NILASAILA INSTITUTE OF SCIENCE AND TECHNOLOGY,SERGARH,BALASORE

LECTURES NOTE ON:-ENVIRONMENTAL SCIENCE

SEMESTER: 1st

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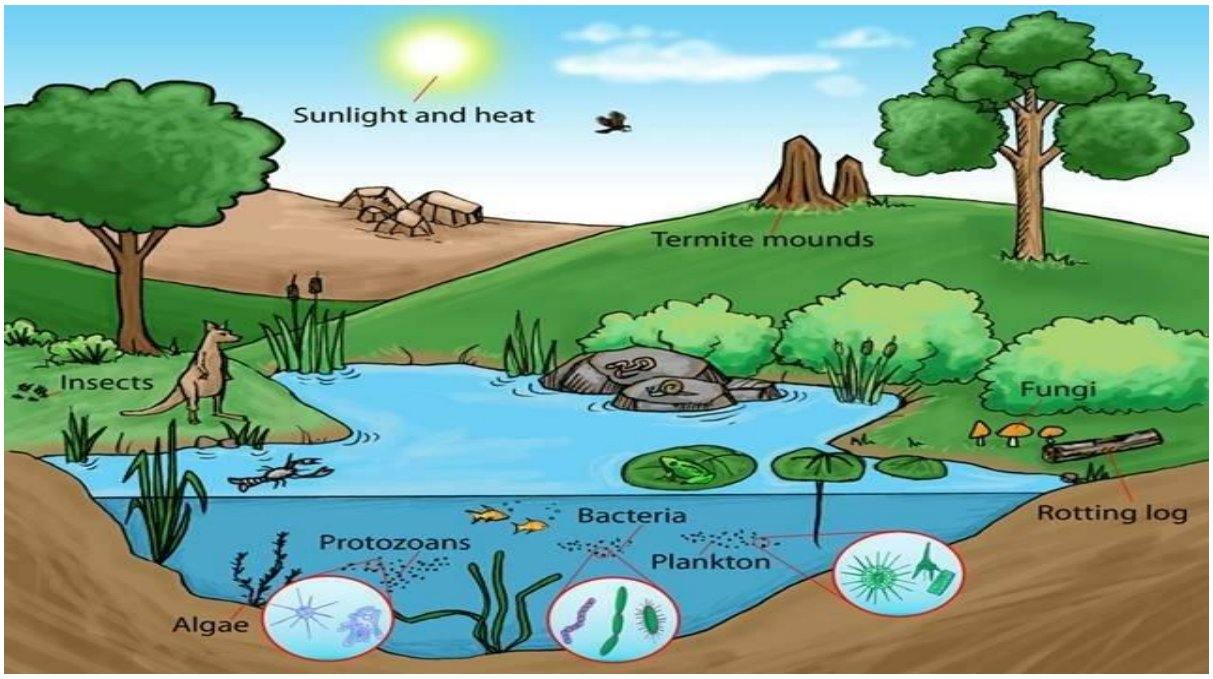
CONTENT

CHAPTER-1

ECOSYSTEM

INTRODUCTION

The term “ecosystem” was first introduced by A.G.Tensley in 1935. He was an English Botanist and one of the pioneers in the field of ecology. Prof A.G.Tensley was educated at University College, and Trinity College, Cambridge, and taught at these universities including Oxford, where he served as a Professor of Botany until his retirement in 1937. Ecology is the study of organism, its surrounding environment, interaction of organism with each other and its surrounding environment. The environment refers to the things and conditions around the organism which directly or indirectly influence the life and development of the organism and their populations. Organism and environment are two non-separable factors in the ecology ecosystem.



AQUATIC AND TERRESTRIAL ECOSYSTEM

An ecosystem can be very small in size like an oasis in a desert, or very big like an ocean, spanning thousands of kilometers. There are two types of ecosystems:

- Natural ecosystem
- Artificial ecosystem

Natural ecosystem

These ecosystems exist and operate in the nature by themselves without any human support and interference. It is a naturally produced biological environment found in nature. Few examples of natural ecosystems are: an ocean, a lake, a pond, a desert, a forest etc. Natural ecosystem can be of two types:

- Aquatic ecosystem
- Terrestrial ecosystem

Aquatic ecosystem

Water supports many lives. Organisms which survive in water are called aquatic organisms. These organisms are dependent on water for their food, shelter, reproduction and all other life activities. An aquatic ecosystem includes a group of interacting organisms which are dependent on one another and their water environment for nutrients and shelter. Examples of aquatic ecosystem include oceans, lakes and rivers. It can be further divided into two types:

- Freshwater ecosystem
- Marine ecosystem

Freshwater ecosystem:

Freshwater ecosystem includes lakes, ponds, rivers and streams, wetlands, swamp, bog and temporary pools. They cover only a small portion of earth, nearly 0.8 per cent. These ecosystem provide habitat for 41% of the world`s fish species. Freshwater ecosystems are classified into two categories namely, lentic and lotic ecosystems. Lotic ecosystems represent flowing water bodies such as rivers, streams etc.

Lentic Ecosystem

Lentic ecosystem refers to all standing water bodies. Lakes and ponds are the main examples of Lentic Ecosystem. The word lentic (from latin word lentus meaning slow or motionless) mainly refers to stationary or relatively still water. These ecosystems are home for algae, crabs, shrimps, amphibians such as frogs and salamanders, for both rooted and floating leaved plants and reptiles including alligators and other water snakes.

Lotic Ecosystem

They mainly refer to the rapidly flowing water bodies which moves in a unidirectional way such as rivers and streams. The word lotic (from latin word lotus meaning washing) mainly refers to flowing water. These ecosystems harbour numerous species of insects such as beetles, mayflies, stoneflies and several species of fishes including trout, Eels, minnow, etc. Apart from these aquatic species, these ecosystems also include various mammals such as beavers, river dolphins and otters.

