GOVERNMENT POLYTECHNIC BARGARH
DEPARTMENT OF MATHEMATICS & SCIENCE

LEARNING MATERAL
ON
ENVIRONMENTAL SCIENCE

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Course Objectives:

Technicians working in industries or elsewhere essentially require the knowledge of environmental science so as to enable them to work and produce most efficient, economical and eco-friendly finished products.

• Solve various engineering problems applying ecosystem to produce eco – friendly products.

• Use relevant air and noise control method to solve domestic and industrial problems.

• Use relevant water and soil control method to solve domestic and industrial problems.

• To recognize relevant energy sources required for domestic and industrial applications.

• Solve local solid and e-waste problems.

Unit-1: Ecosystem:

Structure of ecosystem, Biotic & Abiotic components.

Food chain and food web

Aquatic (Lentic and Lotic) and terrestrial ecosystem

Carbon, Nitrogen, Sulphur, Phosphorus cycle.

Global warming -Causes, effects, process, Green House Effect, Ozone depletion

Unit– 2 Air and, Noise Pollution:

Definition of pollution and pollutant, Natural and manmade sources of air pollution (Refriger ants, I.C., Boiler)

Air Pollutants: Types, Particulate Pollutants: Effects and control (Bag filter, Cyclone separator, Electrostatic Precipitator)

Gaseous Pollution Control: Absorber, Catalytic Converter, Effects of air pollution due to Refrigerants, I.C., Boiler

Noise pollution: sources of pollution, measurement of pollution level, Effects of Noise pollution, Noise pollution (Regulation and Control) Rules, 2000

Unit- 3 Water and Soil Pollution:

Sources of water pollution, Types of water pollutants, Characteristics of water pollutants Turbidity, pH, total suspended solids, total solids BOD and COD: Definition, calculation

Waste Water Treatment: Primary methods: sedimentation, froth floatation, Secondary methods: Activated sludge treatment, Trickling filter, Bioreactor, Tertiary Method: Membrane separation technology, RO (reverse osmosis).

Causes, Effects and Preventive measures of Soil Pollution: Causes-Excessive use of Fertilizers, Pesticides and Insecticides, Irrigation, E-Waste.

Unit– 4 Renewable sources of Energy:

Solar Energy: Basics of Solar energy. Flat plate collector (Liquid & Air). Theory of flat plate col lector. Importance of coating. Advanced collector. Solar pond. Solar water heater, solar dryer. Solar stills.

Biomass: Overview of biomass as energy source. Thermal characteristics of biomass as fuel. Anaerobic digestion. Biogas production mechanism. Utilization and storage of biogas.

Wind energy: Current status and future prospects of wind energy. Wind energy in India. Environmental benefits and problem of wind energy.

New Energy Sources: Need of new sources. Different types new energy sources. Applications of (Hydrogen energy, Ocean energy resources, Tidal energy conversion.) Concept, origin and power plants of geothermal energy.

Unit-5 Solid Waste Management, ISO 14000 & Environmental Management:

Solid waste generation- Sources and characteristics of: Municipal solid waste, E- waste, bio medical waste.

Metallic wastes and Non-Metallic wastes (lubricants, plastics, rubber) from industries.

Collection and disposal: MSW (3R, principles, energy recovery, sanitary landfill), Hazardous waste

Air quality act 2004, air pollution control act 1981 and water pollution and control act1996. Structure and role of Central and state pollution control board.

Concept of Carbon Credit, Carbon Footprint.

Environmental management in fabrication industry.

ISO14000: Implementation in industries, Benefits.

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12. Keshav Kant, Air Pollution & Control, Khanna Publishing House, New Delhi (Edition 2018)

(b) Open source software and website address:

1) www.eco-prayer.org

2) www.teriin.org

3) www.cpcp.nic.in

4) www.cpcp.gov.in

5) www.indiaenvironmentportal.org.in

6) www.whatis.techtarget.com

7) www.sustainabledevelopment.un.org

8) www.conserve-energy-future.com).

UNIT-1: ECOSYSTEM

Environment: Environment can be defined as a sum total of all the living and non-living elements and their effects that influence human life.

Environmental Science: Environmental science is an interdisciplinary academic field that draws on ecology on ecology, geology, meteorology, biology, chemistry, engineering, and physics to study environmental problems and human impacts on the environment.

Ecosystem: An ecosystem is a community of living organisms (plants, animals and microbes) in a particular area. Thus, an ecosystem is a structural and functional unit of biosphere. It is made up of living and non-living beings and their physical environment.

Structure of Ecosystem:

1. **Biotic (Living Components)**

Biotic components in an ecosystem refers to all the living organisms such as plants, animals, and microorganisms. The biotic components of ecosystem comprise of the following trophic levels:

1. **Producers (First Trophic Level)** – Producers otherwise called autotrophs prepare their food by themselves. They form the first level of every food chain. Plants and one-celled organisms, some types of bacteria, algae, etc. come under the category of Autotrophs. Virtually, almost all autotrophs use a process called photosynthesis to prepare food.
2. **Consumers** – At the second trophic level, there are consumers who depend upon others for food.
   - **Primary Consumers (Second Trophic Level)** – Primary consumers eat the producers. They are called herbivores. Deer, turtle, and many types of birds are herbivores.
   - **Secondary Consumers (Third Trophic Level)** – Secondary consumers based at the third trophic level eat plants and herbivores. They are both carnivores (meat-eaters) and omnivores (animals that eat both animals and plants). In a desert ecosystem, a secondary consumer may be a snake that eats a mouse. Secondary consumers may eat animals bigger than they are. Some lions, for example, kill and eat buffalo. The buffalo weighs twice as much as the lions do.
   - **Tertiary Consumers (Fourth Trophic Level)** – Tertiary consumers are animals eating other carnivores. The secretary bird in Africa and the King Cobra specialize in killing and eating snakes but all snakes are carnivores. The leopard seal eats mostly other carnivores - mainly other seals, squids, and penguins, all of which are carnivores.
3. **Decomposers** – Decomposers which don't always appear in the pictorial presentation of the food chain, play an important part in completing the food chain. These organisms break down dead organic material and wastes. Fungi and bacteria are the key decomposers in many ecosystems; they use the chemical energy in dead matter and wastes to fuel their metabolic processes. Other decomposers are detritivores—detritus eaters or debris eaters.

Understanding the food chain helps us know the feeding interrelationship and interaction between an organism and the ecosystem. It also enables us to know the mechanism of energy flow in an ecosystem.

2. Abiotic (Non-living Components)

Abiotic components of an ecosystem refer to all the non-living elements such as temperature, light, humidity, precipitation, gases, wind, water, soil, salinity, mineral, topography, and habitat. The flow of energy and the cycling of water and nutrients are critical to each ecosystem on the earth. Non-living components set the stage for ecosystem operation.

Trophic levels: Trophic levels in an ecosystem represent the different levels of feeding relationships, illustrating the flow of energy and biomass. Organisms are grouped into trophic levels based on their feeding habits, with each level representing a step in the transfer of energy and nutrients.

Food chain and food web

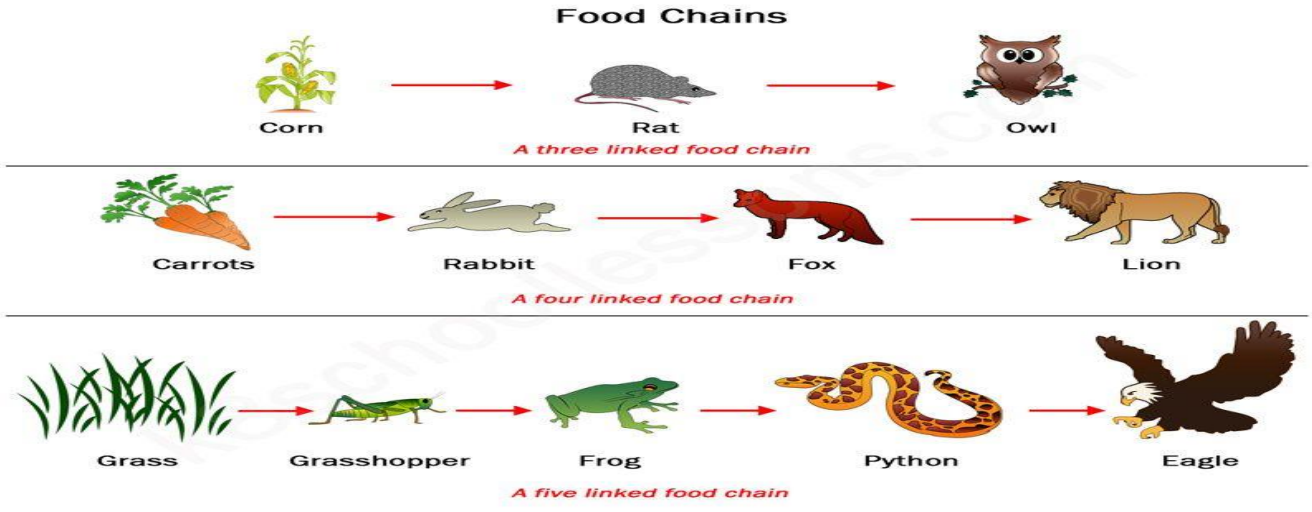
Food Chain

A food chain is a chronological pathway or an order that shows the flow of energy from one organism to the other. In a community which has producers, consumers, and decomposers, the energy flows in a specific pathway. Energy is not created or destroyed. But it flows from one level to the other, through different organisms.

A food chain shows a single pathway from the producers to the consumers and how the energy flows in this pathway. In the animal kingdom, food travels around different levels. To understand a food chain better, let us take a look at the terrestrial ecosystem.

Example of food chain

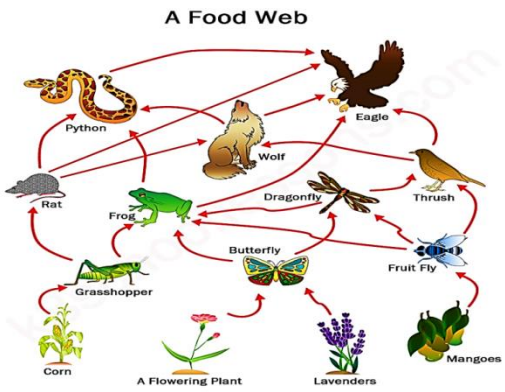
Grass (Producer)→Goat (Primary Consumer) → Man (Secondary consumer)



Food Web:

Food web may be defined as ‘a network of interconnected food chains so as to form a number of feeding relationships amongst different organisms of a biotic community.

A food chain cannot stand isolated in an ecosystem. The same food resource may be a part of more than one chain. This is possible when the resource is at the lower trophic level.



A food web comprises all the food chains in a single ecosystem. It is essential to know that each living thing in an ecosystem is a part of multiple food chains.

A single food chain is the single possible path that energy and nutrients may make while passing through the ecosystem. All the interconnected and overlapping food chains in an ecosystem make up a food web.

Food webs are significant tools in understanding that plants are the foundation of all ecosystems and food chains, sustaining life by providing nourishment and oxygen needed for survival and reproduction. The food web provides stability to the ecosystem.

The tertiary consumers are eaten by quaternary consumers. For example, a hawk eats owls. Each food chain ends with a top predator and animal with no natural enemies (such as an alligator, hawk, or polar bear).

Aquatic Ecosystem

An aquatic ecosystem is a water-based environment where living organisms interact with each other and their surrounding water environment. Examples of aquatic ecosystems include oceans, lakes, rivers, etc.

An aquatic ecosystem includes freshwater habitats like lakes, ponds, rivers, oceans and streams, wetlands, swamp, etc. and marine habitats include oceans, intertidal zone, coral reefs, seabed and so on. The aquatic ecosystem is the habitat for water-dependent living species including animals, plants, and microbes.

1. Pond Ecosystem or Freshwater Aquatic Ecosystem:

They cover only a small portion of earth, nearly 0.8 per cent. Freshwater involves lakes, ponds, rivers and streams, wetlands, swamps, bogs and temporary pools. Freshwater habitats are classified into lotic and lentic habitats. Water bodies such as lakes, ponds, pools, bogs, and other reservoirs are standing water and known as lentic habitats. Whereas lotic habitats represent flowing water bodies such as rivers, streams.

- **Lotic Ecosystems**

A lotic ecosystem is a type of freshwater ecosystem characterized by flowing water, such as rivers and streams. These environments harbor numerous species of insects such as beetles, mayflies, stoneflies and several species of fishes including trout, eel, minnow, etc. Apart from these aquatic species, these ecosystems also include various mammals such as beavers, river dolphins and otters.

- **Lentic Ecosystems**

A lentic ecosystem is a type of freshwater ecosystem characterized by standing or static water habitats. Lakes and ponds are the main examples of Lentic Ecosystem. These ecosystems are home to algae, crabs, shrimps, amphibians such as frogs, for both rooted and floating-leaved plants and reptiles including alligators and other water snakes are also found here.

- **Wetlands**

Wetlands are marshy areas and are sometimes covered in water which has a wide diversity of plants and animals. Swamps, marshes, bogs, black spruce and water lilies are some examples in the plant species found in the wetlands. The animal life of this ecosystem consists of dragonflies and damselflies, birds such as Green Heron and fishes such as Northern Pike.

Terrestrial ecosystem

A terrestrial ecosystem is a land-based community of organisms and the interactions of biotic and abiotic components in a given area.

Types of Terrestrial Ecosystems

There are different types of terrestrial ecosystems, which are widely distributed around the geological zones. They include:

a) Forest Ecosystem:

A forest ecosystem is a complex, dynamic system where living organisms (plants, animals, microbes) interact with each other and their physical environment (soil, climate). These ecosystems are characterized by tall trees and support a wide variety of life. They play a crucial role in maintaining ecological balance and providing numerous benefits to humans.

- A forest ecosystem includes both living (biotic) components like trees, animals, insects, and microorganisms, and non-living (abiotic) components like sunlight, temperature, water, and soil.
- All components of a forest ecosystem are interconnected, with each playing a vital role in the overall functioning and stability of the system.
- Forests are known for their high biodiversity, supporting a wide range of species that depend on the forest for habitat, food, and other resources.
- Forest ecosystems provide numerous valuable services, including carbon sequestration, soil and water conservation, climate regulation, and provision of food and resources.
- Forest ecosystems are dynamic, constantly changing and adapting to environmental conditions, making them resilient to various disturbances.
- Different forest types exist, categorized by climate, rainfall, and dominant tree species. Common examples include temperate forests, tropical rain forests, boreal forests.

b) Grasslands Ecosystem:

A grassland ecosystem is a terrestrial ecosystem where the dominant vegetation is grasses and other herbaceous (non-woody) plants. These ecosystems are often found in areas with moderate rainfall, too little for forests to thrive but enough to prevent desertification. Grasslands are important for supporting diverse wildlife, acting as carbon sinks, and providing essential ecosystem services. These types of

terrestrial ecosystems serve as a home for a wide diversity of animal species, such as elephants, giraffes, hyenas, jackrabbits, lions, rhinos, warthogs and zebras. Other types of grasslands include:

1. Tropical Grasslands
2. Temperate Grasslands

c) Tundra Ecosystem:

Tundra denotes Polar Regions, which are characterized by harsh environmental conditions similar to deserts and is usually windswept, snow-covered and treeless. This type of ecosystem is completely filled with frozen soil throughout the year and in summer, the snow melts and shallow ponds are produced. This gives rise to lichens and a few plants with small and colourful flowers. Animals found in the Arctic tundra include herbivorous mammals (lemmings, voles, caribou, arctic hares, and squirrels), carnivorous mammals (arctic foxes, wolves, and polar bears), fish (cod, flatfish, salmon, and trout), insects (mosquitoes, flies, moths, grasshoppers, and blackflies), and birds (ravens, snow buntings, falcons, loons, sandpipers, terns, and gulls).

d) Desert Ecosystem:

The Desert is a barren region of the landscape, which has extremely high or low temperatures and has scarce vegetation. Depending on the climate and temperature, deserts can be classified into hot deserts and cold deserts. There are many lives that are well-adapted to life in the desert. Animals include – Camels, foxes, hyenas, jackals, scorpions, a few varieties of snakes and lizards. The common plants are acacia, cactus and date palms.

Sahara is an example of a hot desert, which is categorized by high temperatures associated with little rainfall and complicated life for both plants and animals.

Ladakh is an example of a cold desert, which is found on the eastern side of Jammu and Kashmir near the Great Himalayas.

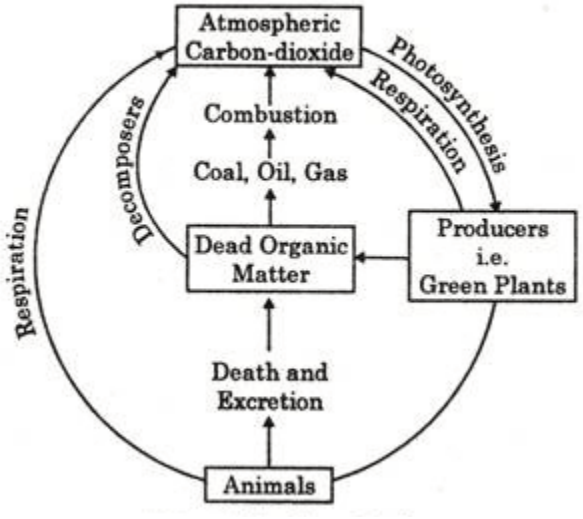
Carbon Cycle:

Carbon cycle is the process where carbon compounds are interchanged among the biosphere, geosphere (includes rocks and minerals on earth's surface), pedosphere (soil mantle of the earth), hydrosphere, and atmosphere of the earth.
Carbon cycle shows the movement of carbon in elemental and combined states on earth. Diamond and graphite are the elemental forms of carbon and in a combined state, it is found as carbonates in minerals and as carbon dioxide gas in the atmosphere.

