the smallest ozone hole in Antarctic since 1984; however, the detection of a rare ozone hole in the Arctic in the late March of 2020 has called for a re-evaluation of the progress made by Montreal Protocol.

In the Montreal Protocol, it was decided to phase out all the substances that cause damage to the ozone layer. It came into force in 1989 and considered the most successful model of international cooperation, especially when other important environmental treaties like Kyoto Protocol have failed to everybody's disappointment. While all the chlorine and bromine containing substances are controlled by the Montreal Protocol, other ozone depleting substances like nitrous oxide are yet to be regulated under the treaty.

Effects of Ozone layer Depletion

A small dose of UV-B radiation is useful as it promotes vitamin D synthesis in living organisms. UV radiation also acts as a germicide that controls microorganisms. However, with the depletion of the ozone layer, the atmospheric shield from the UV rays weakens as it allows harmful rays to reach the earth's surface. Some of the effects of ozone layer depletion are as follows:

- **On Human Beings**
    - Increased risk for developing several skin cancers, skin rashes and skin ageing. Malignant melanoma and basal and squamous cell carcinoma are the most common cancers.
    - Leads to difficulty in breathing, chest pain, and throat irritation.
    - A suppressed immune system may lead to severe infectious diseases.
    - UV rays are harmful to our eyes. Direct exposure to UV rays can lead to Cataract problems, Photokeratitis or snow blindness.
        - Prolonged exposure may permanently damage the cornea.
- It can lead to DNA mutation.

- **On Plants**
    - It affects plant growth by altering the physiological and developmental processes of the plants as it inhibits photosynthesis.
    - Causes mutation.
    - Alters the Biodiversity in different ecosystems.
    - Affects plant competitive balance, plant pathogens and biogeochemical cycles.
- **On Aquatic Ecosystem**
    - Affects the productivity of marine/freshwater organisms.
    - Affects the distribution of phytoplankton, which forms the foundation of aquatic food webs.
    - Damages the early development stages of fish, shrimp, crabs, amphibians and other animals.
    - Affects reproductive capacity and impairs larval development.
- **On Bio-Geochemical Cycles**
    - Affects terrestrial and aquatic bio-geo-chemical cycles, thus altering sources and sinks of greenhouse gases.
    - Alters the delicate balance among different ecosystems.
    - Changes in the production and decomposition of plant matter.
    - Reduction of primary production changes in the uptake and release of important atmospheric gases.
    - Reduction of plankton growth in the upper ocean.
    - Increased degradation of aquatic dissolved organic matter.
- **On Non-Living Materials**
    - Accelerates the photodegradation rates of synthetic polymers, naturally occurring biopolymers and some other materials of commercial interest, thus limiting their lifetime.
    - Affects the quality of these materials, ranging from discolouration to loss of mechanical integrity.

Control Measures:

Control measures for ozone layer depletion primarily focus on reducing the emissions of ozone-depleting substances (ODS). Here are key strategies:

1. International Agreements

- **Montreal Protocol**: This landmark treaty, signed in 1987, aims to phase out the production and consumption of ODS, including chlorofluorocarbons (CFCs) and halons.

2. Regulations and Policies

- **National Legislation**: Countries implement laws to regulate the use of ODS and promote alternatives.
- **Import/Export Controls**: Monitoring and restricting the trade of ODS.

3. Alternatives and Substitutes

- **Adoption of Safer Chemicals**: Encouraging the use of non-ozone-depleting substances in refrigeration, air conditioning, and aerosol products.

4. Public Awareness and Education

- **Outreach Campaigns**: Informing the public about the importance of protecting the ozone layer and encouraging responsible consumption.

5. Research and Monitoring

- **Ongoing Research**: Investing in scientific studies to monitor ozone levels and understand the effects of ODS.
- **Satellite Monitoring**: Utilizing technology to track ozone layer changes and assess recovery.

6. Support for Developing Countries

- **Financial and Technical Assistance**: Providing support to help developing nations comply with ozone protection measures.