Marine ecosystem:

Marine ecosystems can be defined as the interaction of plants, animals, and the marine environment. The term “marine ecosystem” encompasses the salty waters of the earth, and is also known simply as a salt water ecosystem. It includes seas and oceans. Marine ecosystems have more

salt content and greater biodiversity in comparison to the freshwater ecosystems. It covers the largest surface area of the earth. Two third of earth is covered by water and they include oceans, zone, reefs, seabed, hydrothermal vents and rock pools. As the marine ecosystem is more seas, intertidal concentrated with salts it makes difficult for freshwater organisms to live in. Similarly, marine animals cannot survive in fresh water. Their body is adapted to live in saltwater; if they are placed in less salty water, their body may swell. Marine ecosystem can be classified mainly into following two categories:

- Ocean ecosystem
- Coastal ecosystem

Ocean ecosystem

Our planet, earth is gifted with the five major oceans, namely Pacific, Indian, Arctic, Antarctic and the Atlantic Ocean. Among all these five oceans, the Pacific and the Atlantic are the largest and deepest ocean. These oceans serve as a home to many aquatic species. Few creatures of these ecosystems include shellfish, shark, tube worms, crab, small and large ocean fishes, turtles, crustaceans, blue whale, reptiles, marine mammals, seabirds, plankton, corals and other ocean plants.

Coastal ecosystem

Coastal ecosystem comprises of open systems of land and water which are joined together to form the coastal ecosystems. The coastal ecosystems have a different kind of structure, and diversity. A wide variety of species of aquatic plants and algae are found at the bottom of the coastal ecosystem. The fauna is also found in coastal region and it mainly consists of crabs, fish, insects, lobsters, snails, shrimps, etc.

Terrestrial ecosystem

Terrestrial ecosystems are exclusively land-based ecosystems. It comprises a community of organism and their environment that occurs on the land masses of earth surface. Terrestrial ecosystem occupies about 28% of the earth surface. Terrestrial ecosystem is different from aquatic ecosystem with lower water availability .

- Forest Ecosystem
- Grassland Ecosystem
- Tundra Ecosystem
- Desert Ecosystem

Forest Ecosystem

A forest ecosystem consists of various types of microorganisms, plants and animals and all these components live in coordination with each other. Forests help in maintaining the temperature of the earth and plays a major role in carbon sink. They are of great importance in maintaining the ecological balances.

Grassland Ecosystem

The grassland ecosystem is dominated by grasses and herbs. It occupies about 19% of the earth surfaceand usually occurs in the interior parts of the continent. Temperate grasslands and savanna grasslands are some of the examples of grassland ecosystems.

Tundra Ecosystem

Tundra is known for large stretches of bare ground and rock. Tundra ecosystems are devoid of trees and it is also known for patchy mantles of low vegetation such as mosses, lichens, herbs and small shrubs. These ecosystems are found in cold climates or where rainfall is in scarce. These are covered with snow for most of the year. The Arctic or mountain tops are the examples of tundra type ecosystem.

Desert Ecosystem

Deserts are found throughout the world. It covers about 14 percent of the earth surface. These ecosystems are usually covered with cloudless sky and therefore, the sun radiation heats up the desert quickly, resulting in the highest air temperature on the earth. Sky In contrast, nights are very cold as the temperature goes down fast due to loss of heat into the atmosphere through radiation. These are the regions with very little rainfall and thus produces sparse perennial vegetation of widely spaced shrubs.

Artificial ecosystems

Ecosystems that are made and maintained by man is called artificial ecosystem. These ecosystems are made and modified for commercial or other benefits. These can either be aquatic or terrestrial type. Few examples may include park, dam, garden etc. The zoos, aquariums and botanical gardens are examples of artificial ecosystems which are maintained with the aim of conserving biodiversity. In this ecosystem, the plants and animals are placed in well-protected areas similar to their natural habitats and requirements.

STRUCTURE OF ECOSYSTEM

The structure of an ecosystem describes the organisms and physical features of the environment including the amount and distribution of nutrients in a particular habitat. It also provides information regarding the range of climatic conditions prevailing in the area. The various components of an ecosystem may be grouped into two main types:

- Biotic (living) components
- Abiotic (non-living) components

Biotic (living) components

The term “biotic” is a combination of two terms, “bio” which means life and “ic” meaning like. Therefore the term means life-like and is related to all the living entities present in an ecosystem. Or in other words, the living organisms present in an ecosystem form the biotic component. Based on their mode of obtaining food, the organisms occurring in an ecosystem are classified into three categories:

- Producers (autotrophs)
- Consumers (heterotrophs)
- Decomposers (saprotrophs)

Producers (autotrophs)

These include all green plants, blue green algae, some bacteria and free-floating autotrophic microorganisms called phytoplankton. All these organisms possess photosynthetic pigments (e.g. chlorophyll) and can generate their own energy requirement (food) through photosynthesis in presence of sunlight and chlorophyll. As green plants, blue green algae etc. prepare their food for themselves with the help of sunlight, they are known as photo autotrophs or simply autotrophs (i.e. auto = self, trophos = feeder).

Consumers (heterotrophs)

These are mainly the animals. They are unable to synthesize food for themselves. Therefore, they are dependent on the consumers for their food & utilise materials and energy stored by them. They are also known as heterotrophs (i.e. hetros = others, trophos = feeder). The consumers are of four types:

- **Primary or first order consumers or herbivores**: These are the animals which feed on plants or producers. Cattle, deer, goat, rabbit, rats, grasshoppers etc. are the common herbivores in terrestrial ecosystem and snails, mosquito, tadpoles etc. are the common herbivores in the aquatic ecosystem.
- **Secondary or second order consumers or primary carnivores**: The animals which feed on the herbivores are called the primary carnivores or secondary consumers. Examples: cats, foxes, snakes etc. are secondary consumers in the terrestrial ecosystem and water bugs, water beetles, frogs, small fish etc. are secondary consumers in the aquatic ecosystem.

- **Tertiary or third order consumers**: These are the large carnivores which feed on the secondary consumers. Common examples include large fish, water birds etc. in aquatic ecosystems, and wolves, snake etc. in terrestrial ecosystems.