Carbon Cycle Steps

Following are the major steps involved in the process of the carbon cycle:

1. Carbon present in the atmosphere is absorbed by plants for photosynthesis.
2. These plants are then consumed by animals and carbon gets bio-accumulated into their bodies.
3. These animals and plants eventually die, and upon decomposing, carbon is released back into the atmosphere.
4. Some of the carbon that is not released back into the atmosphere eventually becomes fossil fuels.
5. These fossil fuels are then used for man-made activities, which pump more carbon back into the atmosphere.



Carbon Cycle on Land

Carbon in the atmosphere is present in the form of carbon dioxide. Carbon enters the atmosphere through natural processes such as respiration and industrial applications such as burning fossil fuels. The process of photosynthesis involves the absorption of CO_2 by plants to produce carbohydrates. The equation is as follows:

$CO_2 + H_2O + \text{energy} \rightarrow (CH_2O)_n + O_2$

Carbon compounds are passed along the food chain from the producers to consumers. The majority of the carbon exists in the body in the form of carbon dioxide through respiration. The role of decomposers is to eat the dead organism and return the carbon from their body back into the atmosphere. The equation for this process is:

$(CH_2O)_n + O_2 \rightarrow CO_2 + H_2O$

Oceanic Carbon Cycle

This is essentially a carbon cycle but in the sea. Ecologically, oceans take in more carbon than it gives out. Hence, it is called a “carbon sink.” Marine animals convert carbon to calcium carbonate and these forms the raw building materials require creating hard shells, similar to the ones found in clams and oysters.

When organisms with calcium carbonate shells die, their body decomposes, leaving behind their hard shells. These accumulate on the seafloor and are eventually broken down by the waves and compacted under enormous pressure, forming limestone.

When these limestone rocks are exposed to air, they get weathered and the carbon is released back into the atmosphere as carbon dioxide.

Importance of Carbon Cycle

Even though carbon dioxide is found in small traces in the atmosphere, it plays a vital role in balancing the energy and traps the long-wave radiations from the sun. Therefore, it acts like a blanket over the planet. If the carbon cycle is disturbed it will result in serious consequences such as climatic changes and global warming.

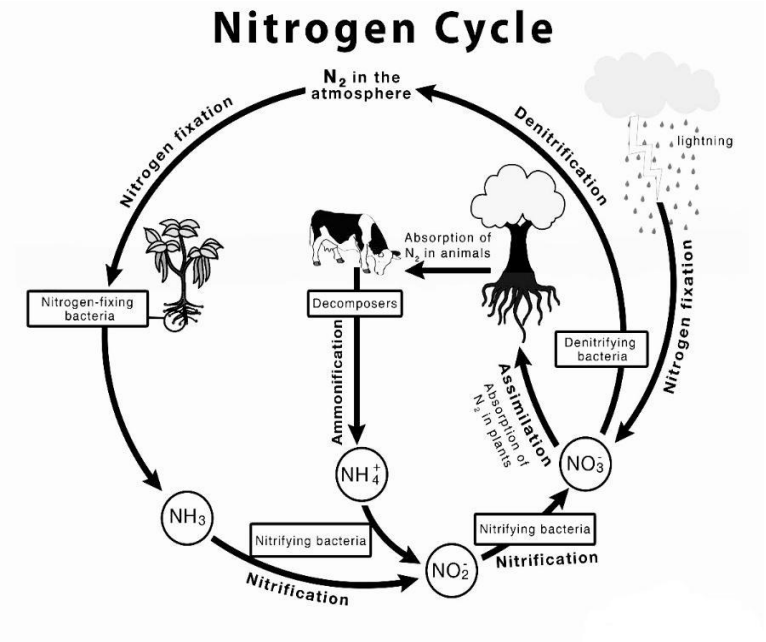
Carbon is an integral component of every life form on earth, from proteins and lipids to even our DNA. Furthermore, all known life on earth is based on carbon. Hence, the carbon cycle plays a vital role in the existence of life on earth.

Nitrogen Cycle:

"Nitrogen Cycle is a biogeochemical process which transforms the inert nitrogen present in the atmosphere to a more usable form for living organisms."

Furthermore, nitrogen is a key nutrient element for plants. However, the abundant nitrogen in the atmosphere cannot be used directly by plants or animals.

It involves several processes such as nitrogen fixation, nitrification, de-nitrification, decay and putrefaction.



Nitrogen gas exists in both organic and inorganic forms. Organic nitrogen exists in living organisms, and they get passed through the food chain by the consumption of other living organisms.

Inorganic forms of nitrogen are found in abundance in the atmosphere. This nitrogen is made available to plants by *symbiotic bacteria* which can convert the

inert nitrogen into a usable form – such as nitrites and nitrates.

Nitrogen undergoes various types of transformation to maintain a balance in the ecosystem. Furthermore, this process extends to various biomes, with the marine nitrogen cycle being one of the most complicated biogeochemical cycles.

Nitrogen Cycle Explained – Stages of Nitrogen Cycle

Process of the Nitrogen Cycle consists of the following steps – Nitrogen fixation, Nitrification, Assimilation, Ammonification and De-nitrification. These processes take place in several stages and are explained below:

Nitrogen Fixation Process

It is the initial step of the nitrogen cycle. Here, Atmospheric nitrogen (N_2) which is primarily available in an inert form is converted into the usable form -ammonia (NH_3).

During the process of Nitrogen fixation, the inert form of nitrogen gas is deposited into soils from the atmosphere and surface waters, mainly through precipitation.

The entire process of Nitrogen fixation is completed by symbiotic bacteria, which are known as Diazotrophs. *Azotobacter* and *Rhizobium* also have a major role in this process. These bacteria consist of a nitrogenase enzyme, which has the capability to combine gaseous nitrogen with hydrogen to form ammonia.

Nitrogen fixation can occur either by atmospheric fixation- which involves lightening, or industrial fixation by manufacturing ammonia under high temperature and pressure conditions. This can also be fixed through man-made processes, primarily industrial processes that create ammonia and nitrogen-rich fertilisers.

Nitrification

In this process, the ammonia is converted into nitrate by the presence of bacteria in the soil. Nitrites are formed by the oxidation of ammonia with the help of *Nitrosomonas* bacteria species. Later, the produced nitrites are converted into nitrates by *Nitrobacter*. This conversion is very important as ammonia gas is toxic for plants.

The reaction involved in the process of Nitrification is as follows:

$$\mathbf{2NH_3 + 3O_2 \rightarrow 2NO_2^- + 2H^+ + 2H_2O}$$

$$\mathbf{2NO_2^- + O_2 \rightarrow 2NO_3^-}$$

Assimilation

Primary producers – plants take in the nitrogen compounds from the soil with the help of their roots, which are available in the form of ammonia, nitrite ions, nitrate ions or ammonium ions and are used in the formation of the plant and animal proteins. This way, it enters the food web when the primary consumers eat the plants.

Ammonification

When plants or animals die, the nitrogen present in the organic matter is released back into the soil. The decomposers, namely bacteria or fungi present in the soil, convert the organic matter back into ammonium. This process of decomposition produces ammonia, which is further used for other biological processes.

De-nitrification

De-nitrification is the process in which the nitrogen compounds make their way back into the atmosphere by converting nitrate (NO_3^-) into gaseous nitrogen (N_2). This process of the nitrogen cycle is the final stage and occurs in the absence of oxygen. De-nitrification is carried out by the denitrifying bacterial species- *Clostridium* and *Pseudomonas*, which will process nitrate to gain oxygen and gives out free nitrogen gas as a by-product.

Importance of Nitrogen Cycle

The importance of the nitrogen cycle is as follows:

1. Helps plants to synthesize chlorophyll from the nitrogen compounds.
2. Helps in converting inert nitrogen gas into a usable form for the plants through the biochemical process.
3. In the process of ammonification, the bacteria help in decomposing the animal and plant matter, which indirectly helps to clean up the environment.
4. Nitrates and nitrites are released into the soil, which helps in enriching the soil with the necessary nutrients required for cultivation.
5. Nitrogen is an integral component of the cell and it forms many crucial compounds and important bio-molecules.

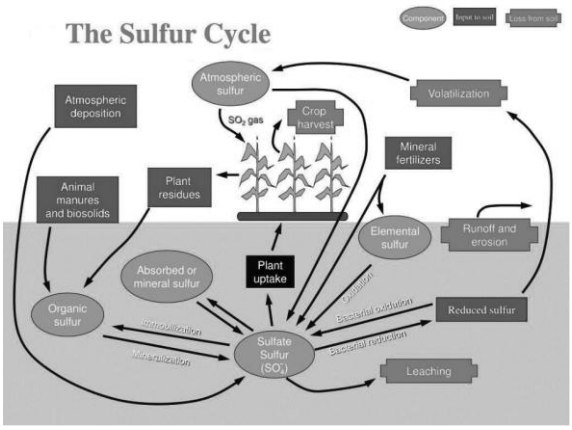
Sulphur Cycle

The sulphur cycle describes the movement of sulphur through the atmosphere, mineral forms and through living things.

Sulphur is one of the most abundant elements on the earth. It is a yellow, brittle, tasteless, odourless non-metal. Sulphur is present in proteins. Plants directly absorb sulphur-containing amino acids such as methionine, cystine, and cysteine.

Sulphur is released into the atmosphere by the burning of fossil fuel, volcanic activities, and decomposition of organic molecules.

On land, sulphur is stored in underground rocks and minerals. It is released by precipitation, weathering of rocks and geothermal vents.



The process of Sulphur Cycle

The process of sulphur cycle is explained below:

- The sulphur is released by the weathering of rocks.
- Sulphur comes in contact with air and is converted into sulphates.
- Sulphates are taken up by plants and microbes and are converted into organic forms.
- The organic form of sulphur is then consumed by the animals through their food and thus sulphur moves in the food chain.
- When the animals die, some of the sulphur is released by decomposition while some enter the tissues of microbes.
- There are several natural sources such as volcanic eruptions, evaporation of water, and breakdown of organic matter in swamps, that release sulphur directly into the atmosphere. This sulphur falls on earth with rainfall.

Steps of Sulphur Cycle

Decomposition of Organic Compounds

Protein degradation releases amino acids that contain sulphur. Sulphates are reduced to H_2S by the action of *De-sulfotomaculum bacteria*.

Oxidation of Hydrogen Sulphide to Elemental Sulphur

Hydrogen sulphide oxidises to produce elemental sulphur. Certain photosynthetic bacteria from the families Chlorobiaceae and Chromatiaceae initiate the oxidation process.

Oxidation of Elemental Sulphur

Elemental sulphur present in the soil cannot be utilized directly by the plants. Therefore, it is converted into sulphates by chemo lithotrophic bacteria.

Reduction of Sulphates

Sulphates are reduced to hydrogen sulphide by *Desulphovibriodesulfuricans.* This occurs in two steps:

- Firstly, the sulphates are converted to sulphites utilizing ATP.

- Secondly, the reduction of sulphite to hydrogen sulphide.

Phosphorous Cycle

"Phosphorus cycle is a biogeochemical process that involves the movement of phosphorus through the lithosphere, hydrosphere and biosphere."

Phosphorus is an important element for all living organisms. It forms a significant part of the structural framework of DNA and RNA. They are also an important component of ATP. Humans contain 80% of phosphorus in teeth and bones.

Phosphorus cycle is a very slow process. Various weather processes help to wash the phosphorus present in the rocks into the soil. Phosphorus is absorbed by the organic matter in the soil which is used for various biological processes.

Since phosphorus and phosphorus-containing compounds are present only on land, atmosphere plays no significant role in the phosphorus cycle.

Steps of Phosphorus Cycle

Following are the important steps of phosphorus cycle:

1. Weathering
2. Absorption by Plants
3. Absorption by Animals
4. Return to the Environment through Decomposition

Weathering

Phosphorus is found in the rocks in abundance. That is why the phosphorus cycle starts in the earth's crust. The phosphate salts are broken down from the rocks. These salts are washed away into the ground where they mix in the soil.

Absorption by Plants

The phosphate salts dissolved in water are absorbed by the plants. However, the amount of phosphorus present in the soil is very less. That is why the farmers apply phosphate fertilizers on agricultural land.

The aquatic plants absorb inorganic phosphorus from lower layers of water bodies. Since phosphate salts do not dissolve in water properly, they affect plant growth in aquatic ecosystem.

Absorption by Animals

The animals absorb phosphorus from the plants or by consuming plant-eating animals. The rate of the phosphorus cycle is faster in plants and animals when compared to rocks.

Return of Phosphorus Back to the Ecosystem

When the plants and animals die they are decomposed by microorganisms. During this process, the organic form of phosphorus is converted into the inorganic form, which is recycled to soil and water.

Soil and water will end up in sediments and rocks, which will again release phosphorus by weathering. Thus, the phosphorus cycle starts over.

Human Impact on Phosphorus Cycle

A number of human activities, use of fertilizers, artificial eutrophication, etc. have a great impact on the phosphorus cycle.

The phosphorus fertilizers increase the level of phosphorus in the soil. Overuse of these fertilizers reduces the fertility of the soil and is also harmful to the microorganisms present in the soil. When these are washed away into the nearby water bodies, they are hazardous to aquatic life.

During the shipping of food from farms to cities, the amount of phosphorus that is washed away in water causes eutrophication. This leads to the growth of algae. These form algal blooms or die, which is toxic to the aquatic ecosystem.

GREEN HOUSE EFFECT:

The greenhouse effect is the process through which heat is trapped near Earth's surface by substances known as 'greenhouse gases.' The phenomenon is like that of green house in which the glass enclosed atmosphere gets heated up due to its insulation from the rest of the environment. The gases such as CO_2, CH_4, CFCs, and water vapours called Greenhouse gases absorb a considerable portion of solar radiation which keeps the earth in a warmth condition, so that the life process is sustained. But, due to the rapid growth of industrialization and population, the concentrations of these gaseous substances are rapidly increasing. Thus, a large fraction of IR radiations and heat waves are absorbed by these gases which help in rising the temperature of the surface of earth.

GLOBAL WARMING:

"Global warming is a gradual increase in the earth's temperature generally due to the greenhouse effect caused by increased levels of carbon dioxide, CFCs, and other pollutants. "

Causes of Global Warming

Following are the major causes of global warming:

1. Deforestation

Plants are the main source of oxygen. They take in carbon dioxide and release oxygen thereby maintaining environmental balance. Forests are being depleted for many domestic and commercial purposes. This has led to an environmental imbalance, thereby giving rise to global warming.

2. Use of Vehicles

The use of vehicles, even for a very short distance results in various gaseous emissions. Vehicles burn fossil fuels which emit a large amount of carbon dioxide and other toxins into the atmosphere resulting in a temperature increase.

3. Chlorofluorocarbon

With the excessive use of air conditioners and refrigerators, humans have been adding CFCs into the environment which affects the atmospheric ozone layer. The ozone layer protects the earth surface from the harmful ultraviolet rays emitted by the sun. The CFCs have led to ozone layer depletion making way for the ultraviolet rays, thereby increasing the temperature of the earth.

4. Industrial Development

With the advent of industrialization, the temperature of the earth has been increasing rapidly. The harmful emissions from the factories add to the increasing temperature of the earth.

In 2013, the Intergovernmental Panel for Climate Change reported that the increase in the global temperature between 1880 and 2012 has been 0.9 degrees Celsius. The increase is 1.1 degrees Celsius when compared to the pre-industrial mean temperature.

5. Agriculture

Various farming activities produce carbon dioxide and methane gas. These add to the greenhouse gases in the atmosphere and increase the temperature of the earth.

6. Overpopulation

An increase in population means more people breathing. This leads to an increase in the level of carbon dioxide, the primary gas causing global warming, in the atmosphere.

Natural Causes of Global Warming

7. Volcanoes

Volcanoes are one of the largest natural contributors to global warming. The ash and smoke emitted during volcanic eruptions goes out into the atmosphere and affects the climate.

8. Water Vapour

Water vapour is a kind of greenhouse gas. Due to the increase in the earth's temperature, more water gets evaporated from the water bodies and stays in the atmosphere adding to global warming.

9. Melting Permafrost

Permafrost is frozen soil that has environmental gases trapped in it for several years and is present below Earth's surface. It is present in glaciers. As the permafrost melts, it releases the gases back into the atmosphere, increasing Earth's temperature.

10. Forest Blazes

Forest blazes or forest fires emit a large amount of carbon-containing smoke. These gases are released into the atmosphere and increase the earth's temperature resulting in global warming.

Consequences of Global warming:

Rise in Temperature

Global warming has led to an incredible increase in earth's temperature. Since 1880, the earth's temperature has increased by nearly 1 degree. This has resulted in an increase in the melting of glaciers, which have led to an increase in the sea level. This could have devastating effects on coastal regions.

Threats to the Ecosystem

Global warming has affected the coral reefs that can lead to the loss of plant and animal lives. Increase in global temperatures has made the fragility of coral reefs even worse.

Climate Change

Global warming has led to a change in climatic conditions. There are droughts at some places and floods at some. This climatic imbalance is the result of global warming.

Spread of Diseases

Global warming leads to a change in the patterns of heat and humidity. This has led to the movement of mosquitoes that carry and spread diseases.

High Mortality Rates

Due to an increase in floods, tsunamis and other natural calamities, the average death toll usually increases. Also, such events can bring about the spread of diseases that can hamper human life.