2.Smog: Sulphurous and photochemical smog,

Smog = **smoke + fog (smoky fog)** caused by the burning of large amounts of **coal, vehicular emission** and **industrial fumes** (Primary pollutants).
Smog contains soot particulates like **smoke, sulphur dioxide, nitrogen dioxide** and other components.
At least two distinct types of smog are recognized: **sulfurous smog** and **photochemical smog**.

Sulfurous smog:

Sulfurous smog is also called “London smog,” (first formed in London).

Sulfurous smog results from a high concentration of SULFUR OXIDES in the air and is caused by the use of sulfur-bearing fossil fuels, particularly coal (Coal was the mains source of power in London during nineteenth century.

The effects of coal burning were observed in early twentieth century).This type of smog is aggravated by dampness and a high concentration of suspended particulate matter in the air.

Photochemical smog:

Photochemical smog is also known as “Los Angeles smog”.

Photochemical smog occurs most prominently in urban areas that have large numbers of automobiles (Nitrogen oxides are the primary emissions).

Photochemical (summer smog) forms when pollutants such as nitrogen oxides (primary pollutant) and organic compounds (primary pollutants) react together in the presence of SUNLIGHT. A gas called OZONE (Secondary pollutant) is formed.

Nitrogen Dioxide + Sunlight + Hydrocarbons = Ozone (Ozone in stratosphere it is beneficial, but near the earth's surface it results in global warming as it is a greenhouse gas)

The resulting smog causes a light brownish coloration of the atmosphere, reduced visibility, plant damage, irritation of the eyes, and respiratory distress.

Effects of Smog:

- The **atmospheric pollution** levels of Los Angeles, Beijing, Delhi, Mexico City and other cities are increased by **inversion** that traps pollution close to the ground.
  Temperature Inversion – Types – Effects on Weather
- It is usually highly toxic to humans and can cause severe sickness, shortened life or death.
- Smog is a combination of airborne particulate matter, like soot, and invisible toxic gases including **ozone (O3), carbon monoxide (CO), sulfur dioxide (SO2)**, which are **carcinogens (cancer causing agents).**
- Temperature inversions are accentuated and **precipitation is reduced**.
- Smog related Haze lowers visibility.

Control Measures of Smog:

Avoid exercising outdoors: When the air is toxic, prefer exercising indoors in a gym or use an exercise machine at home. Also, I would suggest you to avoid intense exercises or heavy weight lifting as they require deep inhaling and exhaling, which could affect your health due to excess smog in the air. Smog can cause cold, pneumonia and even deadly pulmonary diseases such as lung cancer. To keep your children away from the devastating effects of smog, ask your kids to play outdoors only for a limited time if the pollution levels are high. However, engaging them in indoor games would be best during air pollution.

Stay away from high-traffic areas: High traffic areas or busy highways have high pollution levels that are likely to spread up to 1/3rd of a mile. Therefore, you should avoid activities around such areas. If at all you don't have an option to avoid such routes to your office or home, then you can wear Masks N95 and Masks N99 as these are effective in protecting you from some pollutant particles.

Tobacco-free indoors: Say 'NO' to smoking indoors and equally support the initiatives for tobacco-free public places. Smoke not only adds to smog but also worsens the air quality around you. Besides that, passive smoking can be harmful to children causing them bronchial diseases.

Green Home: Keep small plants such as aloe vera, bamboo palm, snake plant, peace lilies and the likes of them in your home to purify the air indoors. Some of them like snake plant are effective enough to remove

trichloroethylene, formaldehyde, toluene, xylene, and benzene pollutants from the air, which are common in homes and offices.

Stop burning wood or trash: Burning of wood and trash releases pollutants in the air. It is one of the major causes of air pollution in our country and must be stopped with immediate effect.

Water pollution

Water pollution is the contamination of water bodies (like oceans, seas, lakes, rivers, aquifers, and groundwater) usually caused due to human activities. Water pollution is any change in the physical, chemical or biological properties of water that will have a detrimental consequence to any living organism.