- **Quaternary Consumers or Fourth Order Consumers or Omnivores**: These are the largest carnivores which feed on the tertiary consumers and are not eaten up by any other animal. Lions, tigers, eagle etc. are the examples in land ecosystems and shark, crocodiles etc. are the examples in aquatic ecosystems

Decomposers or reducers (saprotrophs)

Bacteria and fungi belong to this category. They breakdown the dead organic materials of producers (plants) and consumers (animals) for their food. During metabolism process, they release simple inorganic and organic substances as by-products to the environment. These simple substances are reused by the producers resulting in a cyclic exchange of materials between the biotic organism and the abiotic environment of the ecosystem. The decomposers are known as Saprotrophs (i.e., sapros = rotten, trophos = feeder).

Abiotic (non-living) components

The non-living factors or the physical environment prevailing in an ecosystem form the abiotic components. They have a strong influence on the structure, distribution, behaviour and inter-relationship of organisms. Abiotic components include:

- Inorganic substances
- Organic compounds
- Climatic factors

Inorganic substances

Inorganic substances such as carbon, nitrogen, oxygen, calcium, phosphorus etc. and their compounds (water, carbon dioxide etc.) constitute the main abiotic component. These occur either in the form of compounds dissolved in water, in the soil or in the air.

Organic substances

These include carbohydrates, proteins, lipids etc. These are present in living organism and dead organic matter. The dead organic matter is broken down by the action of decomposers (e.g. bacteria, fungi) into inorganic substances for their recycling.

Climatic factors

These include light, temperature, humidity, wind, rainfall. Water etc. and also edaphic factors such as soil, substrate, topography, minerals etc.

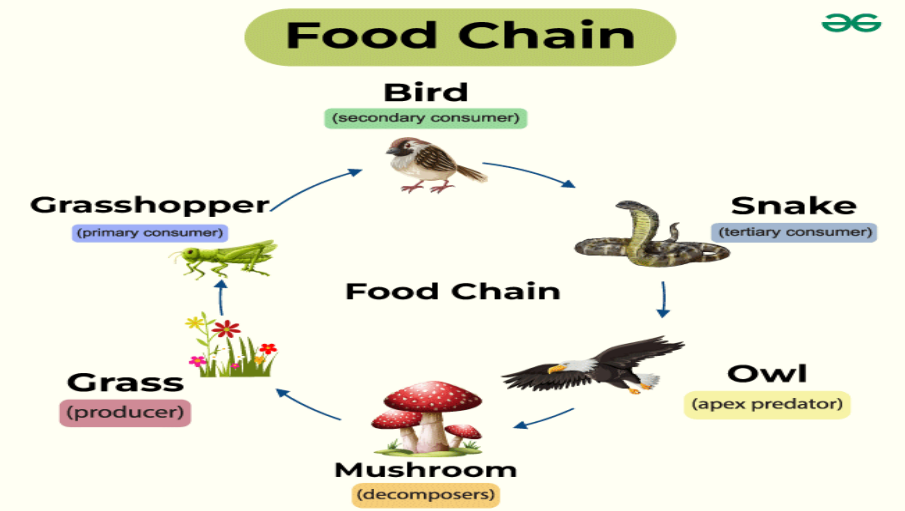
FOOD CHAIN AND FOOD WEB

For survival in eco-system and to get energy one must eat. Food chain and food web show who eats whom & describe the transfer of energy within an ecosystem, from one organism to another. Infect, food chain and food web are the schematic representation of feeding relationship among the various organisms.

Food Chain

The food we eat provide us energy to carry out our day-to-day activity. It is applicable for all other living organism. In ecosystem, all living organisms are interconnected with each other in a systematic chain with respect to their mode of manufacturing food and with their feeding habits. The interactions among various components of the ecosystem involves flow of energy from one component to other component. Food chains regulate and maintain the population size of different animals, thereby maintaining the ecological balance on earth. Let's take an example of a grassland ecosystem, wherein all green plants (e.g. herbs, shrubs, trees etc.) are producers or autotrophs and they are eaten up by primary consumers i.e. herbivores (e.g. cattle, deer, goat, rabbit, rats, grasshoppers etc.). The herbivores are subsequently eaten up by secondary consumers i.e. primary carnivores (e.g. cats, foxes, snakes etc.). The primary carnivores are eaten up by tertiary consumers i.e. larger carnivores (e.g. Wolves, large fish etc.). Finally, the tertiary consumers are eaten up by quaternary consumers i.e. omnivores. Therefore, it can be seen that beginning with the producers, onward to herbivores, carnivores and next level carnivores, all organism are inter-linked in a definite sequential chain and involve in transfer of energy from the producers onward to the last link in the chain. Therefore, the food chain may be defined as the sequential inter-linking of organisms

involving transfer of food energy from the producers, through a series of organism to the last link in the chain i.e.; referred to Omnivores.



Length of Food Chain: The distinct sequential steps in the food chain is the transfer of energy occurs at different trophic levels. For example, green plants (producers), form the first trophic level – the producer level; the plant eaters (herbivores), also called primary consumers, belong to second trophic level– the primary consumer level; and the flesh eaters (carnivores), also called secondary consumer, represents the third trophic level – the secondary consumer level and so on. In ecosystem, different food chains may have two, three or four or maximum five trophic levels. A food chain may end at the

(i) Herbivore (primary consumer) level,
(ii) Primary carnivore (secondary consumer) level,
(iii) Secondary carnivore (tertiary consumer) level
(iv) Tertiary carnivore (quaternary) level

Characteristics of Food Chain

1. A food chain involves transfer of food energy between the living organisms (biotic components) of an ecosystem. In a food chain, repeated eating occurs i.e. each group eats the other group and subsequently eaten by some other group of the organism.

2. In a food chain, flow of energy is unidirectional from sun to producers and subsequently to series of different types of consumers.