Loss of Natural Habitat

A global shift in the climate leads to the loss of habitats of several plants and animals. In this case, the animals need to migrate from their natural habitat and many of them even become extinct. This is yet another major impact of global warming on biodiversity.

OZONE LAYER DEPLETION:

"Ozone layer depletion is the gradual thinning of the earth's ozone layer in the upper atmosphere caused due to the release of certain chemical compounds."

It is observed that CFCs are mainly responsible for the depletion of ozone layer. Chlorine and bromine containing compounds, oxides of nitrogen also contribute towards ozone layer depletion.

Mechanism of ozone layer depletion:

When chlorine containing compounds like CFC is exposed to the sun light, the bond between C and Cl breaks forming chlorine free radical (chlorine atom). This chlorine atom attacks a molecule of ozone forming oxygen and OCl. The OCl thus formed combines with the atmospheric oxygen atom to form oxygen molecule and chlorine atom is regenerated. The regenerated chlorine atom further destroys

another ozone molecule. One chlorine atom can destroy one lakh ozone molecules. Further the life period of a chlorine atom is about 100 years in the atmosphere.

The compounds responsible for ozone layer depletion are known as Ozone Depleting Substances (ODS).

The ozone-depleting substances that contain chlorine include chlorofluorocarbon, carbon tetrachloride, hydrochlorofluorocarbons, and methyl chloroform. Whereas the ozone-depleting substances that contain bromine are halons, methyl bromide, and hydro Bromo fluorocarbons.

Montreal Protocol was proposed in 1987 to stop the use, production and import of ozone-depleting substances and minimise their concentration in the atmosphere to protect the ozone layer of the earth.

Causes of Ozone Layer Depletion

Ozone layer depletion is a major concern and is associated with a number of factors. The main causes responsible for the depletion of the ozone layer are listed below:

Chlorofluorocarbons

Chlorofluorocarbons or CFCs are the main cause of ozone layer depletion. These are released by solvents, spray aerosols, refrigerators, air-conditioners, etc.

The molecules of chlorofluorocarbons in the stratosphere are broken down by ultraviolet radiations and release chlorine atoms. These atoms react with ozone and destroy it.

Unregulated Rocket Launches

Researches say that the unregulated launching of rockets results in much more depletion of the ozone layer than the CFCs do. If not controlled, this might result in a huge loss of the ozone layer by the year 2050.

Nitrogenous Compounds

The nitrogenous compounds such as NO_2, NO, N_2O generally emitted from vehicles are highly responsible for the depletion of the ozone layer.

Natural Causes

The ozone layer has been found to be depleted by certain natural processes such as Sun-spots and stratospheric winds. But it does not cause more than 1-2% of the ozone layer depletion.

The volcanic eruptions are also responsible for the depletion of the ozone layer.

Effects of Ozone Layer Depletion

The depletion of the ozone layer has harmful effects on the environment. Let us see the major effects of ozone layer depletion on man and environment.

Effects on Human Health

Humans will be directly exposed to the harmful ultraviolet radiation of the sun due to the depletion of the ozone layer. This might result in serious health issues among humans, such as skin diseases, cancer, sunburns, cataract, quick ageing and weak immune system.

Effects on Animals

Direct exposure to ultraviolet radiations leads to skin and eye cancer in animals.

Effects on the Environment

Strong ultraviolet rays may lead to minimal growth, flowering and photosynthesis in plants. The forests also have to bear the harmful effects of the ultraviolet rays.

Effects on Marine Life

Planktons are greatly affected by the exposure to harmful ultraviolet rays. These are higher in the aquatic food chain. If the planktons are destroyed, the organisms present in the food chain are also affected.

Solutions to Ozone Layer Depletion

Following are some points that would help in preventing this problem at a global level:

- ***Avoid Using ODS***

Reduce the use of ozone depleting substances. E.g. avoid the use of CFCs in refrigerators and air conditioners, replacing the halon based fire extinguishers, etc.

- ***Minimize the Use of Vehicles***

The vehicles emit a large amount of greenhouse gases that lead to global warming as well as ozone depletion. Therefore, the use of vehicles should be minimised as much as possible.

- ***Use Eco-friendly Cleaning Products***

Most of the cleaning products have chlorine and bromine releasing chemicals that find a way into the atmosphere and affect the ozone layer. These should be substituted with natural products to protect the environment.

- ***Use of Nitrous Oxide should be Prohibited***

The government should take actions and prohibit the use of harmful nitrous oxide that is adversely affecting the ozone layer. People should be made aware of the harmful effects of nitrous oxide and the products emitting the gas so that its use is minimised at the individual level as well.

UNIT - 2: AIR AND NOISE POLLUTION

Pollution:

The presence of harmful substances in the air, land, and water, which can have an adverse effect on living beings and on the environment, is called pollution.

Types of pollution:

There are various types of pollution, like

1. Air pollution
2. Water pollution
3. Soil pollution
4. Noise pollution
5. Radioactive pollution, etc.

Pollutant:

Pollutants are materials that cause pollution. Any substance that makes the air, water or any other natural resource toxic is also called a pollutant.

Examples: Various substances such as *heavy metals, pesticides, herbicides, industrial chemicals, and toxins from improperly disposed-of waste*. Also, *Carbon monoxide, Nitrogen oxides, and Sulfur dioxide* are examples of pollutants.

Primary pollutants:

Primary pollutants are pollutants that are emitted directly into the environment or formed during a process. Examples: Carbon monoxide, carbon dioxide, sulphur dioxide, chlorofluorocarbons, lead, Mercury, NO_X, etc.

Secondary pollutants:

Secondary pollutants are formed in the atmosphere as a result of chemical reaction of primary pollutants with other substances in the atmosphere. Examples: Peroxyacyl nitrates (PAN), ground level ozone, acid rain, smog, etc.

Air Pollution:

Air pollution may be defined as the "introduction of any foreign material to the atmosphere which causes detrimental effects on the environment, living and non-living systems".

Sources of Air pollution:

1. **Natural sources**: The natural sources of air pollution include:
   - Forest fire
   - Volcanic eruption
   - Sandstorm
   - Tornado
   - Garbage decomposition
2. **Manmade sources**: The manmade sources of air pollution include:
   - Internal combustion engines
   - Boilers
   - Refrigeration units

- Industrial emission
- Agriculture
- Thermal power plant
- Waste management

Particulate Pollutants: Particulate pollutants are microscopic liquid or solid particles present in the form of suspension in the air. Particulate matter can be released from different types of human activities such as vehicle emissions, smoke particles, dust particles, and ash from industries.

Particulate matter present in the air is mainly of two types- Viable particles and non-viable particles.

- **Viable Particulate Matter:** These particles include lower living organisms such as algae, bacteria, molds, fungi, etc. They are dispersed into the air. Human beings are allergic to these microorganisms and they can also cause different types of diseases in plants and animals.
- **Non-Viable Particulate Matter:** We can classify these particles based on size and their nature. These particulates include smoke, dust, mist, and fumes.

Effects of Particulate Matter

A particulate pollutant is very dangerous to human health, plants, and to the entire climate. Children and elderly people are prone to diseases caused by particulate pollution. However, normal persons can also experience temporary problems.

Effects on Health

Exposure to particulate pollution can cause irritation of eyes, throat, and nose. It can also cause tightness in chest, difficulty in breathing and decrease in lung function.

Lung Cancer

PM vary in shape and size. Fine particulates can enter easily and penetrate deep into the respiratory systems of human and can affect the lungs. It attacks the bronchi and can cause lung cancer.

Asthma

Reports suggest that particulate pollutants can cause asthma with the increase in the fine pollutant globally. Rising rate of diagnoses links asthma to particulate matter pollution.

Cardiovascular Problems

Fine particles can easily enter the body without facing resistance from the body. Therefore, fine particles have a drastic impact on the heart and the functions of the heart. Therefore, particulate matter is responsible for many cardiovascular diseases. Frequent exposure to PM can lead to a large amount of inhalation of particles. Therefore, accumulation of PM will cause the buildup of plaque in the arteries and vascular inflammation.

Atherosclerosis

Air pollutant inhalation can cause plaque build-up. This will lead to hardening of arteries and in turn cause heart problems.

Birth Defects and Failed Pregnancy

Particles ability to enter into the body makes it easy to enter any pregnant mothers' body and then into the child during long exposure to particulate air pollutants. Thus, the harmful chemical pollutants can cause any type of birth defects. It is also the reason failed pregnancies specifically in town and cities facing extreme levels of pollution.

Death

High levels of aerosols and other pollutants can cause premature death. Air pollution due to coal industries is the cause of many premature deaths every year in India and globally.

Effect on Vegetation and Plants

Particulate pollutants have the ability to block stomatal openings. Therefore, it can retard the photosynthesis process. Hence, air pollutants can damage the plant, reduce crop and vegetation yield, and increase their mortality rate.

Effect on Climate

The rise of particulate pollution is disturbing the environmental balance. Reports suggest particulates matter can negatively impact weather on a regional level. PM decreases the levels of evaporation of water in the Indian Ocean. It is linked to the lack of Indian monsoon or reduction of the Indian monsoon.

Aerosol haze and particulate pollution have the ability to push tropical rainfall and are the reason for a number of droughts human's experiences on a global level. PM causes the decrease in rainfall. It is also responsible for the increase in greenhouse gases and global warming.

Control of Particulate Pollutants:

Particulate pollutants can be controlled by using the following apparatus:

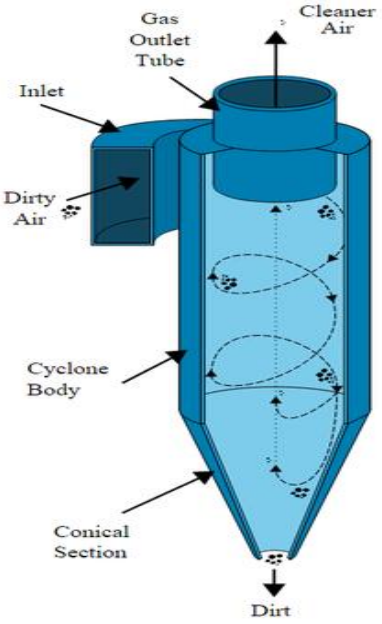
1. Bag Filter
2. Cyclone Separator
3. Electrostatic Precipitator

1. Bag Filter:

Bag filters, commonly known as baghouse or dust collector is a pollution control device used to remove particulate matters from the contaminated gas stream. These bag filters are made up of fabric materials. The filter is usually in the form of cylindrical fabric bags, but it may also be in the form of cartridges that are made up of fabric, sintered metal or porous ceramic. In general, bag filters are capable of collection efficiencies greater than 99 percent. The following steps are involved in the bag filter.

- **Air Sucking**: When the air with dust and dirt in it is blown into the bag, the bag sucks in the air.
- **Filtering**: As the air goes into the bag, the tiny particles like dust and dirt get trapped outside the material of the bag. The clean air comes out on the other side.
- **Maintenance**: Over time, the bag gets filled with dust and dirt. So, a blower mechanism helps to remove the dirt which is collected in a chamber at the bottom of the bag house for safe disposal.

2. Cyclone Separator:



Cyclone separators use the *principle of inertia* to remove particulate matter from flue gases. A cyclone separator is one of many air pollution control devices which remove larger pieces of particulate matter. In addition, several cyclone separators can operate in parallel, and this system is known as a **multi-cyclone**.

The size of the cyclone depends largely on how much flue gas must be filtered; thus, larger operations tend to need larger cyclones.

In a cyclone separator, dirty flue gas is fed into a chamber. The inside of the chamber creates a spiral vortex, similar to a tornado. The lighter components of this gas have less inertia, so

it is easier for them to be influenced by the vortex and travel up it. While larger components of particulate matter have more inertia and are not as easily influenced by the vortex.

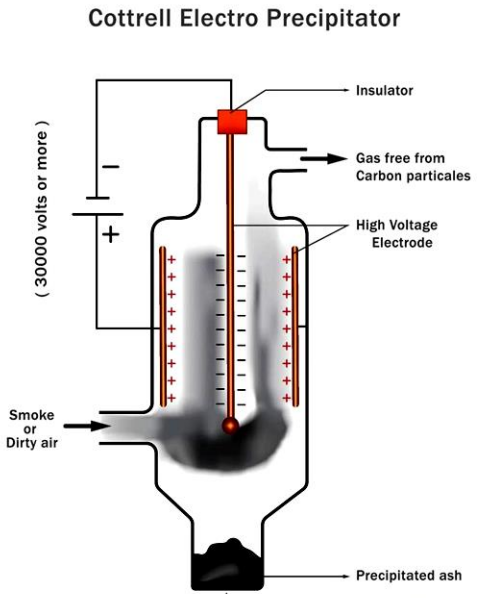
Since these larger particles hit the inside walls of the container and drop down into a collection hopper. These chambers are shaped like an upside-down cone to promote the collection of these particles at the bottom of the container. The cleaned flue gas escapes out the top of the chamber.

Out of all of the particulate-control devices, cyclone separators are among the least expensive. They are often used as a pre-treatment before the flue gas enters more effective pollution control devices.

3. Electrostatic Precipitator (ESP):

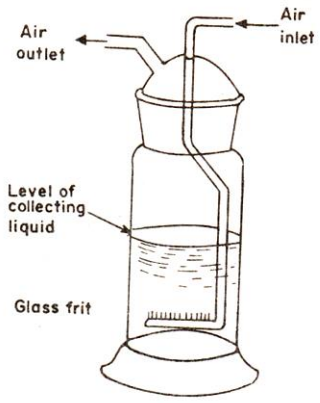
An **electrostatic precipitator** is a type of filter that uses static electricity to remove soot and ash from exhaust fumes before they exit the smokestacks. This is a common air pollution control device.

The operation of ESP is very simple. The dirty flue gas escaping through the smokestack is passed through two electrodes. One of the electrodes is charged with a high negative voltage, and this plate causes particulates inside the smoke to obtain a negative charge as they pass by this electrode. On the other hand, the second electrode carries a similarly high positive voltage. The negatively charged soot particles are pulled towards the positive electrode and stick to it. The precipitated soot and ash are then collected at the bottom of the ESP.



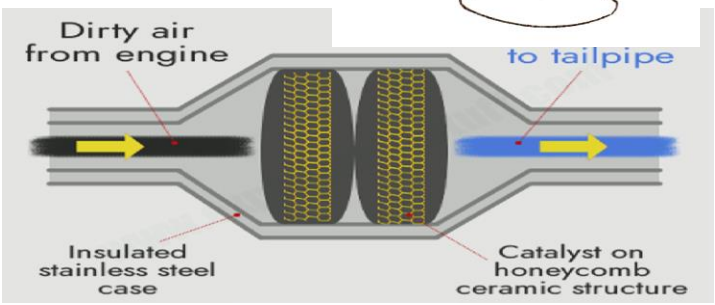
Gaseous pollution control:

The following apparatus are used to control gaseous pollution:



1. **Absorber:** In this method gaseous pollutants are absorbed in a solvent. The impure gas is bubbled through a liquid. Pure water is adequate for collecting some gaseous pollutants such as HF. Alkaline solutions are required for absorbing acidic gases, acidic solutions for collecting alkaline gases and oils and for collecting hydrocarbons.

2. **Catalytic Converter:** A catalytic converter is an emissions control device. The job of the catalytic converter is to convert harmful pollutants into less harmful emissions before they ever leave the vehicle's exhaust system.



   In the catalytic converter, there are two different types of catalyst chambers: a reduction catalyst and an oxidation catalyst.

   The reduction catalyst is the first stage of the catalytic converter. It uses platinum and rhodium to help reduce the NOx emissions.

   When an NO or NO_2 molecule contacts the catalyst, it converts them into nitrogen and oxygen.

$$2NO \xrightarrow{Catalyst} N_2 + O_2$$

$$2NO_2 \xrightarrow{Catalyst} N_2 + 2O_2$$

The oxidation catalyst is the second stage of the catalytic converter. It reduces unburned hydrocarbons and carbon monoxide by oxidizing them over a platinum and palladium catalyst. This catalyst aids the reaction of the CO and hydrocarbons with the remaining oxygen in the exhaust gas.

$$2CO + O_2 \xrightarrow{Catalyst} 2CO_2$$

$$C_XH_Y + O_2 \xrightarrow{Catalyst} CO_2 + H_2O$$

Effects of air pollution due to Refrigerants:

The refrigerants used in refrigerators, such as chlorofluorocarbons (CFCs) and hydrofluorocarbons (HFCs), make great contributions towards air pollution. CFCs and HFCs are greenhouse gases that can contribute to ***climate change*** and ***ozone depletion***. When refrigerants are released into the atmosphere, they react with other chemicals to form smog and contribute to ***global warming***. Additionally, the energy used to power refrigerators can contribute to air pollution if it is generated from fossil fuels. Overall, while refrigerators do not directly cause air pollution, the refrigerants and energy used to power them can contribute to air pollution and climate change.

Effects of air pollution due to IC Engines:

Internal combustion engines emit a large numbers of pollutants like particulate matter, NOx, HCs, etc. which contribute towards air pollution. Combustion engines fuelled by petroleum fuels are also a major source of ***GHG emissions***—mainly CO_2 but also other gases such as CH_4 and N_2O which causes global warming.

From a *public health* perspective, emission of particulate matters and nitrogen oxide must be controlled to ensure healthy air, especially in urban areas.

High levels of diesel particulates can be produced by older generation diesel engines, without diesel particulate filters (DPF). More recently, direct injection gasoline engines became another important source of particulate emissions. Diesel particulate matter (DPM) is a mixture composed of solids, organics, and sulphates which has the greatest effect on health.