Properties of water

Water is a simple molecule consisting of one oxygen atom bonded to two hydrogen atoms. Because of the higher electronegativity of the oxygen atom, the bonds are polar covalent (polar bonds). Water is amphoteric: it has the ability to act as either an acid or a base in chemical reactions. Due to hydrogen bonding, water exhibits the following unique properties:

1. Water is the universal solvent

2. Exists in nature as a solid, liquid, and gas

3. The density of ice is less than liquid water

4. Water exists as a liquid at room temperature

Earth's oceans contain 97% of the planet's water, so just 3% is fresh water, water with low concentrations of salts. The majority of the Earth's water can be classified as being saline (or salt containing). Most freshwater is trapped as ice in the vast glaciers and ice sheets of Greenland. A storage location for water such as an ocean, glacier, pond, or even the atmosphere is known as a reservoir.

Drinking water, also called Potable Water, is the water that is considered safe enough for human and animal consumption. This is water that is generally used for drinking, cooking, washing, crop irrigation, etc. These days chemicals, bacteria, and other pollutants are even affecting our drinking water.

Water Pollution Sources

Water can be contaminated by various human activities or by existing natural features, like mineral-rich geologic formations, Agricultural activities, industrial operations, landfills, animal operations, and small and large scale sewage treatment processes etc. All can potentially contribute to contamination. As water runs over the land or infiltrates into the ground, it dissolves material left behind by these potential contaminant sources. The risks and type of remediation for a contaminant depend on the type of chemicals present.

Point source pollution can be attributed to a single, definable origin.

For example, animal factory farms raise a large number and high density of livestock such as cows, pigs, and chickens. Combined sewer systems that have a single set of underground pipes to collect both sewage and storm water runoff from streets for wastewater treatment can also be major point sources of pollutants.

Nonpoint source pollution is from multiple dispersed sources. The whole of the contribution of pollutants is harmful, but the individual components may not reach harmful concentrations. Nonpoint sources of pollution include agricultural fields, cities, and abandoned mines. Rainfall runs over the land and through the ground, picking up pollutants from throughout

the watershed (including areas of land and smaller streams that drain into a particular body of water). These pollutants might include herbicides, pesticides, and fertilizer from agricultural fields and lawns; oil, antifreeze, animal waste, and road salt from urban areas; and acid and toxic elements from abandoned mines.

Water pollutants are categorized according to whether they arise from chemical, biological, or physical processes.

Chemical Pollutants

Chemical pollution from agriculture, industry, cities, and mining threatens global water quality. Air pollutants from these activities can also enter bodies of water (and become water pollutants) through dry deposition, precipitation, and runoff. Some chemical pollutants have serious and well-known health effects, whereas many others have poorly known long-term health effects.

- **Organic Pollutants**

Organic pollutants include herbicides and pesticides, pharmaceuticals, fuel (such as oil spills), industrial solvents and cleansers, and synthetic hormones associated with pharmaceuticals. These synthetic hormones can act as endocrine disruptors. Many are persistent organic pollutants (POPs), which are long-lived in the environment, biomagnify through the food chain, and can be toxic.

- **Inorganic Pollutants**

Inorganic pollutants include nutrients like nitrate (NO_3^-) and phosphate (PO_4^{3-}), heavy metals, chloride (Cl^-), and radioactive isotopes released from mining or nuclear accidents (such as cesium, iodine, uranium, and radon gas).

Biological Pollutants

Pathogens (infectious microorganisms or viruses) enter water primarily from human and animal fecal waste due to inadequate sewage treatment. In many underdeveloped countries, sewage is discharged into local waters either untreated or after only rudimentary treatment. In developed countries untreated sewage discharge can occur from overflows of combined sewer systems, poorly managed livestock factory farms, and leaky or broken sewage collection systems.