3. Usually, there are 3 to 4 trophic levels in a food chain. In few cases there may be maximum of 5 trophic levels.

4. Omnivores organisms may occupy different trophic positions in different food chain different types of consumers.

Food Web

Food web is a network of food chains which are interconnected at various trophic levels so as to form a number of feeding junctions amongst different organisms of a biotic community. In nature, food chain do not operate in isolation as because in natural environment, each organism is generally eaten by two or more kinds of organism which, intern are eaten by several other organism. Thus, instead of straight line food chain, the relationship among organisms forms an interlinking pattern called a food web. For example, plant may be eaten up by caterpillar, rat, goat etc. Grasshopper may be eaten away by frog, rat may be eaten away by cat, dear may be eaten away by tiger. A food web, thus, provides alternative pathways of food availability. If a particular species of producer is destroyed by a disease or any other reason in the ecosystem, the herbivores of that area can feed on other species of producers. Similarly, if some herbivore species is eliminated from the ecosystem, secondary consumers may feed on other species of available herbivores. Availability of the alternatives in a food web make the ecosystem more stable. Hence, the alternative food energy available in the nature form a sort of interlocking pattern called food web. In food webs, any given species may operate simultaneously at more than one tropic levels.

Characteristics of Food Web

1. Each food web is formed by interlinking of food chains and it is never straight, like food chain.

2. A food web provides alternative links of food availability.

3. Availability of more alternatives in the food web, make the ecosystem more stable.

4. Food webs help in development of ecosystem

CARBON, NITROGEN, SULPHUR, PHOSPHORUS CYCLE

Energy in the form of sunlight enters into our eco-system, flows through it and leaving in the form of heat in the atmosphere. However, there are six most common element in the form of Carbon, Nitrogen, Sulphur, Phosphorus, Hydrogen and Oxygen which get recycled by taking variety of chemical forms. All these elements are very much important for the survival of living organisms in the eco-system. By recycling processes, they remain stored for long or short duration in the atmosphere, on land, in water or beneath the earth's surface as well as in the bodies of living organism.

Carbon cycle

Carbon is an essential element for all life forms on earth. Whether these life forms, take carbon to help produce food or release carbon as part of respiration, the intake and output of carbon is a component of all plant and animal life. Carbon is economically important to human life, in the form of fossil fuels. Carbon is in a constant state of movement from one place to another through different processes such as photosynthesis, burning fossil fuels and simply releasing breath from lungs. The movement of carbon through these processes is known as carbon cycle. Following are the major steps involved in the carbon cycle process:

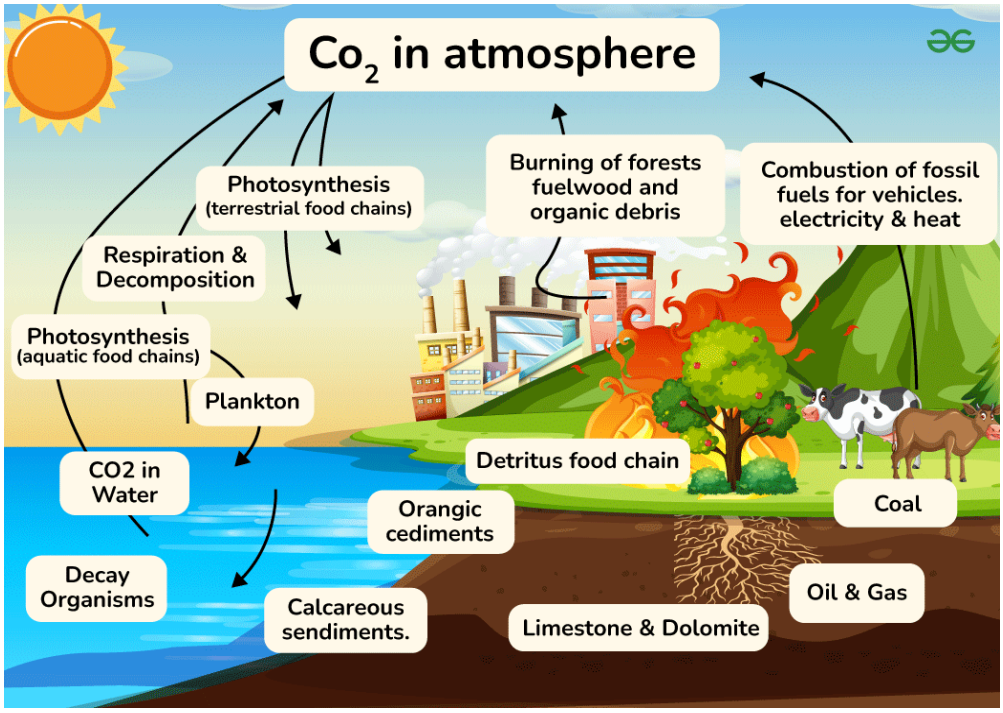
- Carbon present in the atmosphere is used by plants to build leaves and stems.
- These plants are then digested by animals and carbon gets accumulated into their bodies.

• These animals and plants eventually die, and upon decomposing, carbon is released back into the atmosphere and stored in the form of gasses such as carbon dioxide.

• Some of the carbon that is not released back into the atmosphere eventually become fossil fuel.

• These fossil fuels are then used for man-made activities, resulting in more carbon emission to the atmosphere in the form of carbon dioxide

The carbon cycle is vital to life on Earth. Nature tends to keep carbon levels balanced, it means that the amount of carbon produced naturally is equal to the amount of carbon absorbed naturally. Maintaining this carbon balance allows the planet to remain hospitable for life. Scientists believe that humans have upset this balance by burning fossil fuels, which has added more carbon to the atmosphere than usual and led to climate change and global warming.