Diesel emissions contain numerous compounds like poly-nuclear aromatic hydrocarbons (PAH), nitro-PAHs, aldehydes, and other hydrocarbon derivatives. The chemical substances are highly toxic for human health.

Some health studies investigate the effects of “whole diesel exhaust” that includes both gaseous pollutants and the particulate phase.

Effects of air pollution due to Boilers:

Boilers are combustion devices used to heat water or to produce steam. Steam is produced in boilers by heating water until it vaporizes. The steam is then used to produce heat / electricity or to run machinery. I.C. Boilers emit a variety of hazardous air pollutants, particle pollutants and volatile organic compounds. Some of the pollutants emitted are Nitrogen oxide, Sulfur dioxide, Carbon monoxide, Hydrogen chloride, cadmium, mercury etc.

Noise pollution

Noise pollution can be defined as any unwanted or disturbing sound that affects the health and well-being of humans and other organisms.

The sound is typically described in terms of loudness, and it is measured in decibels (dB). Not all sound is considered as noise pollution. According to the World Health Organization (WHO), noise **above 65 dB** can be considered as noise pollution. Noise becomes harmful when it **exceeds 75 dB** and painful above 120 dB.

Sources of noise pollution

The noise pollution is caused mainly due to **industrialization, urbanization and modern civilization.** There are many sources of noise pollution:

- **Industrial sources:** The industries such as textile mills, printing press, metal works etc. contribute heavily towards noise pollution. Many industrial cities in India like Kolkata, Kanpur etc. are more affected as industrial zones are not separated from residential zones specially in case of small-scale industries.
- **Transport vehicles:** In urban areas automobiles are big sources of noise pollution. In the recent past, there has been enormous growth in traffic volume due to increase in number of vehicles such as busses, trains, trucks etc. resulting in increased noise pollution. Airports located near the residential areas create lots of noise pollution during their landing and taking off. Heavy trucks, buses, trains, motor bikes, mopeds etc. also contribute to the noise pollution.
- **Household noise:** The household activity is also a source of many indoor noises such as noise of playing children, infants crying, moving of furniture etc. Domestic gadgets like mixer-grinder, pressure cookers, exhaust fans, washing machines and entertainment equipment such as radio, music system, television sets are all indoor sources of noise pollution.
- **Public address system (PA system):** Many public functions such as political rallies, strikes, elections, religious and other social events etc. use PA system normally in a very loud volume and thus are become the source of noise pollution.
- **Agriculture machines:** Heavy types of machinery and equipment such as tractors, thrashers, powered tillers, harvesters etc. are being used in many agricultural farms. These machineries may create noise pollution of level more than 90 dB to 98 dB.
- **Defense equipment:** A lot of noise pollution is created by artillery, tanks, explosions, shooting practices etc. by defense personnel.
- **Miscellaneous sources:** The construction site, blasting, stone crusher etc. are some of the other sources of noise pollution.

Measurement of noise pollution level:

Noise pollution is measured in decibels (dB), which is a logarithmic unit that describes the loudness of a sound:

- **Decibels A (dBA)**: Decibels adjusted to human hearing
- **Sound pressure level (SPL)**: Another term for loudness

The World Health Organization (WHO) defines noise above 65 dB as noise pollution. Noise can be harmful at levels above 75 dB, and painful at levels above 120 dB.

Some equipment used to measure noise pollution includes:

- **Sound level meters**: Record and measure sound pressure over a period of time
- **Calibrators**: Produce a stable sound at a specific frequency and level

Here are some examples of noise levels in different environments:

- **Library**: About 35 dB
- **Moving bus or subway train**: About 85 dB
- **Building construction**: Can be as high as 105 dB at the source

Effects of Noise pollution:

Some of the major effects of noise pollution are:

- **Hearing problems:** Constant exposure to loud levels of noise may result in loss of hearing. It may also reduce our sensitivity to sounds that our ears pick up unconsciously in our day-to-day life.
- **Psychological issues:** Our psychological health may be influenced by noise pollution in working areas such as offices, construction sites or even in homes. It may result in disturbance of sleep, constant stress, fatigue, anxiety, depression etc. These, in turn, may cause more severe and chronic health issues in the later stage of life.
- **Physical problems:** Excessive noise level may cause high blood pressure, headaches, respiratory problems, racing pulse etc.
- **Cognitive issues:** Noise pollution may affect brain responses and ability to focus which may result in low performance levels over time. The study reveals that the school children residing near railway stations or airports have problems in learning.
- **Sleeping disorders:** High level of noise is likely to affect our sleeping pattern and it may lead to very uncomfortable and irritating situations. It may result in early fatigue and affect our performance in the office as well as in home.
- **Cardiovascular issues:** High level of noise may cause high blood pressure, cardiovascular disease and stress-related heart problems.
- **Communication barrier:** Noise pollution may act as a barrier in free communication among the people. This may lead to misunderstanding and also difficulty in understanding each other. It may affect badly the teaching learning process in the classroom, laboratories and workshops.

- **Effect on wildlife:** Noise pollution affects wildlife more than humans as they are more dependent on sound. Animals may suffer from hearing loss and become inefficient in hunting which may lead to disturbing the balance of eco-system.

Noise pollution (Regulation and Control) Rules, 2000:

The increasing noise levels in public places from various sources have detrimental effects on human health and the psychological well-being of the people. It is considered necessary to regulate and control noise producing and generating sources with the objective of maintaining ambient air quality standards in respect of the noise.

In order to address above issues, the principal rules were published in the Gazette of India, vide S.O.123(E), dated 14.2.2000 and subsequently amended vide different orders. The main features of the Noise Pollution (Regulation and Control) Rules, 2000 are described under the sub-headings:

Some important compliances under Noise Pollution (Regulation and Control) Rules, 2000.

1. A person cannot play a loudspeaker, public address system, sound producing instrument, musical instrument or a sound amplifier *at night-time* except in closed premises like auditorium, conference rooms, community halls or banquet halls.

2. The persons using loudspeakers or public address shall maintain the noise level not exceeding 10 dB (A) above the ambient noise standards for the area specified or 75 dB (A) whichever is lower.

3. The persons owning a private sound system or a sound producing instrument shall not, exceed the noise above 5 dB (A) the noise standards specified for the area in which it is used.

4. A person shall not burst sound emitting firecrackers in silence zone or during nighttime.

5. A person is restricted from using sound emitting construction equipment's during nighttime in residential areas and silence zones.

6. A person shall not do the following acts in silence zone

   (a) Playing any music or uses any sound amplifiers,

   (b) A drum or blows a horn either musical or pressure, or trumpet or beats or sounds any instrument, or
   (c) Playing any musical or other performance of a to attract crowd
   (d) Bursting sound emitting firecrackers
   (e) Using a loudspeaker or a public address system.

7. A person shall not use the horn in silence zones or during nighttime in residential areas except during a public emergency.

8. (1) Anyone who contravenes the provisions of this Act shall be punishable with imprisonment for a term which may extend to five years or with fine which may extend to one lakh rupees, or with both, and in case the failure or contravention continues, an additional fine which may extend to five thousand rupees for every day during contravention continues.
(2) If the person continues to contravention beyond a period of one year after the date of conviction, the offender shall be punishable with imprisonment for a term which may extend to seven years.

UNIT - 3: WATER AND SOIL POLLUTION

Water Pollution:

Water pollution may be defined as "the introduction of any foreign material to water bodies which changes its colour, taste or any other physical or chemical composition causing adverse effect on living and non-living things".

Sources of water pollution:

The most significant sources of water pollution are:

- **Sewage (Wastewater):** The sewage water carries pathogens, a typical water pollutant, other harmful bacteria, and chemicals that can cause serious health problems and thereby diseases.
- **Agricultural Pollution:** Excess **c**hemical fertilizers and pesticides are used by farmers are mixed up with runoff water and enter the waterbodies to pollute water.
- **Oil Spillage:** Oil spills from pipelines, refineries, ships, etc. enter into the sea. It causes problems for local marine wildlife, including fish, birds, and other aquatic lives.
- **Industrial Waste:** Many toxic chemicals and pollutants are produced from different industries as their waste products which cause water pollution.
- **The burning of fossil fuels:** Fossil fuels like coal and petroleum oil, when burnt, produce a huge amount of ash in the atmosphere. The particles which contain toxic chemicals when mixed with water vapour result in acid rain causing water pollution.
- **River dumping and Marine Dumping:** The garbage produced by households in the form of paper, plastic, food, aluminium, rubber, glass, is collected and dumped into the rivers and seas. They not only cause water pollution but also harm aquatic animals.

Types of water pollutants

Water pollutants can be classified into the following four types:

- Pathogens
- Organic materials
- Inorganic compounds
- Macroscopic pollutants

Pathogens

Pathogen refers to bacteria, viruses, protozoa and more. Excessive number of bacteria can heavily contaminate the water. The two most common pathogenic bacteria include coli-form and E Coli bacteria.

Organic Material

MTBE (methyl tert-butyl ether) is quite a common volatile organic chemical. Earlier MTBE was used as an air-cleaning gas additive. However, it was banned later but the time to erase it completely from water is quite long.

Similarly, the water which contains organic materials can result in deadly diseases like tumours in the testicles, leukaemia, thyroid glands and kidneys, lymphoma, and more.

Inorganic Material

Inorganic materials like heavy metals including copper, arsenic, barium, mercury, zinc, mercury and more can be dangerous water pollutants.

Macroscopic Pollutants

The most common example of macroscopic pollutants is the trash including plastic waste that ends up in the water. Due to their non-biodegradable nature, they end up collecting in oceans and other water bodies. This is a very severe problem causing the 'great pacific garbage patch' which can be compared to the size of France.

Similarly, other types of these pollutants are small plastic pellets, metal, pieces of wood, shipping containers, shipwrecks and more.

Characteristics of water pollutants:

1. **Turbidity:** Turbidity is the measurement of water clarity or transparency. Suspended particles – such as silt, algae, plankton, and sewage make water turbid. These particles scatter and absorb light rays rather than allowing light to be transmitted straight through the water.

   Turbidity of water is measured with a ***Nephelometer***, also known as a turbidity meter. Turbidity meters utilize a light and photo detector to measure light scatter, and read out in units of turbidity, such as *Nephelometric turbidity units (NTU) or Formazin turbidity units (FTU).*

2. **P^H:** P^H is a measurement of acidity or alkalinity of solutions. It may be defined as 'the negative logarithm of H^+ ion concentration in moles per litre. ($P^H = -\text{Log}_{10}[H^+]$). The scale ranges from 0 (very acidic) to 14 (very basic). It is normal for water to have a range of between 6.5 and 8.5 on the scale. P^H in water may fluctuate with differing environmental factors.
3. **Total suspended solids:** Total Suspended Solids (TSS) is a measurement of the total solids in a water or wastewater sample that are retained by filtration. TSS can be measured in real-time with our TSS probe to improve wastewater process control and plant efficiency.
   To measure TSS in real-time, Real Tech's innovative TDS sensors utilize near infrared (NIR) light as measurement in this region minimizes or eliminates interference from other absorbing compounds, improving accuracy and reliability of results.
4. **Total solids:** Total solids are dissolved solids plus suspended and settleable solids in water. In stream water, dissolved solids consist of calcium, chlorides, nitrate, phosphorus, iron, sulphur, and other ions particles that will pass through a filter with pores of around 2 microns (0.002 cm) in size. Suspended solids include silt and clay particles, plankton, algae, fine organic debris, and other particulate matter. These are particles that will not pass through a 2-micron filter.
5. **Biochemical Oxygen Demand (BOD):** Biochemical oxygen demand (also known as BOD or biological oxygen demand) is the amount of dissolved oxygen (DO) consumed by aerobic bacteria growing on

the organic material present in a water sample at a specific temperature over a specific time period. BOD is applied to determine the aerobic destructibility of organic substances.

Calculation of BOD:

A sample of water is taken in an air-tight container and placed in a controlled environment at a designated temperature for a period of five days. The initial and final levels of dissolved oxygen (DO) in the sample are measured both before and after the five-day incubation period. BOD test is conducted at a temperature of 20°C. The biochemical oxygen demand (BOD) can be determined by subtracting the initial DO from the final DO. The initial DO is recorded immediately after the dilution of the sample, and any subsequent oxygen consumption during the measurement period is considered in the calculation of BOD.

The higher the BOD, the greater the organic pollution level of the water.

Drinking water has a BOD level of 1-2 ppm. When the BOD value of water is in the range 3 - 5 ppm, the water is moderately clean. Polluted water has a BOD value in the range of 6 - 9 ppm.

6. Chemical Oxygen Demand (COD):

Chemical Oxygen Demand is a measure of the amount of oxygen required to break down organic matter in water. It's an important parameter in water quality monitoring, particularly in wastewater treatment.

- COD measures the amount of oxygen consumed by organic matter in water when it's oxidized with a boiling acid potassium dichromate solution.
- COD can indicate the presence of all types of organic matter, including biodegradable and nonbiodegradable. High COD levels can be caused by a number of things, including solid waste, food waste, and dying bacteria.
- COD is used to characterize water bodies, sewage, industrial wastes, and treatment plant effluents. It can also be used to monitor compliance, optimize wastewater treatment, and identify pollution sources.
- High levels of organic pollution which may cause waterborne diseases.

COD is typically measured in milligrams per liter (mg/L) or parts per million (ppm). Common COD ranges:

1. Drinking water: <10 mg/L
2. Wastewater: 100-1,000 mg/L
3. Industrial effluent: 1,000-10,000 mg/L

Calculation of COD:

The organic matter present in the water sample is oxidized by potassium dichromate in the presence of sulfuric acid, silver sulfate and mercury sulfate to produce carbon dioxide (CO_2) and water (H_2O). The quantity of potassium dichromate used is calculated by the difference in volumes of ferrous ammonium sulfate consumed in blank and sample titrations. The quantity of potassium dichromate used in the reaction is equivalent to the oxygen (O_2) used to oxidize the organic matter of wastewater.

Difference between BOD & COD

BOD	COD
BOD stands for Biological Oxygen Demand.	COD stands for Chemical Oxygen Demand.
It is the amount of oxygen the microbes require to decompose organic matter under aerobic conditions.	It is the total amount of oxygen required to break down both the biodegradable and non-biodegradable organic matter by chemical oxidation.
BOD is a biochemical oxidation process	COD is a chemical oxidation process.
It can be determined by putting a sealed water sample under specific temperature conditions(20^oC) for five days.	It can be determined by placing a water sample with a strong oxidizing agent under specific temperature conditions(150^oC) for a short period.
It takes several days for the incubation period.	Can be measured relatively quickly, often within a few hours.
Specifically measures biodegradable organic matter.	Measures both biodegradable and non-biodegradable organic substances.
It is always lower than COD.	It is always higher than BOD.
It is used to assess the level of organic pollution, microbial activity, and treatment efficiency.	It is used to quantify the amount of oxidisable pollutants found in water bodies.

Waste Water Treatment:

Primary Methods:

1. Sedimentation:

Sedimentation is a water treatment process that removes suspended particles from water using gravity.

- In sedimentation, water passes through a basin where the velocity is reduced so that gravity can remove particles from the water flow. The particles that settle out are called sludge.
- Sedimentation improves the filtration process by reducing the concentration of particles in the water. It can also reduce the amount of coagulating chemicals needed.
- Sedimentation can be used before coagulation to reduce heavy sediment loads, or after coagulation to reduce the concentration of solids in suspension.
- There are several methods for sedimentation, including horizontal flow, radial flow, inclined plate, ballasted floc, and floc blanket sedimentation.
- Adding coagulants like aluminium sulphate, polyaluminium chloride, or ferric sulphate to the water can speed up the sedimentation process.
- After sedimentation, the water is usually filtered to remove any remaining suspended materials and pathogens.

2. Froth Floatation:

Froth flotation is a wastewater treatment process that uses air bubbles to separate suspended solids, fats, oils, and grease from water:

- Air is dissolved into water under pressure, then released into a flotation tank to create air bubbles. The bubbles trap dispersed particles, which float to the surface and form a froth layer. A skimmer removes the froth, leaving clear water behind.
- Froth flotation is used to remove oil from wastewater in oil refineries, chemical production plants, and other similar industries.
- Froth flotation is also used in mineral processing and paper recycling.

Secondary Methods:

1. Activated sludge treatment

The activated sludge process is a biological wastewater treatment process that uses microorganisms to break down organic matter in wastewater.

The process involves:

- **Mixing and aeration**: Air or oxygen is pumped into a tank to mix and aerate the wastewater and microorganisms.
- **Biological flocs**: The microorganisms grow and clump together to form a mass called activated sludge.
- **Settling**: The sludge settles in a tank, separating it from the treated water.
- **Sludge recycling**: Some of the sludge is recycled back to the aeration tank, while the rest is treated and disposed of.

2. Trickling filter:

A trickling filter is a biological reactor that uses microorganisms to remove organic matter from wastewater. It's also known as a biofilter, biological filter, or biological trickling filter.

- Pre-settled wastewater is sprayed over a bed of material with a high surface area, such as crushed rocks, gravel, or plastic filter media.
- Microorganisms grow in a biofilm on the surface of the medium, feeding on nutrients from the wastewater.
- The microorganisms absorb and stabilize the organic matter in the wastewater, producing water and carbon dioxide.
- The biological film eventually breaks off and washes down through the medium bed.
- The treated wastewater and broken-off film are collected by an underdrainage system.