Physical Sources of Pollution

Trash, sediments, and thermal pollution arise from physical sources of pollution. Excess sediments enter bodies of water when various land uses, such as mining, deforestation, and agriculture increases erosion. Sediments can carry toxins or excess nutrients with them, and they cloud the water (resulting in **turbidity**. High temperature disrupt aquatic organisms for several reasons; one is that warmer waters cannot hold as much dissolved oxygen

Water treatment and purification technologies

Wastewater treatment involves the following processes:

1. Preliminary treatment—The velocity of the wastewater from the sewer lines is reduced as it enters the treatment plant. This allows sand, gravel and other heavy materials to settle out into grit tanks. Mechanical cleaning bar screens then remove rags, sticks, plastic and other foreign objects from the Wastewater.
2. Primary treatment—The screened wastewater flows into a primary settling tank where it is held for several hours allowing solid particles to settle to the bottom of the tank. Fats, oil and grease (FOG) are skimmed from the tanks, dried and sent to the landfill.
3. Secondary treatment—Secondary treatment is a biological treatment process. The principal requirement of a biological treatment process are an adequate amount of bacteria that feed on the organic material present in wastewater, oxygen and some means of achieving contact between the bacteria and organics. The organic matter is metabolized to more stable inorganic forms.

   Several methods are used:

   the activated sludge system, biological film system, Rotating biological contactor,

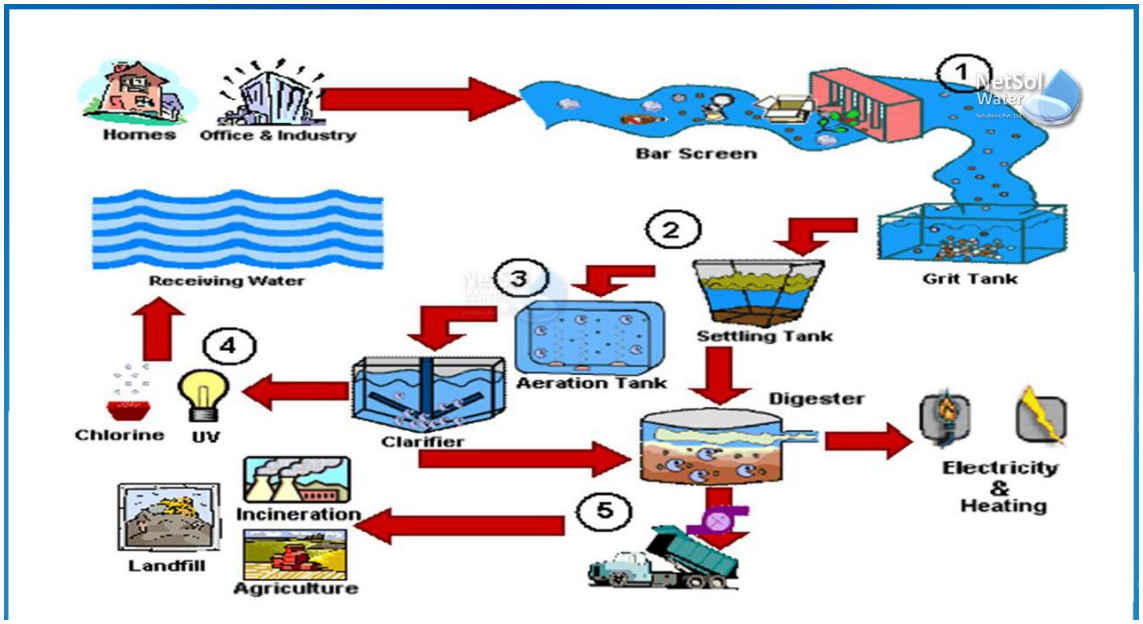
4. Tertiary or Advanced Wastewater Treatment