Nitrogen Cycle

Nitrogen, or N (scientific abbreviation), is a colourless, odourless element. Nitrogen is present all around us. It is in the soil under our feet, in the water we drink, and in the air we breathe. Nitrogen is important to all living things, including us. It plays a key role in plant growth. Nitrogen is an essential component of DNA, RNA and proteins, the building blocks of life. All organisms require nitrogen to live and grow. Forms of Nitrogen: (a) Organic forms: Ammonium (NH_4), Nitrite (NO_2), Nitrate (NO_3), Nitrous oxide (N_2O) and Nitric oxide (NO). (b) Inorganic form: Nitrogen gas (N_2). The nitrogen cycle includes movement of nitrogen through both living and non-living things. It moves through the atmosphere, soil, water, plants, animals and bacteria. In order to move through the different parts of the cycle, nitrogen need to change its forms. In the atmosphere, nitrogen exists as a gas (N_2), but in the soils it exists as nitrogen oxide (NO) and nitrogen dioxide (NO_2). It is used as a

fertilizer in other forms, such as ammonia (NH_3) and ammonium nitrate (NH_4NO_3). There are five stages in the nitrogen cycle which include:

- Nitrogen fixation
- Nitrogen assimilation
- Ammonification
- Nitrification
- Denitrification.

Stage 1: Nitrogen Fixation

Nitrogen is the most abundant element in Earth's atmosphere and approximately 78% of the atmosphere is nitrogen. But plants and other living organisms are not able to use nitrogen in its gaseous form. For nitrogen to be available in the usable form for plant and other living organisms, it must be converted into different chemical forms. The process of converting nitrogen into biologically available nitrogen (organic matter) is called nitrogen fixation. A small amount of nitrogen can be fixed when lightning provides the energy needed for nitrogen to react with oxygen, producing nitrogen oxide (NO) and nitrogen dioxide (NO_2). These forms of nitrogen then enter soils through rain or snow. Nitrogen can also be fixed through the industrial process that manufactures fertilizer. This form of fixing occurs under high heat and pressure, during which atmospheric nitrogen and hydrogen are combined to form ammonia (NH_3), which may then be processed further, to produce ammonium nitrate (NH_4NO_3), a form of nitrogen that can be added to soils and used by plants. Most nitrogen fixation occurs naturally, in the soil, by bacteria.

Stage 2: Ammonification

It is the process of releasing ammonia by certain microorganisms utilising organic compounds derived from the dead organic remains of plants and animals and excrete of animals. The microorganisms specially involved are actinomycetes and bacilli.

Stage 3: Nitrification

In nitrification process the ammonia is converted into compounds called nitrites (NO_2) and nitrates (NO_3). These nitrates are used by plants and also animals that consume the plants. Although nitrite is not usable by plants and animals directly, other bacteria can change nitrites into nitrates, a form that is usable by plants and animals. Nitrification requires the presence of oxygen, so nitrification can happen only in oxygen rich environment like circulation of flowing water and the surface layers of soil and sediments.

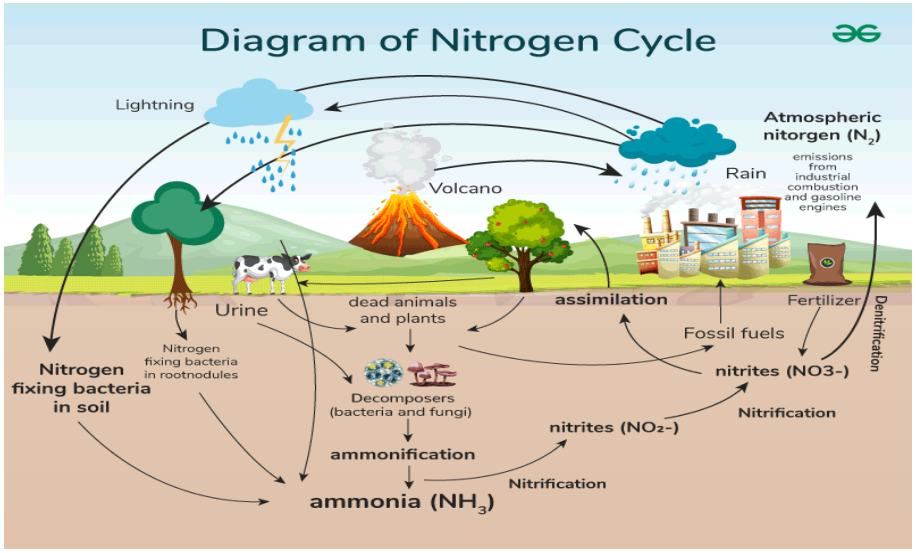
The process of nitrification is important to plants, as it produces an extra stash of available nitrogen that can be absorbed by the plants through their root systems.

Stage 4: Nitrogen Assimilation

In this process inorganic nitrogen in the form of nitrates, nitrites and ammonia is absorbed by the green plants via their roots and then it is converted into nitrogenous organic compounds.

Nitrates are first converted into ammonia which combines with organic acids to form amino acids. Amino acids are used in the synthesis of proteins, enzymes, chlorophylls, nucleic acids etc.

Stage 5: Denitrification : In the fifth stage of the nitrogen cycle, nitrogen returns to the air as nitrates and are converted to atmospheric nitrogen (N2) by bacteria through the process called denitrification. This results in an overall loss of nitrogen from soils, as the gaseous form of nitrogen moves into the atmosphere, back where we began our story.



Sulphur cycle

Sulphur is associated with the foods having high rich protein such as dairy products, eggs, fish, meat and sea food. Sulphur helps to make cell rigid and strong that are found in the hair, nails and skin. Sulphur in plants help to form important enzymes and assist in the formation of plant proteins. Fertilizers, pesticides and manure are the primary source of sulphur for plant. Sulphur cycle describes the movement of sulphur through ocean, land and atmosphere. The sulphur cycle is explained below:

• In atmosphere sulphur is found in the form of sulphur dioxide (SO2) and enters in three ways, from (i) decomposition of organic molecules, (ii) volcanic and geothermal vents and (iii) burning of fossil fuels by humans

. • Sulphur is deposited on land in four major ways namely, precipitation, direct fallout from the atmosphere, rock weathering and geothermal vents.