- The collected liquid is passed to a settling tank to separate solids and liquids.
- Trickling filters remove about 85% of organic matter from wastewater.

3. Bioreactor:

A bioreactor is a chamber in a wastewater treatment process that supports a biologically active environment where bacteria and protozoa grow and consume substances in the wastewater. There are many different types of bioreactors, including:

- Membrane bioreactors (MBR)
- Anaerobic membrane bioreactors (AnMBRs)
- Packed bed biofilm reactors
- Moving bed biofilm reactors
- DSFF bioreactors

Bioreactors can be aerobic, anoxic, or anaerobic, depending on the presence of oxygen and nitrates:

- **Aerobic**: Removes organic matter and oxidizes ammonia to nitrate.
- **Anoxic**: Removes nitrogen from nitrates to nitrogen gas.
- **Anaerobic**: Removes organic matter.

Tertiary Methods:

1. Membrane separation technology:

In this method pressurized waste water is passed through a number of semipermeable membranes to separate particles, contaminants, or solutes from water or other fluids. This technology is widely used in water treatment, wastewater reuse, and industrial processes.

Membrane separation applications:

1. Drinking water treatment
2. Wastewater reuse and recycling
3. Industrial process water treatment
4. Desalination
5. Food and beverage processing

Advantages:

1. High removal efficiency for contaminants
2. Compact and space-saving design
3. Low energy consumption
4. Flexibility in operation and control
5. Can be used for a wide range of applications

2. Reverse Osmosis (RO)

Reverse Osmosis

Reverse osmosis (RO) is a water treatment process that uses a semi-permeable membrane to purify wastewater by removing up to 99% of contaminants:

- RO systems force water through a semi-permeable membrane, separating the more concentrated side (more contaminants) from the less concentrated side (fewer contaminants).
- RO is a good choice for wastewater treatment because:
    - It is safer than traditional methods that use chemicals
    - It Requires little maintenance
    - It Saves money by reusing water

RO is used in the wastewater industry for tertiary water treatment. It can also be used to clean industrial wastewater so it can be reused, which helps to relieve pressure on freshwater reserves.

Soil Pollution:

What is Soil Pollution?

Soil pollution refers to the contamination of soil with anomalous concentrations of toxic substances.

Causes, Effects and Preventive measures of Soil Pollution:

1. Excessive use of Fertilizers:

Soil pollution due to excessive fertilizer use has severe environmental and health impacts.

Causes:

1. Over-application of synthetic fertilizers
2. Lack of soil testing and nutrient assessment
3. Poor agricultural practices
4. Inadequate fertilizer storage and handling

Effects:

1. Soil degradation and nutrient imbalance
2. Water pollution through runoff and leaching
3. Air pollution through ammonia emissions

4. Soil microorganism disruption
5. Plant nutrient deficiencies and reduced crop yields
6. Human health risks through food contamination

Preventive Measures:

1. Soil testing and nutrient assessment
2. Balanced and targeted fertilizer application
3. Organic and integrated nutrient management practices
4. Crop rotation and intercropping
5. Minimum tillage or no-till farming
6. Cover cropping and mulching
7. Fertilizer storage and handling best practices
8. Education and training for farmers and agricultural professionals
9. Policy and regulatory frameworks for sustainable fertilizer use

2. Pesticides and insecticides:

Soil pollution due to pesticides and insecticides has severe environmental and health impacts. Here's a comprehensive overview:

Causes:

1. Overuse and misuse of pesticides and insecticides
2. Lack of integrated pest management (IPM) practices
3. Poor application techniques and equipment
4. Inadequate pesticide storage and disposal

Effects:

1. Soil contamination and persistence
2. Groundwater pollution through leaching
3. Surface water pollution through runoff
4. Soil microorganism disruption and decline
5. Beneficial insect and pollinator decline
6. Human health risks through exposure and food contamination
7. Development of pesticide-resistant pests

Preventive Measures:

1. Integrated Pest Management (IPM) practices
2. Crop rotation and biological control

3. Organic and cultural control methods
4. Targeted and minimal pesticide application
5. Proper application techniques and equipment
6. Pesticide storage and disposal best practices
7. Education and training for farmers and agricultural professionals
8. Policy and regulatory frameworks for sustainable pesticide use
9. Monitoring and testing for pesticide residues
10. Development of alternative and sustainable pest control methods

3. Irrigation:

Soil pollution due to irrigation has significant environmental and health impacts. Here's a comprehensive overview:

Causes:

1. Over-irrigation and waterlogging
2. Use of poor-quality water (e.g., saline, wastewater)
3. Inadequate drainage and water management
4. Lack of soil moisture monitoring
5. Irrigation system design and maintenance issues

Effects:

1. Soil salinization and alkalization
2. Waterlogging and reduced soil aeration
3. Nutrient leaching and depletion
4. Soil structure degradation and erosion
5. Increased risk of soil-borne diseases
6. Reduced crop yields and quality
7. Groundwater contamination

Preventive Measures:

1. Efficient irrigation system design and maintenance
2. Soil moisture monitoring and management
3. Use of good-quality water (e.g., rainwater, freshwater)
4. Drip irrigation and precision irrigation techniques
5. Crop selection and rotation for water efficiency
6. Mulching and cover cropping for soil protection
7. Regular soil testing and nutrient management

8. Integrated water management and drainage systems
9. Farmer education and training on sustainable irrigation practices
10. Policy and regulatory frameworks for water conservation and efficient use

4. E-Waste:

Soil pollution due to e-waste has severe environmental and health impacts. Here's a comprehensive overview:

Causes:

1. Improper disposal of electronic waste (e-waste)
2. Lack of recycling and proper treatment facilities
3. Burning of e-waste in open areas
4. Dumping of e-waste in landfills
5. Contamination of soil through e-waste leachate

Effects:

1. Soil contamination with toxic heavy metals (e.g., lead, mercury)
2. Presence of hazardous chemicals (e.g., PCBs, dioxins)
3. Soil acidification and nutrient depletion
4. Groundwater pollution through leaching
5. Bioaccumulation of toxins in plants and animals
6. Human health risks through exposure and food contamination

Preventive Measures:

1. Responsible e-waste disposal and recycling
2. Establishment of proper treatment and recycling facilities
3. Implementation of extended producer responsibility (EPR)
4. Education and awareness campaigns for consumers
5. Encouragement of sustainable consumption and production patterns
6. Development of environmentally friendly products
7. Regular monitoring and testing of soil and groundwater
8. Remediation and restoration of contaminated soil
9. Policy and regulatory frameworks for e-waste management
10. International cooperation and agreements for e-waste control

UNIT - 4: RENEWABLE SOURCES OF ENERGY

Non-Renewable Energy Resources: The energy resources which cannot be renewed or reproduced are called non-renewable energy resources. Examples: Fossil fuels like petrol, diesel, kerosene, etc. uranium.

Renewable Energy Resources: The energy resources which can be renewed or reproduced are called renewable energy resources. Examples: solar energy, tidal energy, wind energy, etc.

Solar Energy:

Solar energy is the radiant heat and light from the sun that can be captured and used to generate electricity, heat, and cool buildings. It is generally used to generate electricity, to cook food and to desalinate water.

Flat Plate Collector (liquid and air)

- A **Flat Plate Collector** is a heat exchanger that converts the radiant solar energy from the sun into heat energy.
- It collects, or captures, solar energy and uses that energy to heat water in the home for bathing, washing and heating, and can even be used to heat outdoor swimming pools and hot tubs.

Advantages of flat plate collector includes

- easy to manufacture
- low manufacturing Cost
- little maintenance

COMPONENTS OF FLAT PLATE COLLECTOR:

- **Black plate surface** – to absorb incident solar radiation
- **Glass cover** – to transmit radiation to the absorber at the same time prevent heat loss from the surface
- **Tubes** -containing the fluid/air to transfer the heat from the collector
- **Support structure-** to provide protection and hold the collector components

- **Insulation**- in sides and bottom of the collector to prevent heat losses

WORKING PRINCIPLE

- The solar radiation is absorbed by the plate having black surface and then absorbed heat get transferred to the fluid/air filled in the tubes.
- For transfer of heat, either a medium, liquid or air can be used in the flat plate collectors.
- When a metal sheet is placed to solar radiation, the temperature of the sheet will start rising till the rate at which energy (solar radiation) is received is equal to the rate at which energy is getting transferred or lost from the metal sheet.
- The temperature of the metal sheet after which no further increment is noted is termed as the "equilibrium" temperature.
- Now, if the back of the plate is protected with heat insulating material, and the exposed surface of the plate is painted in black colour and it is covered with glass sheets, then the equilibrium temperature will be much higher than that for the simple exposed sheet.
- This metal sheet can be converted into a heat collector by adding a water/air circulating system.
- The absorbed heat from the heat collector gets transferred to the water/air in the tube and finally transferred to a storage tank.

TYPES OF FLAT PLATE COLLECTOR

1. **Water based flat plate collector:**
   - In this type, water is used as a medium of heat transfer.
   - Water is most commonly used as liquid fluid because of its high volumetric heat capacity and high mass density, which allows using small tubes and pipes for the heat transfer.
2. **Air based flat plate collector:**
   - In this type of collector, air is used as the medium of heat transfer instead of liquid/water.
   - This type of plate collector is used for space heating or crop drying.
   - A fan is usually required to facilitate air low in the pipe.

THEORY OF FLAT PLATE COLLECTOR

Theory of flat plate collectors is very simple. When a metal sheet is exposed to solar radiation, the temperature of the sheet will start rising till the rate at which energy (solar radiation) is received is equal to the rate at which energy is transferred or lost from the metal sheet. The temperature of the metal sheet after which no further increment is noted is termed as the "equilibrium" temperature. Now, if the back of the plate is protected with heat insulating material, and the exposed surface of the plate is painted in black colour and it is covered with glass sheets, then the equilibrium temperature will be much higher than that for the simple exposed sheet. This metal sheet can be converted into a heat collector by adding a water/air circulating system. The absorbed heat from the heat collector gets transferred to the water/air in the tube and finally transferred to a storage tank.

IMPORTANCE OF COATING

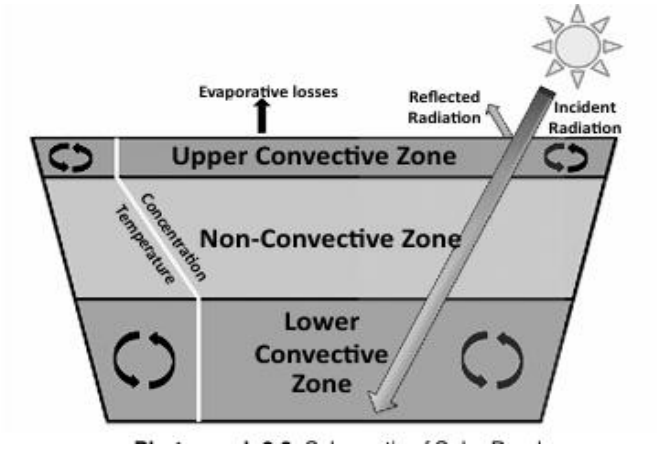
- The solar absorber surface is the fundamental part of a solar thermal collector, as it is responsible for the solar radiation absorption and for reduction of radiation heat losses.
- These plates are usually made of metal having good heat conductor property, usually copper or aluminium. Sometimes these absorber plates are painted with special coatings designed to absorb and retain heat better than the normal black paint.
- Special coatings help to enhance the plate absorber properties such as
  - ✓ High temperature tolerance
  - ✓ Resistance to uv radiation.
  - ✓ Moisture degradation
  - ✓ Durability
  - ✓ Optical characteristics

ADVANCED PLATE COLLECTORS

- In conventional plate collector system, water can be heated up to 80°C, which limits their applications largely for providing hot water and space heating.
- For power generation, the fluid temperatures in the range of 120°C - 130°C is required.
- To achieve this range of temperature, in place of normal plate absorber, evacuated (vacuum) glass tubes coated with selective coating black absorber are used. Plate collector with these arrangements is called as advanced plate collector.
- Using advanced plate collector, temperature can be enhanced to 150°C thereby enhancing application range of the collector to power generation, solar air conditioning system etc.

SOLAR POND

- It is a solar energy collector which is large in size and looks like a pond.
- in an ordinary pond, the sun rays fall on the water and the heated water from within the pond rises and reaches the top but loses the heat into the atmosphere through evaporation. The net result is that the pond water remains at the atmospheric temperature.
- In solar pond, loss of heat from the water is prevented by dissolving salt, concentration of which increases with the depth of water in the pond and making it too heavy to rise.



ZONES OF SOLAR POND:

A solar pond mainly has three zones.

1. Upper convective zone

2. Gradient zone or non-convective zone

3. Storage zone or lower convective zone

1. Upper Convective Zone:

- The top zone is the surface zone called Upper Convective Zone, which is normally at atmospheric temperature and has very little salt content.

2. Lower Convective Zone :

- The bottom zone is the most salty zone. In this zone, the solar energy is stored in the form of heat, and therefore, it is called as the storage zone or Lower Convective Zone.

3.Non-Convective Zone:

- In this zone, the salt content increases with increase in the water depth and thereby creates a density gradient.
- If we consider a particular layer in this zone, water of that layer cannot rise, as the layer of water above this zone has less salt content and is, therefore, lighter.
- Similarly, the water from this layer cannot fall as the water layer below this zone has a higher salt content and is, therefore, heavier.
- Thus, this gradient zone acts as a transparent insulator permitting sunlight to reach the bottom zone but also entrapping it there.

Working principle:

- When sunlight is incident on solar pond, most of the incoming sunlight reaches the bottom and thus the “storage zone” heats up.

- As the loss of heat is prevented from this zone due to the insulator zone just above it, the bottom of the pond is warmed to extremely high temperature and sometimes it may reach more than 80^0C.

- Finally, heated water from the bottom level is transferred to pipes, circulating through the pond to extract thermal energy.

Applications of solar pond:

- The solar pond may be used for the production of chemicals, food, textiles and other industrial products.
- It can also be used to warm greenhouse, swimming pools, and other buildings and offices. The heat can also be converted to electricity.
- It is especially useful in remote locations. The solar pond can also purify water for municipal water systems through desalination.

Advantages:

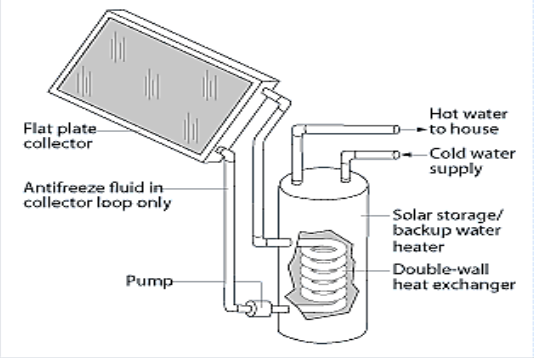
- It can be used all year, day and night, regardless of condition of weather.
- It can be used as an alternative to fossil fuel technologies in rural areas, in less-developed countries, where large ponds can be built.
- It is more cost-effective than energy from the flat-plate solar water-heating systems that are commonly used in the buildings.
- It does not contribute to air pollution.

Disadvantages:

- It requires a large area of land and therefore, may be unsuitable for densely populated areas.
- The pond also requires a continuous and large supply of salt water and also high level of solar energy inputs.
- Regular maintenance is very much needed to keep it in a working condition.
- Though solar ponds can be constructed anywhere, it is economical to construct them at places where low-cost salt, good supply of sea water or water for filling and flushing, high solar radiation, and land at low cost are available.

SOLAR WATER HEATER:

The solar water heater is the simplest application of solar thermal energy. Solar water heaters are classified as active and passive solar water heaters. In active solar water heaters, the water is circulated from the solar collector to the water storage by using a water pump. In passive solar water heaters, heat is transferred from the collector to the water tank located at the top of the collector by the process of natural circulation.



Components of solar water heater:

The main components of solar water heater include:

1. A collector
2. Insulated tank
3. Supporting arrangements
4. Connecting pipes

Working principle:

- First of all, the Sun rays fall on the Solar Collector, which is consisted of a black absorbing surface (absorber) that absorbs solar radiation and transfers the heat energy to water flowing through it.
- After this, heated water is collected in a tank, insulated to prevent heat loss. Then the circulation of water from the tank through the collector and back to the tank continues automatically. Most solar water heating systems use a pump to circulate the water from the tank to the collector and back. This process continues automatically as long as there is sunlight available, maximizing the efficiency of the system.

Advantages:

- Solar energy is free and abundant.
- Solar thermal panel occupies less space.
- Solar thermal panels are more efficient.
- We can save money by paying less electricity bill.
- It is an Eco-friendly way to heat water for the domestic need.

Disadvantages:

- Capital investment and installation cost in high.
- Annual maintenance is required to check the working of pump, anti-freezing etc.
- It depends on the availability of direct sun light.
- It is not useful during rainy or foggy days.

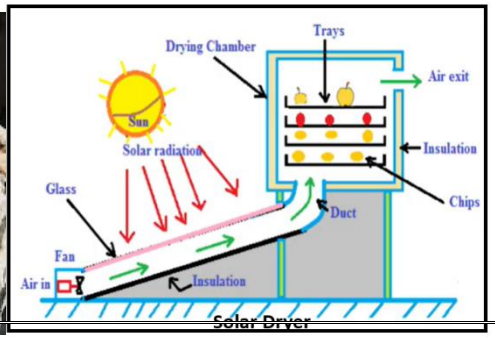
SOLAR DRYER:

Solar dryer is a device which is used to remove the moisture from crops, vegetables, chips and fruits with the help of solar radiation or energy. The Solar dryer provide more heat than the atmospheric temperature.