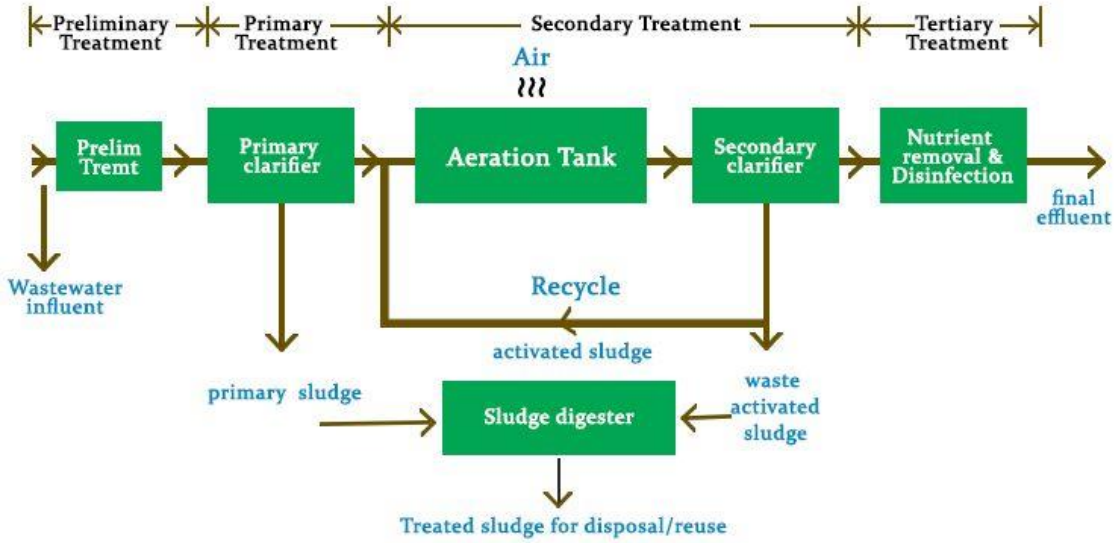
   If Water produced is required to be of higher water quality Standards (in case the water to be put to some direct reuse) then advanced wastewater treatment is carried out.

   A wide variety of methods are used in advanced waste treatment, which include the removal of

   (a) Suspended solids.
   (b) BOD).
   (c) Plant nutrients, (d) Dissolved solids and (e) toxic substances.

5. Final treatment—The wastewater that remains can be disinfected to kill harmful micro-organisms before being released into receiving waters. Although there are many methods available to kill these micro-organisms, ultraviolet disinfection, ozonation and chlorination are few of them.
6. Solids processing—Primary solids from the primary settling tank and secondary solids from the clarifier are sent to digesters for solids processing. During this process, micro-organisms use the organic material present in the solids as a food source and convert it to by-products, such as methane gas and water. Digestion results in a 90% reduction of pathogens and the production of a wet soil-like material called "biosolids" that contain 95-97% water. In order to remove some of this water, mechanical equipment such as a belt filter press or centrifuge are used to squeeze water from biosolids, reducing its volume prior to being used in soil amendment or composting.





Treatment with Chlorine and/or Chloramine Most communities use either chlorine or chloramines. Some communities switch back and forth between chlorine and chloramines at different times of the year or for other operational reasons.

Ozone Disinfection Ozone disinfection, or ozonation, is an unstable molecule which readily gives up one atom of oxygen providing a powerful oxidizing agent which is toxic to most waterborne organisms. It is an effective method to inactivate harmful protozoa that form cysts. It also works well against almost all other pathogens..

Ultraviolet Disinfection Ultraviolet disinfection of water is a purely physical, chemical-free process. Even parasites such as Cryptosporidium or Giardia, which are extremely resistant to

chemical disinfectants, are efficiently reduced. UV disinfection does not remove dissolved organics, inorganic compounds or particles in the water.

Fluoridation The mineral fluoride occurs naturally on earth and is released from rocks into the soil, water, and air. All water contains some fluoride. Usually, the fluoride level in water is not enough to prevent tooth decay; however, some groundwater and natural springs can have naturally high levels of fluoride. Fluoride has been proven to protect teeth from decay. Water fluoridation prevents tooth decay by providing frequent and consistent contact with low levels of fluoride.