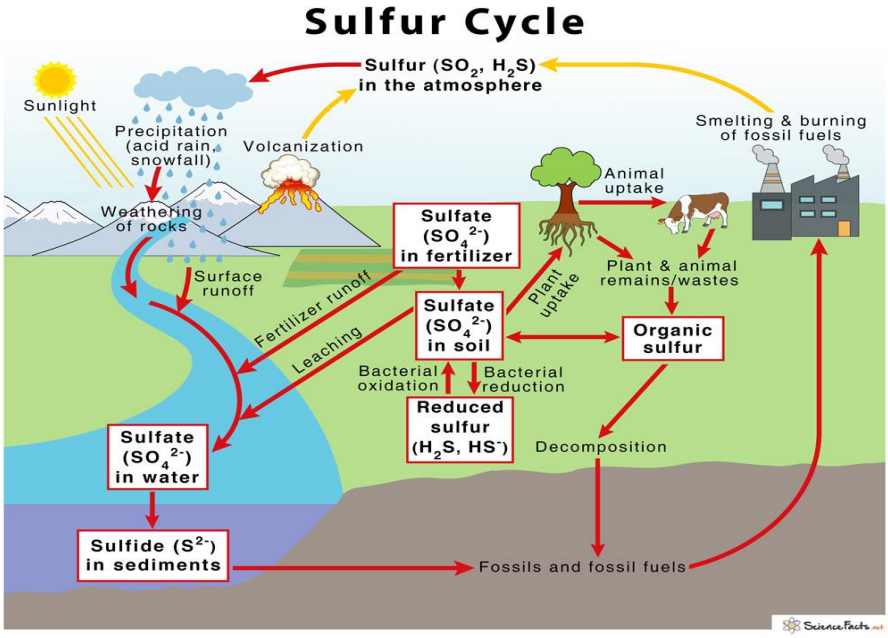
• Sulphur enters the ocean via runoff from land, from atmospheric fallout and from under water geothermal vents.

• In atmosphere, sulphur comes in contact with the air and is converted into sulphates.

• These sulphates are consumed by plants and microbes and are converted into organic forms.

• Converted organic forms of sulphur is then consumed by animals and thus sulphur moves in the food chain.

• When animals die, some of the sulphur is released to the atmosphere by their decomposition, thus a sulphur cycle gets completed. Remaining sulphur enters into the tissues of microbes.



Phosphorus Cycle

Phosphorus is an essential nutrient for all living organisms like animals and plants. It plays a critical role in cell development and is a key component of molecules that store energy, such as ATP, DNA and lipids (fates and oil). Insufficient phosphorus in the soil may result in the poor crop yield. Since phosphorus and phosphorus containing compounds are present only on land, atmosphere plays no significant role in the phosphorus cycle. Phosphorus cycle is a very slow process which involves three key steps as mentioned below:

• Weathering
• Absorption by plant and animal
• Return to the environment via decomposition Weathering Since the main source of phosphorus is found in rocks, the first step of phosphorus cycle involves extraction of phosphorus as phosphate salts from the rocks by weathering. These salts are washed away into the ground and get mixed in the soil. Absorption by plants and animals Plants, fungi and microorganisms are able to absorb phosphate salts, dissolved in water and grow. Phosphorus can also be washed into the water systems and plant can also directly absorb phosphorus from the water and grow. In addition to plants, animals also get phosphorus from drinking water and eating plants. However, the amount of phosphorus present in the soil is very less and therefore, farmers apply phosphate fertilizer on agricultural land.

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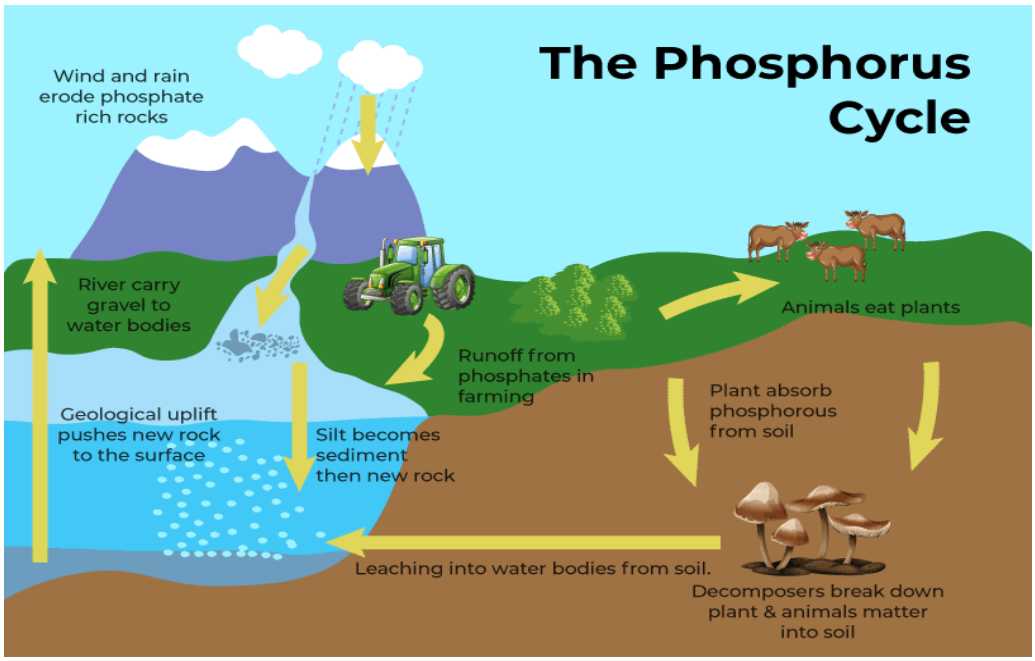


Global warming

Our earth is surrounded by atmosphere which comprises of clouds, dust particles, gases (carbon dioxide, methane, nitrous oxide etc.) and water vapours. These elements, present in the atmosphere, filter and scatter large quantity of solar radiation falling on the earth. Only about 48% of the solar radiation reaches the surface of the earth and only 1% of it is absorbed by the plants. The solar radiation falling on earth surface is reflected back as infra-red radiations into the atmosphere. Part of the infra-red radiations pass through the atmosphere. Most of the remaining infra-red radiations are absorbed by the gasses present in the atmosphere and re-emitted in all directions. These re-emitted infra-red radiations, keep the earth surface warm and the mean annual temperature at150C. Had these re-emitted infra-red radiations not been there, the average temperature on the earth would have been (-)200C, almost same as that of the moon which lacks atmosphere. Warming of earth surface and troposphere caused by the presence of water vapour, carbon dioxide (CO2), methane (CH4), chlorofluorocarbons (CFCs) and nitrous oxide (N2O) in the atmosphere is called Greenhouse Effect. These gases are called greenhouse gasses. Global warming is a term used for the rise in the average temperature of the earth's climatic system and its related effects. Global warming is caused by increasing concentration of greenhouse gasses and other

human caused emissions. Increasing or decreasing amount of greenhouse gasses within the atmosphere act to either hold in or release more of the heat from the sun.