Components of solar dryer:

A solar dryer consists of the following components:

- Transparent glass



- Drying chamber
- Fan & duct
- Insulation
- Drying substance

Working Process:

- The principle of solar drying technique is to collect solar energy by heating up the air volume in solar collectors and transmit the hot air from the collector to an attached drying food chamber where food to be dried are kept.
- This is more hygienic technique of food drying as there is no secondary contamination of food products through rain, dust, insects, birds etc.
- The products are drying by hot air only and there is no direct impact of solar radiation (sunshine) on the products. Solar dryers are suitable for drying large quantity of food products and for small scale farmers and food producers.

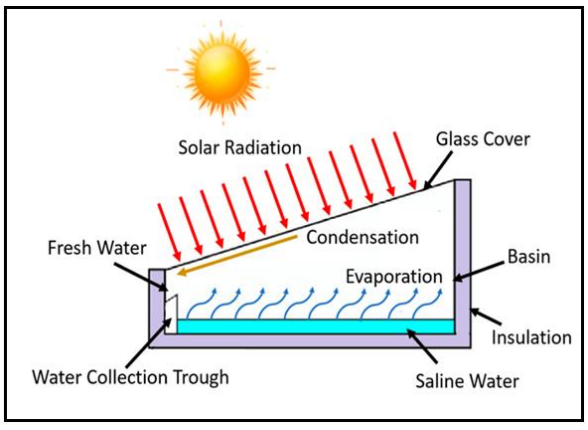
SOLAR STILLS:

- Solar still is a device which is used to convert saline (salt) water or contaminated water into distilled water by vaporization by the heat of sun and condensation. It is originally designed for army and navy.
- Solar still installation may provide about 15 to 50 litres of drinking water per day.

Components of solar stills:

Solar stills consist of

1. Water inlet pipe
2. Container
3. Transparent cover.
4. Blackened surface
5. Insulation
6. Pure water collector



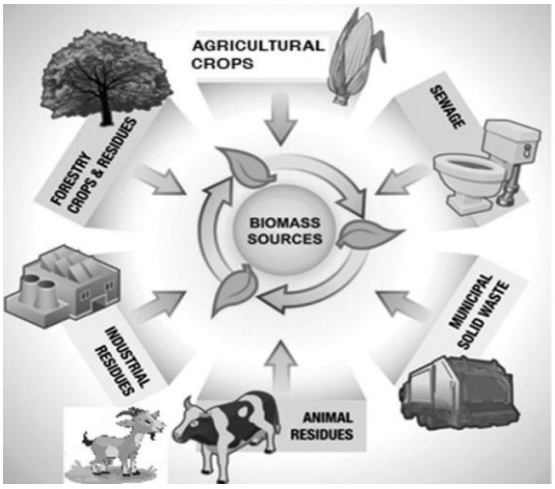
Working process:

- It works on the principle of evaporation and condensation process.
- The solar still absorbs the solar radiation. As the energy is absorbed, it starts to heat the water.
- As the temperature rises, water is converted into steam and evaporates towards the glass ceiling, leaving impurities in the basin below.
- The water slowly condenses on the glass, forming pure water droplets.
- The water droplets roll down into clean water basin which is collected and used for drinking or cooking purpose.

Advantages of solar stills:

- Low maintenance cost.
- Low energy consumption.
- Simple technique required.
- Less skilled labour required.

Biomass:



Biomass is the mass of renewable organic materials that comes from living organism, including plants, animals and microorganisms or from a biochemical perspective, cellulose, lignin, sugars, fats and proteins. It is a source of renewable energy. It has always been a major source of energy for mankind and estimated to contribute *10% to 14%* of the world's total energy supply.

The most common biomass sources used for energy are *plants, wood and organic wastes*. However, major biomass sources may include:

1. Wood and wood processing wastes.
2. Agricultural crops and waste materials.
3. Municipal solid wastes.
4. Animal manure and sewage waters.

Thermal Characteristics of Biomass as Fuel:

Biomass can be a source of liquid fuel or gaseous fuel or solid fuel. Out of these fuels, solid fuel is most commonly used. The important thermal characteristics of solid biomass fuel may include:

- Heat value
- Moisture content
- Composition
- Fuel size and density

Heat Value: Heat value of a fuel may be defined as the amount of heat available in the fuel. It is one of the most important characteristics of a fuel. The heat value of a fuel depends on its chemical composition.

The heat value of a fuel can be expressed as: *the higher heating value or the lower heating value*. The higher heating value (HHV) is the total amount of heat energy available in the fuel, which includes the energy contained in the exhaust gases, whereas lower heating value (LHV) does not include the energy

contained in the exhaust gases. The heat content of a fuel usually does not have the fixed value. Hence, the heat value of a biomass fuel should be expressed as a range rather than a fixed value.

Moisture Content: Moisture content effects the burning property of a biomass fuel. Biomass fuel with high moisture content burn less readily than a low moisture content biomass fuel, hence provide less useful heat per unit mass. Therefore, low moisture level fuels are preferred than the high moisture level fuels. Much of the energy in wet fuel is used to heat and vaporize the water. However, extremely dry fuel can cause problems such as dust that spoils equipment or can even contribute to an explosion hazard.

Composition: The composition of various biofuels affects its performance. The main compositional properties include ash content, susceptibility to slagging and fouling, and percent volatiles.

"Ash contents" are the mass fraction of incombustible materials in a biofuel. It is an important parameter, which can reduce the combustion efficiency or clog the ash handling mechanisms.

"Slagging and fouling" problems occurs when the generated ash begins to melt and start depositing inside the combustion equipment. Under certain circumstances, the ash can partially melt, forming deposits on the combustor surfaces (fouling) or hard chunks of material in the base of the combustion chamber (slagging/clinkering). High mineral content as well as dirt in the fuel generally cause fouling and slagging problem. Therefore, fuel should be kept free of soil and other contaminants. Slagging and fouling can be minimized by keeping the combustion temperature low enough to avoid the ash formation.

The "percent volatiles" in a fuel is a property that refers to the fraction of the fuel which gets volatilize and turn to gas when heated to a high temperature. Fuels with "high volatiles" will tend to vaporize before combustion. It is called as flaming combustion. This property may affect the performance of the combustion chamber and should be taken into account while designing a biomass fuel combustor.

Fuel size and density: The size and density of the biomass fuel particles are also important factors that affects its thermal characteristics. They affect the rate of heating and drying during the combustion process and thus burning characteristics of the fuel gets affected. The type of handling equipment depends mainly on the size of the fuel particles. The wrong size fuel may have an impact on the efficiency of the combustion process, and it may result in jamming or damage of the handling equipment. Smaller-sized fuel is mostly preferred for commercial systems as it is easier to use it in an automatic feed system. Normally, fuel size and density are over-looked and should be given careful consideration while selecting a fuel type.

Anaerobic Digestion:

- Anaerobic digestion is a chemical process through which organic matters such as animal manure, food wastes, wastewater biosolids etc. are broken down by microorganisms (bacteria) in the absence of oxygen.
- During anaerobic digestion process biogas and bio-fertiliser are produced.
- Biogas is mostly comprised of carbon dioxide (CO_2) and methane (CH_4) with very little amount of water vapour and other gases.

- The methane gas thus produced may be used as a fuel for cooking or heating or to generate electricity.
- Anaerobic digestion process is also used in the municipal wastewater treatment. The quantity of solids produced from wastewater treatment can be reduced through anaerobic digestion process thereby reducing its disposal cost.
- Environmental pollution due to animal manure can be avoided using anaerobic digestion process which reduces the volume of waste, produces useful methane and also provides a by-product that can be used as fertilizer.
- Plant waste from agriculture can also be processed by anaerobic digestion process to produce biogas. The residual material left after anaerobic digestion process is called "digestate." Digestate is rich in nutrients and can be used as fertilizer for crops.

Biogas Production Mechanism:

Biogas is produced by biomass using anaerobic digestion process which involves multistep biological and chemical process. It is beneficial in not only waste management but also energy creation. Biogas can be produced from a variety of raw materials, which may include:

• From industry and enterprises

• Food wastes from shops

• Biowaste generated by consumers

• Sludge from wastewater treatment plants

• Manure and biomass generated from agriculture wastes

The mechanism of biogas production from biomass involves following steps:

1. Collection of Biowastes from various sources.

2. Crushing of biowastes to make its consistency as even as possible and removal of any unwanted nonbiodegradable waste from the mixture.

3. Making of Slurry of the biomass by adding water.

4. Adding slurry to the biogas plant and pumping into the pre-digester tank where enzymes secreted by bacteria break down the biomass into an even finer consistency.

5. Sanitization of the biomass by heating the mixture at 70 ^{0}C and above for minimum one hour. During this process any harmful bacteria present in the biomass is removed.

6. Pumping the sanitized biomass into the main biomass reactor in which biogas production takes place.

7. Fermentation of biomass. In this process, microbes feed on the organic matter, such as proteins, carbohydrates and lipids, and their digestion transforms these matters into methane and carbon dioxide.

8. Breaking of the organic matter into biogas which is mainly a mixture of methane and carbon dioxide, water vapour and other gases, approximately in three weeks duration.

9. Collection of biogas in a spherical gas holder placed at the top of the biogas reactors.

After this, the biogas is ready for use by industries, enterprises and consumers. The residual solids and liquids created in biogas production are referred to as digestate. This digestate goes into a post-digester reactor and from there further into storage tanks. Digestates are well suited for uses such as fertilization or for other gardening purpose.

Utilization of Biogas:

Biogas is produced throughout the anaerobic digestion process. Biogas is a renewable energy source that can be used in a variety of ways. Biogas can be used to:

- Produce mechanical power, heat and/or electricity
- Fuel boilers and furnaces, hot water systems, air heaters.
- To run fuel vehicles; and
- Supply in homes and other business centres for their use

With appropriate cleaning or upgrade, biogas can be used in all applications that were developed for natural gas. The three basic end uses for biogas may categorised as:

Production of heat: The most straightforward use of biogas is as thermal (heat) energy. In areas where fuels are scarce, small biogas systems can provide the heat energy for basic cooking and water heating. It may also be used in gas lighting systems for illumination.

Electricity generation: In most cases, biogas is used as fuel for combustion engines, which convert it to mechanical energy which in turn provide power to an electric generator to produce electricity.

Vehicle fuel: Biogas can be used as a fuel in gasoline vehicles provided the biogas is upgraded to natural gas quality.

Digestate is the material that is left over following the anaerobic digestion process. Digestate can be made into products like, Flowerpots, Soil treatment and Fertilizers.

Storage of Biogas:

Appropriate biogas storage system is essential for the efficiency and safety of a biogas plant. There are two main reasons for storing biogas:

(i) Storage at plant location for on-site usage, as and when it is required and

(ii) Storage at distribution points or systems.

There are two broad categories of biogas storage system:

(i) Internal biogas storage tanks that are integrated with the anaerobic digester and
(ii) External Biogas storage tanks which are separated from the anaerobic digester.

Further, based on its application, it can be classified as; Low-pressure biogas storage, Medium-pressure biogas storage, and High-pressure biogas storage.

Low-pressure biogas storage: It is the simplest and least expensive storage system used for onsite applications and intermediate storage of biogas. This system operates at low pressures below 2 psi. The floating biogas storage tank on the digester form falls under this category. It can be made of steel, fiberglass or a flexible fabric material. Flexible fabric materials commonly used for these gas holders include high-density polyethylene (HDPE), low-density polyethylene (LDPE), and linear low-density polyethylene (LLDPE). Sometimes, a separate tank is also installed along with floating gas holder for the storage of digestate and raw biogas as well.

Medium-pressure biogas storage: Biogas can also be stored at medium pressure (between 2 and 200 psi) biogas storage. However, the additional requirements of safety, scrubbing and high maintenance associated with these tanks make them more costly. To prevent corrosion of the tank components and to ensure safe operation, the biogas must first be cleaned by removing H_2S. Biogas that has been upgraded to bio-methane by removing H_2S, moisture, and CO_2 are stored in these tanks. However, the cleaned biogas must be slightly compressed prior to the storage.

High-pressure biogas storage: Bio-methane is stored in this type of storage. Bio-methane is less corrosive than biogas, in addition being more valuable as a fuel. Usually, production of such fuel exceeds immediate on-site demand; hence the bio-methane must be stored for future use. It is normally stored either as compressed bio-methane (CBM) or liquefied bio-methane (LBM). It is stored in high pressure ranges between 2000 psi to 5000 psi.

Wind Energy:

Wind power technology is one of the fastest growing renewable energy technologies. Wind energy is the kinetic energy associated with the movement of atmospheric air. Wind first hits a turbine's blade, causing them to rotate and turn the turbine connected to them. The turbine shaft is connected to a generator, which produces electricity through electromagnetism principle. The amount of power that can be generated from wind depends upon the size of the turbine and its blade length.

Current status and future prospects of wind energy

Due to the various environmental issues associated with the usage of traditional source of energy, most of the users are on high pressure to start looking for alternatives and sustainable energy to minimize the carbon foot prints and its emission.

Globally the wind generation capacity is increasing very fast.

- It has increased many folds from 7.5 gigawatts (GW) in 1997 to 598 GW by 2018.
- It has been increased by 7% in 2019 to reach the value of 645 GW.
- Between 2009 to 2013 the production of electricity using wind energy has doubled.

- In 2016, wind energy accounted for 16% of the electricity generated by all other renewable energy source.
- Worldwide renewable jobs have increased considerably and reached more than 11 million people in 2018. For creating jobs, China was the highest in the list followed by EU, Brazil, Us and India.

In the recent years, the wind power installations have increased many folds. The developments and advancements in wind power generation systems are rapidly updated and thereby attracting worldwide interest. Global Wind Energy Council suggest that wind energy systems could provide 20% of the global demand for electricity by 2030. Due to the growing demand for electric vehicles as well as public transport, future demand for electricity may increase many folds.

Potential of wind energy to provide 20% of global electricity production by 2050 has been established through various research work. In this respect, the Global Wind Energy Council (GWEC) envisions 5.8 TW of wind energy by 2050. GWEC anticipated that the China would remain the world's largest market with 1789 GW of wind power by 2050. India is predicted to generate (452 GW) of wind power by 2050. Currently India has the fourth highest wind installed capacity in the world with total installed capacity of 39.25 GW (as on 31st March 2021).

Wind energy in India

India's wind energy sector is progressing consistently. It's project operation capabilities and manufacturing base has been increased to about 10,000 MW per annum.

As on March 2021, India currently has the fourth highest wind installed capacity in the world with total installed capacity of 39.25 GW. It has also generated around 60.149 billion Units during 2020-21.

The compound annual growth rate for wind generation has been 11.39% between 2010 and 2020, and for installed capacity, it has been 8.78%. India government is helping private sectors by providing various fiscal and financial incentives such as Accelerated Depreciation benefit, concessional custom duty exemption on certain components of wind electric generators.

In addition to this, Generation Based Incentive (GBI) Scheme was available for the wind projects commissioned before 31 March 2017. In addition to the facilities stated above, following steps have also been taken to promote the installation of wind power generating facilities:

1. Providing technical support including identification of potential sites and wind resource assessment with help of National Institute of Wind Energy, Chennai.

2. The inter-state transmission charges and losses have been waived out, in order to facilitate inter-state sale of wind power. However, to avail this facility, wind power project needs to be commissioned by March, 2022.

3. With an objective to provide a framework for procurement of wind power through transparent process of bidding, guidelines have been issued for Tariff Based Competitive Bidding Process for procurement of power from grid connected wind power projects.

4. Bidding process have been standardised and roles and responsibilities of various stakeholders are also clearly defined.

5. These guidelines are provided with the aim to facilitate the distribution licenses to procure wind power at competitive rates and in a cost-effective manner.

Potential of Wind Energy in India

India has a large potential for wind energy, with estimates of 590–695.5 gigawatts (GW) of onshore and offshore wind potential. The Government, through National Institute of Wind Energy (NIWE), Chennai has installed over 800 wind-monitoring stations all over country and issued wind potential maps at 50m, 80m, 100m and 120m above ground level. The recent assessment indicates a gross wind power potential of 302.25 GW in the country at 100 meter and 695.50 GW at 120 meter above ground level. The seven windy states having wind energy potential are: Gujarat, Rajasthan, Maharashtra, Tamil Nadu, Madhya Pradesh, Karnataka and Andhra Pradesh.

Environmental benefits of wind energy

The main Environmental benefits of wind energy include:

- Wind is an unlimited, freely available renewable resource. Therefore, it is a sustainable technology.
- As the wind is a natural occurrence resource, harvesting the kinetic energy of wind doesn't affect currents of wind cycles in any way.
- It is a clean, non-polluting way to generate electricity.
- It does not emit air pollutants or greenhouse gases.
- It is eco-friendly for generating electricity.
- The maintenance cost of turbines and generation of wind power is minimal.
- Wind power turbines can be placed wherever necessary as it needs very little space.

Environmental problem of wind energy

The major problem of wind energy is the initial cost involved for constructing turbines and wind facilities which is extremely expensive. Other problems may include the following:

- The giant size of wind power turbines distracts viewers from the beautiful surroundings.
- Wind turbines may be dangerous to flying birds.
- Usually, the wind turbines are located in the remote areas. Hence, the cost of travel and maintenance on the turbines increases and is time consuming.
- Offshore wind turbines require boats and can be dangerous to manage.

- ❖ Some wind turbines tend to generate a lot of noise which can be unpleasant.
- ❖ In the darkness/at night it may be difficult for incoming boats to see wind turbines thus may lead to collisions.