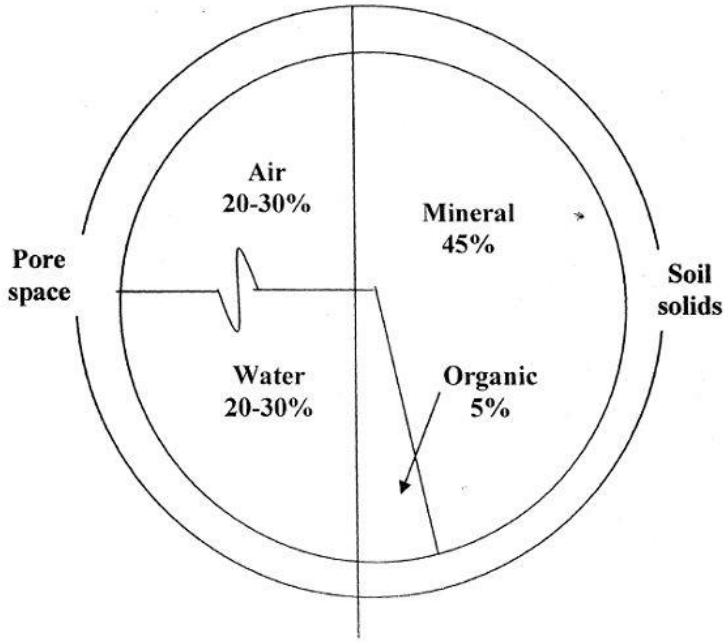
Soil pollution

Origin and nature of soil

Soil is defined as a dynamic natural body on the surface of the earth in which plants grow, composed of mineral and organic materials and living forms. The soil is made-up of broken-down rock material of varying degree of fineness and changed in varying degrees from the parent rocks by the action of different agencies such that the growth of vegetation is made possible.

COMPONENT OF SOIL (VOLUME BASIS):

The soil consists of four major components (Fig.1.1) i.e. mineral matter (45%), organic matter (5%), soil air (20-30%) and soil water (20-30%).



Weathering is a natural process of breakdown and transformation of rocks and minerals into unconsolidated residues, called **regolith**. In other words, the process of transformation of solid rocks into soils is known as weathering.

Weathering processes are two types:

(1) physical weathering brought about by the mechanical action of the various weathering agents, is designated as **disintegration,** and

(2) chemical weathering is designated as **decomposition**.

<u>Sources of Soil Pollution</u>:-

- "Any change in the physical, chemical & biological properties of soil due to natural or man-made activities is known as soil-pollution.
- The main cause of this degradation is overgrazing deforestation & agricultural activities.

Various Sources

A) **Natural Sources:-** Some of the natural sources are -

- Landslides, earthquakes, landslides, hurricanes & floods.
- Such natural disasters cause severe damage to the composition of soil.
- **Man – Made Sources:-**

1) Industrial Wastes:-

- Contain different kind of toxic, flammable and non-biodegrable substances that may persist in the soil for a long time and destroy the composition of soil such as Mercury, Zinc , Iron and Cd etc.

2) Mining:-

- Mining activities leave behind heap of mining wastes containing several toxic substances and contaminate the soil.

3) Agricultural Wastes :-

- Non judicious use of chemical fertilizers, pesticides, insecticides and fumigants remain in the soil for long percale of without degradation causes soil pollution.

4) Domestic Wastes:-

- Kitchen and food wastes, paper etc are biodegradable but glass, plastic materials, metal cans etc are non-biodegradable. Improper disposal of hazardous domestic wastes such as batteries, paints, medicines, glass bulbs, spray cans etc contribute greatly to soil pollution.

5) Radioactive Waste:-

- Radioactive substances from nuclear power plants are released in to the soil.
- **Strontium** gets deposited in the bones and tissues instead of calcium.

6) Biological agents:-

- Soil gets large quantities of human and animal excreta which constitute the major part of land pollution.
- In addition to these excreta faulty sanitation, municipal garbage, waste water and wrong methods of agricultural practices also induce heavy soil pollution.
- Pathogens exerted by human and animals such as bacteria and parasitic worms contaminate the soil.
- Pathogenic soil bacteria like salmonella typhus causes infections of intestinal tract.

Soil pollution and plant growth

Soil pollution, a significant environmental concern, poses a direct threat to plant growth and agricultural productivity. It occurs when harmful substances such as heavy metals, pesticides, and industrial waste accumulate in the soil, disrupting its natural properties and hindering the growth and development of plants.