The global annual temperature has increased in total by a little more than 1 degree Celsius, between 1880 to 1980. For the last 40 years, we have seen the global annual temperature rise by 0.18 degree Celsius per decade. Now the climate scientist have concluded that we must limit global warming to 1.5 degree Celsius by 2040 to avoid most devastating effects: the extreme droughts, wildfires, floods, tropical storm and other disasters that we refer to collectively as climate change.

Ozone depletion

Ozone is a tri-atomic molecule made up of three atoms of oxygen, O3. Very little quantity of ozone is present in the lower part of atmosphere, called troposphere. However, good amount of ozone is present in the upper part of atmosphere, called stratosphere which is about 18-50 km above the equator. Its maximum concentration is at 23-25 km above equator. This rich zone of ozone in the stratosphere is called ozone layer or ozonosphere. The ozone layer act as a shield for life on earth and it is commonly called ozone shield as this region intercepts high energy ultraviolet (UV) radiations and allows low energy UV radiations to reach the earth's surface. The thinning of ozone layer is commonly called ozone depletion. Air pollutants and chlorofluorocarbons (CFCs) are mainly responsible for depletion of ozone layer in stratosphere. In addition to this, methane (CH4) and oxides of nitrogen (NOx) also contribute in thinning of ozone layer. Chlorofluorocarbons (CFCs) are synthetic, harmful chemicals, widely used in fire extinguishers, in air conditioners as coolants; in aerosol sprayers and as propellants. Once released in the air, these harmful chemicals produce 'active chlorine' (CI and CIO radicals) in the presence of UV radiations. These radicals through chain reactions, then destroy the ozone by converting it into oxygen. Due to this, the ozone layer in the upper atmosphere (i.e. stratosphere) becomes thinner. You will be surprised to know that a single 'active chlorine' converts one lakh molecules of ozone into oxygen. Amount of atmospheric ozone is measured by Dobson spectrometer and is expressed in Dobson units (DU).

Ozone Depleting Substances (ODS)

These are the substances which react with the ozone layer in the stratosphere and destroy it. The main ODS are Chlorofluorocarbons, methane, nitrous oxide, carbon tetrachloride and chlorine. Out of these, Chlorofluorocarbons are the principal ODS.

Effect of Ozone Depletion

The thinning of ozone layer allows more UV radiations to pass through and strike the earth. These causes harmful effects on man, animals and plants such as skin cancer, herpes, dimming of eye sight, cataract in eyes, lowering the immune system, increased embryos in the mother's uterus, global warming etc.

CHAPTER-2

Air and Noise Pollution

INTRODUCTION

" We still have too much air and water pollution and we still need to work to reduce it. But we also need to put the problem of pollution into a historical as well as scientific perspective".

Ronald Reagan, Ex-president of United States of America the air is composed of 78% nitrogen, 21% oxygen, and 0.9% argon. The remaining elements include carbon dioxide, water vapour, hydrogen, and other trace elements. The atmosphere is a delicate balance of elements and particles. Air pollution occurs when there is an alteration to the composition of air. The main sources of air pollution are transportation, factory emissions, biomass consumption, agriculture production etc. The air pollution is caused due to excessive concentration of suspended particulate matter (SPM), carbon dioxide, nitrogen oxide in the atmosphere emitted from the sources that burns fuel. Air pollution including noise pollution is a significant risk factor for human health conditions, causing allergies, respiratory and cardiovascular disease as well as lung damage. It is also a major contributor to global warming and climate change.

DEFINITION OF POLLUTION AND POLLUTANT

The word pollution come from Latin word "polluere" that means contamination. Hence in layman terms, the pollution is something that contaminates the environment. It may be defined as the presence of harmful substances in the air, water and soil which can have adverse effect on living beings and on the environment. Due to pollution, undesirable changes occur in the physical, chemical or biological characteristics of air, water and soil that may be harmful for any living organism.

Types of Pollution: There are mainly five types of pollution:

- Air Pollution
- Land pollution
- Radioactive pollution Air Pollution
- Water pollution
- Noise pollution

Air pollution

Air pollution may be defined as the undesirable presence of one or more contaminants such as dust, fumes, gas, mist, odour, smoke, or vapour which are detrimental to human health in particular and the planet as a whole. Air pollution in many cases prevents photosynthesis process in plants which has serious consequences on the purification of air we breathe. It is a major contributor to global warming and climate change. Air pollution is indeed a significant risk factor for human health conditions, causing allergies, respiratory and cardiovascular diseases.

Water Pollution

Water pollution can be defined as the contamination of a stream, river, lake, ocean or any other water body, degrading water quality and rendering it toxic for the environment and human. The main causes of water pollution include sewage and waste water, urbanisation and deforestation, agriculture, industries, marine dumping and radioactive waste. Water pollution harms biodiversity and ecosystem. It has very negative impacts on human health. Many diseases such as diarrhea, cholera, typhoid, dysentery and skin infection result from drinking or being in contact with contaminated water.

Land Pollution

Land pollution refers to any physical or chemical changes in soil condition that may adversely affect the human health, plants and animals. Most soil pollutants are agricultural chemical, fertilisers and pesticides. Dumping of waste which may include municipal wastes, untreated sewage, industrial effluents etc. also pollutes the soil when harmful substances from dump leak into it.