NEED OF NEW ENERGY SOURCES

- ➢ The energy produced from any source other than fossil fuels may be termed as new energy or alternative energy.
- ➢ At present, we are mostly dependent on the fossil fuels for the power generation, causing depletion of these finite materials. Hence, if we are not careful now, our precious, non-renewable resources may get exhausted soon.
- ➢ Also, burning fossil fuel in power plants has much adverse impact on our environment. Entire ecosystem gets destructed due to the various types of pollution created by burning of fossil fuel. Hence, there is a need of new energy sources to overcome all the above stated issues.

Different types of new energy sources

New energy sources may be renewable or non-renewable type. Renewable energy sources are derived from naturally available energy sources such as sun, wind and water. These sources are referred as renewable or sustainable. There are new energy sources which falls under non-renewable category, e.g., nuclear energy source.

There are 8 most used new energy sources:

1. ***Wind energy:*** Wind farms capture the wind flow by using turbine and converting it into electricity.
2. ***Solar energy:*** Solar energy is harnessed directly from radiant energy emitted through sunlight and converting it into heat, electricity or hot water.
3. ***Hydroelectric energy:*** This energy is generated mostly in the dams. Water flows through the turbines located in the dam site to produce electricity.
4. ***Geothermal energy:*** Geothermal power is generated by tapping underground reservoir of hot water and steam. Geothermal electricity can be directly used for the purpose of heating and cooling of buildings.
5. ***Bioenergy:*** Bioenergy is generated from organic materials known as biomass or biofuel. Biogas generated from anaerobic digestion process and used to generate electricity.
6. ***Nuclear energy:*** Nuclear energy is created in the form of heat through the fission process of atoms.
7. ***Hydrogen energy:*** Hydrogen is used as clean burning fuel as it generates fewer pollutants leading to cleaner environment.
8. ***Ocean Energy:*** Ocean energy refers to all forms of energy derived from sea. The movement of the ocean's waves, tides, and currents carries energy that can be harnessed and converted into electricity to power homes, buildings and cities. Ocean energy is environmentally friendly and renewable source of energy.

Applications of Hydrogen energy

Hydrogen has many applications, including:

- ***Transportation:*** Hydrogen fuel cells can power vehicles, including cars, buses, delivery vans, and semi-trucks. Hydrogen can also be used as a lightweight fuel for air and shipping transportation.
- ***Electricity generation:*** Hydrogen fuel cells can generate electricity by combining hydrogen and oxygen atoms. Hydrogen can also be burned for electricity generation.
- ***Industrial processes:*** Hydrogen is used in industrial processes such as:
    - Petroleum refining
    - Fertilizer production
    - Treating metals
    - Processing foods
    - Metal alloying
- ***Heating:*** Hydrogen can be used to heat homes and businesses.
- ***Backup energy:*** Green hydrogen can be used as a backup energy source for renewable energy plants.
- ***Microgrids:*** Green hydrogen can be used in microgrids to provide electricity to remote areas.
- ***Energy storage:*** Hydrogen storage is an important technology for enabling hydrogen use.

Application Ocean energy resources

Oceans cover more than 70% of earth's surface, making them the world's largest solar collectors. Just a small portion of heat trapped in the ocean can power the entire world. From the ocean mainly two types of energy can be harvested: Thermal energy and Mechanical energy.

Thermal energy: It is harvested from the temperature difference of the warm surface waters and the cool deeper water. The technological concept to harvest the thermal energy in the ocean is universally called "Ocean Thermal Energy Conversion (OTEC)" and is currently under development stage. OTEC converts the temperature difference of warm surface water and cold deeper waters into energy. Depth of cold-water zone is about 1000 m below the surface. The required water temperature difference is minimum 200C to operate the OTEC power cycle on a satisfactory way. Thermal energy resource is concentrated on certain zones. On this zone, approximately 66 developing nations including USA and Australia are located. Ocean thermal energy is used to generate electricity.

Mechanical energy: This energy consisting of both potential and kinetic energy is harvested from the tides, waves and currents of the ocean. Ocean mechanical energy is very different from the ocean thermal energy. Tides, waves and currents are intermittent source of energy whereas; ocean thermal energy is quite constant. The electricity conversion from all the three energy sources usually involves mechanical devices.

Tidal energy conversions: Tides are caused by the interaction of sun-moon-earth system. Tides rise and fall is the product of the gravitational and centrifugal forces, of primarily the moon with the earth. The difference of level between low and high tide is used to produce electricity. The use of tidal energy requires a barrage (dam) across a shallow area, where the difference in the level of low and high tide should be at least 5 meters. The tide basin is filled and gets emptied everyday with the flood tides when the water level rises and with the ebb tides when the water level falls. Low-head turbines are installed in

the barrage along with the sluice gates that allows water to flow from one side of the barrage to inside the tidal basin. The difference in elevation creates a hydrostatic head that generates electricity through electrical turbines.

Concept, origin and power plants of geothermal energy

The word geothermal comes from the Greek word Geo means earth and therme means heat. Geothermal energy is basically heat stored within the earth. People all over the world use geothermal energy primarily to heat buildings and to produce electricity.

Concept and Origin of geothermal energy

People in ancient time, including Romans, Chinese and Native Americans has used hot mineral water from natural pools and springs for bathing, cooking and heating purpose. Initially, such uses of geothermal energy were limited to the places where hot water and steam were accessible. The hottest part our planet called the core is situated about 2900 kilometres below earth's surface. Temperature of the core is more than 5000^0C. Radiating heat from core is warming rocks, water, gas and other geological materials. If underground rock formations are heated to temperature about 700^0C-1300^0C they get partly melted and become magma. Magma heats nearby rocks and underground aquifers. From this heated aquifers, hot water can be released through hot springs, steam vents and mud pots. These are the sources of geothermal energy. Their heat can be captured and used directly to heat structures such as buildings, vehicle parking space etc.

Power plants of geothermal energy

Geothermal power plants are used to generate electricity using geothermal energy. Their working principle is similar to the coal or nuclear power plant except the source of power. In geothermal powerplant, earth's heat replaces the boiler of a coal plant or reactor of a nuclear plant. Hot water or steam is extracted from the earth through a series of wells and used in the geothermal power plant. There are mainly three types of geothermal power plants and the choice of plant depends on the state (steam and water) and temperature of the available geothermal energy.

1. Dry steam power plant

2. Flash steam power plant and

3. Binary cycle power plant

Dry steam power plant: These plants use dry steam from geothermal reservoir. The steam from the production well travels directly to a turbine, which drives a generator to produce electricity. After transferring its energy to the turbine, steam gets condensed and injected back into the earth. These are the oldest type of geothermal power plants. These plants require highest temperature and can only be used where underground temperature is quite high.

Flash steam power plant: Flash steam power plants are the most commonly used geothermal power generation plant today. This is mainly due to the lack of naturally occurring high-quality steam. For this plant, water temperature must be over 180^0C. The underground hot water is pumped through the well into a tank kept at the surface level. The surface water tank is kept under much lower pressure, causing some of the fluid to rapidly vaporise, or flash. The vapour then drives the turbine which in turn drives generator and thus electricity is generated. The unused water, which could not become steam, is cycled back into the well or it can be flashed again in a second tank to extract some more energy.

Binary cycle power plant: Binary cycle power plant differs from other two types of geothermal plant. In this, the water or steam from geothermal reservoir never comes in contact with the turbine or generator unit. Here, a secondary loop (hence the name binary) containing a fluid with a low boiling point, such as pentane or butane is used. The water from the well flows through a heat exchanger, which transfers its heat to the fluid having low boiling point. Water vaporizes from these fluids due to its low boiling point. It is then passed through a turbine, drives it and subsequently, the generator to produce electricity. It is expected that these plants will be most commonly used in future simply because it can make use of water with low temperature than other two types of power plants.

UNIT - 5: SOLID WASTE MANAGEMENT, ISO 14000 & ENVIRONMENTAL MANAGEMENT

SOLID WASTE GENERATION

In our daily life, we generate lots of used solid materials and throw them away. Solid waste is a complex mixture of diverse materials. The composition of waste varies from season to season, region to region. It cannot be transported through water into the streams nor can be readily escape into the atmosphere. Solid wastes are generated from various sources/activities of the society, such as waste from households, public institutions, offices, markets, restaurants, industry, construction sites, agricultural activities etc.

Sources and Characteristics of Municipal Solid Wastes

Municipal solid waste is defined as waste collected and treated by or for municipalities. It comprises both liquid and solid wastes.

Sources of Municipal Solid Wastes

Main sources of municipal solid wastes may be classified into the following categories:

1. *Residential sources:* Wastes from household and residential areas. These are the major sources of municipal solid wastes.
2. *Institutional sources:* Wastes from government and public institutions such as schools, colleges universities, government offices etc.
3. *Commercial establishments:* Wastes from business centres such as food and drink establishments, shops, banks etc.
4. *Health facilities:* Wastes from hospitals and other health facilities.
5. *Construction and demolition activities:* Wastes from various types of construction and demolition activities such as construction of apartments, demolition of slums etc.
6. *Industrial sources:* Wastes from various types of industrial processes.
7. *Agricultural sources:* Wastes from agricultural activities.
8. *Open areas:* Wastes from roadside dustbins, street sweeping and other public places.
9. *e-wastes*: Waste from electronic devices like computers, phones, radio etc. and household appliances such as cookers, washing machines etc.

Characteristics of Municipal Solid Wastes

Identification of characteristics of municipal solid waste is important for its proper management. The characteristic of solid waste includes physical and chemical parameters.

Physical characteristics

They are important for the selection and operation of equipment and also for the analysis and design of disposal facilities. It may include the following parameters:

Density: Density of waste is its mass per unit volume (Kg/m3). It is required for the design of landfills, storage, and type of collection and transport vehicles.

Moisture content: It is the ratio of the weight of water to the total weight of waste. Cost of collection, transport and economic feasibility of waste treatment by incineration depends upon the moisture content of the waste.

Size of waste constituents: Size of raised constituents are required for the design of mechanical separators, shredder and waste treatment processes.

Calorific value: It is the amount of heat generated from combustion of unit weight of a substance, expressed in kcal/kg.

Permeability: The permeability of compacted wastes is an important physical property because it governs the movement of liquids and gases in a landfill.

Compressibility: It is the degree of physical changes in the solid waste when subjected to pressure.

Chemical characteristics

The chemical characteristics of Municipal solid waste may include PH value, Nitrogen, Phosphorus, and potassium, total carbon etc. and bio-chemical characteristics may include carbohydrates, proteins, natural fibre etc. Heavy metals, pesticides, insecticides etc. may fall under toxicity characteristics.

Biodegradable and Non-biodegradable Solid Wastes

Biodegradable wastes: These are the waste materials which can be easily degraded by natural factors like microorganisms (e.g., bacteria, fungi etc.), abiotic components (e.g., sunlight, water, oxygen etc.). They transform them into simple organic matters which can be used as fertilizers, manure, compost, biogas and more. Therefore, this makes them eco-friendly. Biodegradable wastes, found in municipal solid wastes include green waste, food waste, paper waste, biodegradable plastics etc. Some of the wastes includes human waste, slaughterhouse waste etc.

Non-biodegradable wastes: These are the wastes which cannot be decomposed or degraded by natural agents. Therefore, they remain in the ecosystem for long duration without decompose and harm our environment. They are not at all ecofriendly. Most of the inorganic waste such as plastic cups, bottles, e-wastes etc. come under non-biodegradable category. Some of these wastes which can be recycled and can be used again are known as “Recyclable waste and those which cannot be used again are known as “non-recyclable waste”.

Sources and Characteristics of e-wastes

Sources of e-waste:

Various source of e-waste may be categorized into following categories:

Home Appliances: It may include, Microwaves, Home Entertainment Devices, Electric cookers, Heaters, Fans etc.

Electronic Utilities: Heating Pads, Remote Controls, Television Remotes, Electrical Cords, Lamps, Night Lights, Treadmills, Smart Watches, Heart Monitors, etc. may be included in this category.

Communications and Information Technology Devices: Cell phones, Smartphones, Desktop Computers, Computer Monitors, Laptops, etc. may fall under this category.

Office Equipment: This category may include, Copiers/Printers, IT Server Racks, IT Servers, Cords and Cables, Phone & PBX systems, Audio & Video Equipment, Network Hardware, Power Strips & Power Supplies, Uninterrupted Power Supplies (UPS Systems), Power Distribution Systems (PDU's), etc.

Medical Equipment: This category may include, Dialysis Machines, Imaging Equipment, Video Equipment, Power Supplies, Uninterrupted Power Supplies (UPS Systems), etc.

Home Entertainment Devices: It may include, DVDs, Stereos, Televisions, Video Game Systems, etc.

Characteristics of e-Waste

e-waste contains both hazardous and non-hazardous substances in their components.

Hazardous substances: The hazardous substances that are mostly found are plastic, lead, mercury, cadmium, arsenic, CFCs, PVC etc. These substances have a great potential to harm or pollute the environment and human health (carcinogenic diseases, liver, kidney, brain damages etc.).

Non-Hazardous substances: These are the substances which can be used again without harming the environment. The different metals when they are recycled back, have a great advantage in the manufacturing processes of different industries. For example, the aluminium, copper and gold that is often found in electronic goods is considered to be non-hazardous. Plastic and glass are the material found in computer parts are also not hazardous.

Sources of Bio-medical waste

The sources of biomedical wastes are the place or location, where these wastes are generated. The sources may be classified into two broad categories: Major and Minor sources.

Major sources generate more amount of the wastes compared to the minor sources and on regular basis. These sources include Hospitals, Emergency care facilities, dialysis centres, transfusion centres, blood banks, clinical laboratories, research laboratories, mortuaries, veterinarians and nursing homes.

Minor sources include medical clinics, cosmetic clinics, home care and paramedics.

Characteristics of Bio-medical waste

Biomedical waste is characterized on the basis of its source of generation and level of hazard to the environment. It can be classified into two categories: non-hazardous wastes and hazardous wastes.

Non-hazardous Bio-medical wastes are type of waste which does not pose any direct threat to the people and environment as they are non-toxic by nature. But still, it should not be thrown be in open areas or sewer line because of the risk it may pose threat to the environment. The non-hazardous wastes may include wash water, paper cartoons, packaging materials, food remnants etc. These wastes are generated mainly from various organizations, maintenance of hospital and health care centres.

Hazardous Bio-medical wastes are the waste which pose direct threat to the people and environment because of their toxic and infectious characteristics. The various hazardous wastes may include:

1. Infectious wastes: Infectious waste containing pathogens (bacteria, viruses, parasites, fungi etc.) in large quantity may pose threat to the humans. Infectious wastes include human/animal tissue, feces and urine from the infected patients, blood-soaked bandages, surgical gloves, cultures, swabs used to inoculate cultures, isolation wards waste, equipment that have been in contact with the infected patient etc.
2. Pathological wastes: Human tissues or fluids e.g., body parts, blood and other body fluids, foetuses etc.
3. Pharmaceutical wastes: It contains pharmaceuticals of expiry date, contaminated pharmaceutical bottles, boxes etc.
4. Radioactive wastes: The treatment where radioactive isotopes are used generate radioactive waste like nuclear medicine treatments, cancer therapies and medical equipment. Radioactive waste has the potential to harm the human health.

METALLIC WASTES

Several kinds of heavy metals such as alloy steel, aluminium, copper, zinc, lead etc. are used in industrial process every day in very large quantity. Rapid industrialization has raised the demand for these metals, at the same time, the reserve of high-grade ores is also depleting. Metallic wastes are generated during various industrial processes. Heavy metals like Au, Ag, Ni, Cu, Zn, Cr etc. are found in these metallic wastes. These valuable metals can be recovered from these waste materials by recycling process such as ***calcination, roasting, smelting, refining etc***. and reused. Microorganisms such as Penicillium, Aspergillus acid, thiobacillus trioxane, Leptospiral ferroxidase and Sulphurous acid are also used for recovering the metals. Metals can be recycled repeatedly without degrading their properties. Steel is the most recycled material on the planet. The other highly recycled metals include aluminium, copper, silver, brass and gold. Because of its recycling property, scrape/waste metal has value, which motivates people to collect it for the sale and recycling processes. Recycling of metals also has environmental impact. It helps in preserving natural resources. It also has social impact as it helps in creating jobs in the society. Recycling process includes collection of scrap metals, sorting from the mixed scrap metal stream, processing, melting in a large furnace, purification, solidifying and transportation.

NON-METALLIC WASTES

A large portion of non-metallic wastes consists of wastepaper, wood, lubricants, plastics, glass, rubber textiles, printed circuit boards etc. Due to growing consumer demand, the quantity of generation of these wastes is increasing day by day. Recycling process of these waste materials is complex and expansive resulting in increased volume of dumps and landfills.

a. Lubricant

It is a substance used to reduce the friction between various parts of the machinery. A lubricant can be in liquid, gaseous or even semisolid forms. Used oils such as engine lubrication oil, hydraulic fluids, and gear oils which are used in cars, bikes, or lawn mowers can pollute the environment, if they are not recycled or disposed-off properly. Used oil can be re-refined into lubricants, processed into fuel oils, and can be used as raw materials for the refining and petrochemical industries.

b. *Plastics*

In our day-to-day life we use many plastic objects like carry bags, containers, bottles, etc. which are normally thrown to the environment after they are being used.