Soil pollutants disrupt the delicate ecological balance of crop systems. Each plant requires a specific soil type for optimal growth. However, most plants struggle to adapt to alterations in soil chemistry, resulting in stunted growth or diminished crop yields. Moreover, essential soil microorganisms like bacteria and fungi, crucial for soil cohesion, decline in the presence of toxic elements, exacerbating soil erosion and reducing fertility, rendering land unsuitable for agriculture.

Some effects on plant growth

• The balance of ecological system is affected due to contamination of the soil.

• Plants are mostly unable to adapt to the change in the chemistry of the soil in short time period.

• The microorganisms found in the soil decline and create additional problems of soil erosion. • Fertility of the soil decreases due to soil pollution, making it unsuitable for agriculture and local vegetation to survive.

• Soil pollution is hazardous to health.

• Polluted lands cannot support most forms of life.

The chemicals present in the soil due to pollution are toxic and can decrease the fertility of the soil, thereby decreasing the soil yield. Agriculture on contaminated soil produces fruits and vegetable that lack quality nutrients. Consumption of these may be poisonous and cause serious health problems to people consuming them.

Soil Remediation techniques

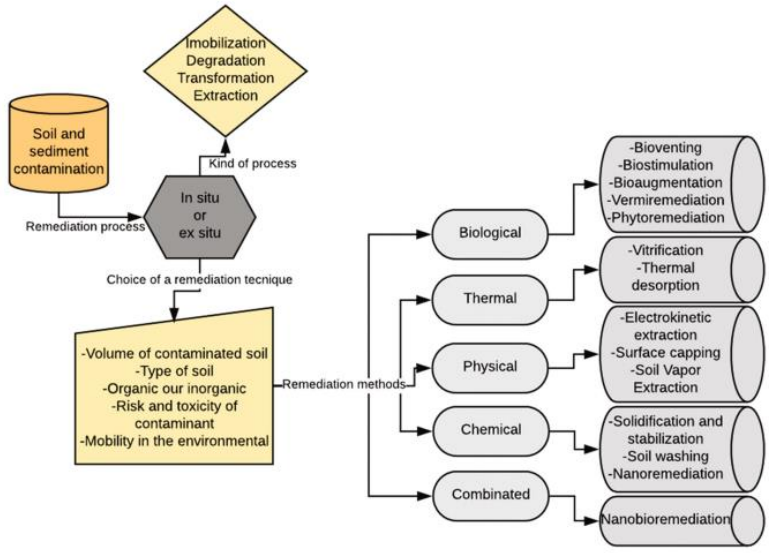


Fig. 1. Technologies that are used for the remediation of contaminated soils and sediments

Physical Processes: Physical processes refers to the immobilization or withdrawal of contaminants from the soil or sediment by some physical means. The main technologies used include:

- Surface Capping: This technique simply covers the contaminated site with a low permeability material.
- Vapor Extraction: This technology is applied in-situ to remove volatile and subvolatile organic contaminants from the soil, usually in unsaturated soils.
- Electrokinetic Remediation: A low-density electrical current is applied in the soil through electrodes and this induces the migration of the cations from the soil to the cathode and the anions to the anode through the established electrical field.

Chemical Processes Chemical processes are the main methods used to remove contaminants, and their mechanisms include adsorption, retaliation, load exchange, oxidation, reduction, or a combination

- Solidification and Stabilization: This technique, also known as chemical immobilization, captures or immobilizes contaminants in-situ or ex-situ by introducing chemical agents to convert mobile pollutants into hasty forms or strongly adsorbed. This technology does not remove contaminants from the soil; it only prevents them from moving.
- Soil Washing: This ex-situ technology uses aqueous solutions to extract contaminants from the environment. The excavated soil is mixed with the solution that will make the extraction and is then agitated. After washing, the clean soil can be reseated at the place of origin and should be made the treatment of the extraction solution.

Biological Processes Biological processes involve environmental decontamination by living things, such as plants, animals or micro-organisms These methods include adsorption processes, transformation, or degradation of contaminants.

Thermal Processes Thermal processes involve the heating of the subsurface, leading to the mobilization, volatilization, or destruction of contaminants in the soil or sediment. Heating methods include conductive heating, electric resistance heating, steam heating, and radio frequency heating

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