Most of the plastics are non-biodegradable. Plastic pollution on land endangers plants and livestock, as well as humans who live off the land. Also, plastic pollution is seen in oceans which has adverse effects on aquatic lives. Animals can be poisoned by plastic pollution, that can have a negative impact on human food supplies.

c. *Rubber*

Rubber is a polymer material and is one of the essential materials in many applications due to its unique properties such as high elasticity, very durable and high resistance to the environmental agents. It is widely used in automobile sectors, healthcare, household etc. However, this unique property of rubber making it very difficult to degrade easily.

Increase of rubber waste has become major threat for the environment globally. Land fill dumping and open burning are among the common methods of disposing waste rubber which leads to water, air and soil pollution. Waste and discarded rubber should be utilized in various applications such as erosion control, back water and floatation device, cement concrete, bitumen products etc.

COLLECTION AND DISPOSAL

Municipal Solid Wastes (MSW) consists of everyday items, we use and throw them away. This mainly comes from our home, schools, colleges, offices, business centers, hospitals etc. These wastes can be categorized into two categories: (i) bio-degradable waste of waste such as food and kitchen waste, flowers, leaves, fruits, paper etc. (ii) non-biodegradable wastes such as construction and demolition wastes, plastic, glasses, e-wastes etc. Due to rapid urbanization, India is facing big challenges in municipal solid waste management. Solid waste management involves three basic functional elements, collection, processing and disposal of the solid wastes.

Collection of Municipal Solid Waste (MSW)

Solid waste collection is the first functional element of solid waste management. It refers to collection of solid wastes from the places such as residential, institutional, commercial, public parks and industrial area as well. Following basic collection system of solid wastes collection may be adopted based on the availability of services:

Door-to-door collection: This is the most commonly used system of solid waste collection. It is carried out on regular basis as per the pre-informed timings and scheduling.

Collection from roadside: In this system, waste generators place their waste containers or bags on the roadside on a pre-decided day/or days for collection.

Block collection system: In this system, waste generators are responsible for bringing their waste to collection vehicle.

Communal system: In this system, the collection points/container is located in a public place and the waste generators need to keep their waste into the designated place/container. Based on the mode of operation, methods of collection of solid waste from collection points, may be of two types; (i) Hauled-container system and (ii) Stationary-container system.

***Hauled-container system**:* In this system an empty storage container also called as drop-off box is hauled to the storage site to replace the container full of waste, which is then hauled to the processing point, transfer station or disposal site.

***Stationary-container system**:* In this system the containers used for the storage of waste, remain at the point of collection. The collection vehicle stops alongside the storage containers, and collection crews load the waste from the storage containers into the collection vehicles and then transport the wastes to the processing point, transfer station or disposal site.

Disposal of Municipal Solid Waste (MSW)

Disposal is the third functional element of solid waste management after collection and processing. In past, dumps and disposal at river and sea were the common practice. Now a days, due to inherent environmental problem, it is not allowed. However, waste dumping in open area and burning continue to one of the most popular methods in India. Most of the cities and town dispose of their wastes in low-lying areas in the outskirts of the city which leads to various environmental and human health issues. The wastes dumped on the roadside, sometimes overflowing from drains or floating on the surface of the river is very common phenomenon in India. At present, sanitary landfill method is used more frequently for the disposal of municipal solid waste.

3R, Principles

The 3R principle refers to reducing waste, reusing and recycling resources and products. All 3Rs help us to reduce the amount of waste we generate. It is one of the principles of solid waste management. Basically, the 3R concept is a sequence of steps on how to manage waste properly. The first of 3Rs, reducing is the best way to go about managing solid waste. It is quite simple, the less we use the less waste we will produce. Some of ways mentioned below may help in reducing the waste generation:

• Buying products with less packaging to minimize the waste generated from product packaging.

• Avoiding disposable goods such as paper plates, cups, napkins, etc.

• Buying durable goods to avoid frequent disposal.

• Use electronic mail for communication wherever possible.

The second of 3Rs, is reuse. It makes economic and environmental sense to reuse products. If you reuse something as opposed to throwing it keeps away the waste from landfills. Sometimes it involves creativity also. Some of the ways are mentioned below:

- Reuse products in different ways. For example, use a coffee can to pack tiffin; use plastic microwave dinner trays as picnic dishes.
- Sell old clothes, appliances, toys and furniture or donate them to charities.
- Use ceramic coffee mug instead of paper cups.
- Use grocery bags or bring your own bags to the store.

The final and probably the best-known R of 3Rs stands for recycling. It involves manufacturing of new products from the old and used materials, using necessary recycling process. Begin recycling at home and at work:

- Buy products from recycled materials.
- Purchase recycled materials for office supply, equipment etc.
- Use recycled paper for letterhead, copier paper, newsletter etc.

Energy Recovery

Energy recovery from waste means conversion of waste into various forms of energy such as heat, electricity, fuel etc. It can be done through variety of processes, such as combustion, gasification, anaerobic digestion etc. Municipal solid waste (MSW) contains both organic as well as inorganic substances. The latent energy present in its organic fraction can be recovered for suitable utilization by adopting suitable waste processing and treatment methodologies.

The option of energy recovery from wastes may be kept open and should be incorporated in the over-all scheme of waste management along with the 3Rs concept. Energy can be recovered from the organic fraction of waste (biodegradable as well as non-biodegradable) basically through two methods as mentioned below:

(i) ***Thermo-chemical conversion***: In this process, organic matters are decomposed using thermal de-composition to produce either heat energy or fuel oil/gas. This process is useful for the wastes containing high percentage of organic non-biodegradable matter and low moisture content. The main technological options under this category include Incineration and *Pyrolysis/ Gasification*.

(ii) ***Bio-chemical conversion***: In this process, organic matters are decomposed by microbial action to produce methane gas. This process is preferred for wastes having high percentage of organic bio-degradable matter with high level of moisture/ water content, which helps microbial activity. The main technological option under this category is *Anaerobic Digestion.*

Parameters affecting Energy Recovery: The parameters which affect the recovery of Energy from Wastes (including MSW), includes: Quantity of waste, and its Physical and chemical characteristics (quality). The actual production of energy also depends upon the specific treatment process employed, in addition to the above two parameters.

Sanitary landfill

Sanitary landfill is a method of waste disposal used more frequently now a days. It is an engineering burial of wastes. It consists of spreading waste on the ground, compacting it, and covering it with the soil. There are generally two methods of sanitary land filling: Area method and Trench method.

The area method is used, when excavation is not possible, especially when the ground water level is high.

Trench method is used when it is possible to excavate. This method has the benefit of having the cover material right at the site from the earth excavated from the trench. Sanitary landfill sites are kept isolated from the environment until it become safe. It is considered to be safe for the environment when it is completely degraded biologically, chemically and physically. The gas produced from the byproducts of sanitary landfill can be used as fuel for combustion or they can be processed into another fuel.

Hazardous waste

The wastes containing toxic substances are known as Hazardous waste. These are generally generated from industry, hospital and residence. These wastes may be in the form of solids, liquids or gases. These wastes can have very harmful effects on the human health and environment, when left inappropriately treated or managed. Improper hazardous waste storage or disposal frequently contaminates ground water and surface water. It can also be source of dangerous land pollution. Many pesticides, herbicides, paints, industrial solvents, fluorescent light bulbs and mercury-containing batteries are classified as hazardous wastes, so are the medical waste products such as cultures, human tissue, contaminated gloves, sharps, PPE kit etc.

Because of the harmful nature hazardous waste cannot be disposed of by common means. Depending on the physical and chemical state of the waste, treatment and solidification processes might be required. Hazardous waste needs to be treated scientifically. Hazardous waste may contain either of the properties like ignitability, reactivity, corrosivity and toxicity.

Disposal of Hazardous waste

The disposal of hazardous wastes in a proper manner is very much essential for both citizens and business owner as well. In general, these wastes were regularly disposed of into landfills. Our natural water systems used to get contaminated due to continuous seeping of chemicals from the dumped wastes which in turn were very much harmful for humans as well as for animals and aquatic organisms. Hence, it became very much essential that the hazardous wastes are properly disposed so that these harmful effects can be reduced as much as possible. Some of the methods discussed below can be adopted for the safe disposal of hazardous wastes:

Incineration: By burning the waste materials in high temperature can destroy the toxic wastes. Although the method of incineration releases toxic gases which may affect our environment, but now a days more effective incinerators are developed that limit the quantity of emissions released in the atmosphere. Flammable wastes can also be burned and used as energy sources.

Recycling: It is one of the best methods to reduce quantity of hazardous wastes. We must try to reuse the used materials instead of just throwing them away, although it may need some creativity. Most flammable materials can be recycled into industrial fuel. Some materials with hazardous constituents can be recycled, such as lead acid batteries etc.

Sharing or Donating: If we have anything extra and find it unusable, may be shared or donated to someone who need it. By sharing or donating, we will be able to reduce hazardous wastes generation.

AIR QUALITY ACT 2004

Air Quality Act, 2004 was notified in Government Gazette of Republic of South Africa on 24 February 2005.

The National Environmental Management: Air Quality Act 39 of 2004 is a law in South Africa that aims to:

- Protect the environment by preventing pollution and ecological degradation
- Promote sustainable development while also supporting economic and social development
- Establish national standards for air quality monitoring, management, and control
- Identify substances that threaten health and the environment
- Regulate emissions from various sources, including motor vehicles, open fires, and incinerators

Air pollution control act 1981

The Act was enacted in 1981 and amended in 1987 to provide for the prevention, control and reduction of air pollution in India. The Act was passed under Article 253 of the Constitution of India with the aim to prevent, control and mitigate air pollution.

Objectives:

1. To establish central and State Boards to monitor air quality and control pollution.
2. Prevention, control and abatement of air pollution.
3. To confer on the Boards the powers, to implement the provisions of the Act and assign the Boards functions relating to pollution.

The Act also defines some relevant terms such as air pollution, air pollutant, automobile, industrial plant etc.

The heavily polluted areas are being termed as “Air Pollution Control Area” and where no industrial plant can be operated in without prior consent or permission of the State Pollution Control Board (SPCB). The Central and State Boards are given the task of controlling and preventing air pollution. The

State Boards have the powers to charge a polluter in a court of law to prevent him from polluting the air.

The Boards have the powers to authorize any person to enter and inspect the premises of the polluter and to collect samples for analysis of the pollutants, like emissions from Chimneys, flues, ducts or any other outlets.

The Water (Prevention and Control of Pollution) act 1974

The Water (Prevention and Control of Pollution) Act was enacted in 1974 to provide for the prevention and control of water pollution, and for the maintaining or restoring of hygienic water in the country. The Act was amended in 1988.

Water Act is enacted with the aim of prevention and control of Water Pollution in India.

Objectives

- To provide for the prevention, control and reduction of water pollution.
- The Act sets out the establishment of Central and State Boards.
- The Act defines terms such as pollution, sewage, commercial pollution, distribution etc.
- The Act also provides the functions of the Central and State Boards.
- Water Boards have the power to obtain information, take pollution samples from any industry / area in use and conduct research in any area and measure and maintain a record of flow or volume and other aspects of any stream or source.

STRUCTURE AND ROLE OF CENTRAL POLLUTION CONTROL BOARD

Organisational structure of Central Pollution Control Board

The Central Pollution Control Board (CPCB), a statutory organisation, was constituted in September, 1974 under the Water (Prevention and Control of Pollution) Act, 1974.

The Central Board consists of the following members:

1. A chairman having knowledge or practical experience in matters related to environmental protection to be nominated by the central government.
2. One member-secretary having knowledge and experience of engineering and management aspects of pollution control to be nominated by the central government.
3. Not more than five persons from amongst the members of state boards, not more than three non-officials to represent interest of agriculture fishery, agriculture-trade etc. are nominated by state government.

Functions of the Central Board at the National Level

1. It advises the Central Government on any matter about prevention and control of water and air pollution and improvement of the quality of air.

2. Plan a nation-wide programme for the prevention, control or abatement of water and air pollution.
3. Co-ordinate the activities of the State Board and resolve disputes among them.
4. Provide technical assistance and guidance to the State Boards, carry out and sponsor investigation and research relating to problems of water and air pollution, and for their prevention, control or abatement.
5. Plan and organise training of persons engaged in programme on the prevention, control or abatement of water and air pollution.
6. Organise a comprehensive mass awareness programme on the prevention, control or abatement of water and air pollution.
7. Collect, compile and publish technical and statistical data relating to water and air pollution and the measures devised for their effective prevention, control or abatement.
8. Prepare manuals, codes and guidelines relating to treatment and disposal of sewage and trade effluents as well as for stack gas cleaning devices, stacks and ducts.
9. Disseminate information in respect of matters relating to water and air pollution and their prevention and control.
10. Lay down, modify or annul, in consultation with the State Governments concerned, the standards for stream or well, and lay down standards for the quality of air.
11. Perform such other function as may be prescribed by the Government of India.

STRUCTURE AND ROLE OF STATE POLLUTION CONTROL BOARD

Every State has its own Pollution Control Board (PCB). It is established to implement Environmental laws and rules within the concerned state's jurisdiction. The main function of every PCB is to create awareness among the people regarding the sustainable development and to join hands for a pollution free environment in the State with the help of all stakeholders. The State Pollution Control Board works under the supervision of CPCB (Central Pollution Control Board). The CPCB has provided all its function and powers to the SPCB.

Functions of the State pollution control Board:

The primary motive of SPCB is to assist the industries and entrepreneurs to discharge their responsibilities to safeguard the environment. The major functions of the State Pollution Control Board are:

• Assessment of ambient air quality.

• Assessment of water quality.

• Issuance of NOC (No-Objection Certificate) keeping environmental pollution under consideration.

• Issuance of Consent under provisions of section 21 of the Air Pollution Act 1981. (no one can establish or operate an industrial plant in an air pollution control area without the prior consent of the State Pollution Control Board)

• Issue of consent under provisions of section 25/26 of the Water Pollution Act 1974. (the establishment or use of new or existing outlets for discharging sewage or trade effluent)

• Collection and assessment of Water Cess, under provision of Water Cess Act 1977.

• Assessment and identification of municipal and industrial pollution sources and control.

• Arrange mass awareness programmes.

• Development of pollution control technologies.

• Notification of emission and effluent standards.

• Instituting legal action against defaulters.

• Implementing Bio-medical Waste Rules, 1998.

• Issuance of Authorization under the Hazardous Waste management Rule, 1989.

Concept of Carbon footprint

A carbon footprint is a measure of the amount of greenhouse gases released into the atmosphere by a person, organization, event, or product. It's calculated by adding up all the emissions from every stage of a product or service's life, including production, use, and end-of-life.

- Carbon footprints include emissions from all gases that contribute to global warming, such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases.
- Carbon footprints are usually expressed in units of carbon dioxide equivalents, which accounts for the different amounts of heat each gas traps.
- We can reduce our carbon footprint by making small changes to our actions, such as eating less meat, taking fewer connecting flights, and line drying our clothes. We can also use public transportation, bicycles, or electric scooters.

Concept of Carbon credit

A carbon credit is a permit that allows the owner to emit a certain amount of carbon dioxide or other greenhouse gases. Carbon credits are generated by projects that reduce, avoid, or remove greenhouse gas emissions.

- Carbon credits are generated by projects that remove carbon from the atmosphere, such as reforestation, or reduce the amount of carbon released into the atmosphere, such as renewable energy projects.
- One carbon credit represents the reduction or removal of one metric ton of carbon dioxide or its equivalent.
- Carbon credits can be bought, sold, transferred, and exchanged in carbon markets.
- Organizations that are regulated under a cap-and-trade system can use carbon credits to meet their cap. If an organization produces fewer tons of carbon emissions than it is allocated, it can sell or hold the remaining carbon credits.

- Projects that generate carbon credits are independently audited to verify the amount of carbon emissions they have avoided or reduced.
- It can also have other positive benefits, such as empowering communities, protecting ecosystems, and restoring forests.

ENVIRONMENTAL MANAGEMENT IN THE FABRICATION INDUSTRY

An environmental management system (EMS) is a structured system designed to help manufacturing industries including fabrication industry to manage their environmental impacts and improve environmental performance caused by their products. Fabrication industry requires to adopt strategies and activities that help in reducing the environmental impact. ISO14001:2015 sets out the criteria for an environmental management system which helps an organization to set up their effective environmental management system.

ISO14001:2015 specifies the requirements for an EMS that an organization or industry can use to improve its environmental performance and manage its environmental responsibilities in a systematic manner that contributes to the environmental sustainability. It also helps an organization/industry to achieve the expected outcomes of its EMS, which provide value for the environment.

ISO 14000

ISO 14000 is a set of rules and standards created to help industries to reduce industrial waste and environmental damage. It also helps industries to achieve environmentally friendly business goals and objectives. The ISO 14000 was introduced in 1996 by the International Organisation of Standards.

The ISO 14000 certification can be used as a marketing tool for engaging environmentally conscious consumers and may help industries to adopt mandatory environmental regulations. If a manufacturing unit agrees with ISO 14000 regulations, it means that it is dedicated to the principles of sustainable development and environmental conservation, and needs to follow some set of principles, like:

1. Environmental management as one of the highest priorities.

2. Follow legislative requirements for environmental protection during the course of a manufacturing process.

3. Ensure environmental planning at every step of the manufacturing process.

4. Provide resource material and training, pertaining to conservation, to all those engaged in the manufacturing process.

5. Demand commitment from everyone in the organization towards the environmental protection and clearly assign responsibility and accountability.

6. Establish management discipline for achieving targeted performance.

7. Review the environmental management system being followed at frequent intervals and identify the opportunities for improvement.

The ISO 14000 helps industries to protect the components of environment such as water, air, flora, fauna etc. The ISO 14000 provisions help to take benefits from the natural resources and conserve the environment for the future civilization.