Noise Pollution

Noise pollution can be defined as any unwanted or disturbing sound that effects the health and well being of humans and other organism. Sound is measured in decibels. Sound that reaches 85 decibels or more is considered harmful for human ear. Noise pollution has its impact on millions of people on daily basis. The most common health problem in human is hearing loss. Exposure to loud noise may also cause high blood pressure, heart disease, sleep disturbances and stress. The main sources of noise pollution include traffic noise, air traffic noise, construction noise, catering and night life, animals etc.

Radioactive Pollution

Radioactive pollution is defined as increase in the natural radiation level in the environment caused mainly by human activities. The sources of radiation pollution involve any process that emanates radiation in the environment. Causes of radiation pollution include research and medical procedures and waste, nuclear power plants, TVs, computers, radio waves, cell phones, etc. However, the most common ones that can pose moderate to serious health risks are: Nuclear explosions and detonations of nuclear weapons, Defensive weapon production, Nuclear waste handling and disposal, Mining and Nuclear accidents.

Pollutants

Pollutants are the harmful substances which brings undesirable and harmful changes in the physical, chemical or biological characteristics of air, water and soil. Smoke from industries and automobiles, domestic and commercial sewage, radioactive substances from nuclear plants and discarded household articles (tins, bottles, broken crockery etc.) comes under the category of pollutants.

Types of Pollutants: Pollutants can be categorised into following categories:

Water Pollutants: The runoff from industries, agriculture fields and even from urban areas contribute largely to the water pollution. In addition, raw sewage is a major pollutant of water.

Soil Pollutants: The main source of soil pollutant include municipal and industrial wastes, overdose of pesticides and herbicides etc.

Air Pollutants: The major source of air pollutant is burning fossil fuels and it happens due to factory emission and automobiles. Also acid rain has adverse effect on forests and their inhabitants.

Noise Pollutants: Major noise pollutant include horns of automobiles, loudspeakers, fire crackers, electrical appliances, traffic noise etc.

Radioactive Pollutants: Radioactive pollutant include radiation released in nuclear power plant accidents, use of nuclear weapons, mining, spillage of radioactive chemicals, cosmic and other natural sources like gamma rays, radiation used for the treatment of diseases like cancer etc.

Natural and manmade sources of air pollution

Air pollution may be caused by various processes and it may be natural or manmade (anthropogenic). Natural sources of air pollution It is caused due to continuous and temporary natural events and it cannot be prevented.

Natural sources of air pollution are described below

Volcano Activities: Volcanic eruptions emit a series of toxic gases including sulphur and chlorine. It also emits particulate matter in the form of ash particles. Volcanic eruptions are restricted to localised area.

Winds and Air Current: It can mobilise soil and other pollutants and spread it over the large areas.

Wild Fires: It emit carbon monoxide and particulate matter into the atmosphere. It may affect significant areas although they can be restricted and contained to small area.

Microbial Decaying Process: Microorganisms present in the environment have a major role in natural decaying processes of living organisms. This activity results in the natural release of gases especially methane gas and causes air pollution.

Increasing Temperature: It contribute to an increase in the amounts of contaminants volatilizing from polluted soil and water into the air.

Manmade sources of air pollution

It is caused due to human activities and it has huge impact on environment and also on all of us. Manmade sources of air pollution are described below:

Mining and Smelting: Crushing & processing of mineralogical deposits emits a variety of metals into the atmosphere and creates pollution.

Foundry Activities: It emits a variety of metals into atmosphere due to processing of metallic raw materials (including the use of furnaces).

Various Industrial Processes: These may emit both organic and inorganic contaminants through accidental spills and leaks of stored chemicals or mis-handling and storage of chemicals–especially inorganic chemicals of volatile nature.

Transportation: Vehicles emits a series of air pollutants in the form of gases such as carbon monoxide, sulphur oxides, nitrogen oxides and particulate matter.

Construction and Demolition Activities:

These activities pollute the air with various construction materials, specially demolition of old buildings which may contain a series of banned chemicals such as PCBs, PBDEs, Asbestos etc.

Coal Power Plants: Burning of coal in coal power plant may emit a series of gases as well as particulate matter with metals (such as As, Pb, Hg) and organic compounds (especially PAHs).

Waste Incineration: In this process, various toxic gases, and particulate matter is emitted into the atmosphere, depending on the composition of waste.

Landfill Disposal Practices: Due to the natural microbial decaying activity in the disposal area methane gas is generated and pollute the environment.

Agriculture: Agricultural activity pollute the air through emissions of ammonia gas and the application of pesticides/herbicides/insecticides which contain toxic volatile organic compounds.

Defence Activities: These activities may pollute the air by emitting toxic gases through practices and training.

Smoking: Smoking emits a series of toxic chemicals including a series of organic and inorganic chemicals, some of which may be carcinogenic also.

Storage and Use of Household Products: House hold products such as paint, sprays, varnish, etc. that contains organic solvents which volatilize in the air and we feel smell while using them.

Refrigerants: It is used in various electronic equipment such as refrigerator, air-conditioner etc. These are mainly responsible for creating greenhouse effect in the atmosphere, that warms the planet.

I.C. Boilers: These are combustion devices used to heat water or to produce steam. I.C. Boilers creates air pollution by emitting hazardous air pollutants in the atmosphere.

Air Pollutants

"Air pollution is the excessive concentration of foreign matter in the air which adversely affects the well-being of the individual or cause damage to property". - American Medical Association 30 Environmental Science the foreign matter which causes air pollution are called air pollutants. Air pollutants include gasses, liquid droplets and solid particles.

They are classified according to the source of emission into two main groups:

(i) Primary Pollutants and

(ii) Secondary Pollutants.

Primary Pollutant

The primary pollutants are emitted from a source directly into the atmosphere. The source can either be a natural processes such as sand storms, volcanic eruption or anthropogenic (by humans) such as industial and vehicle emissions. The major primary pollutants are oxides of Sulphur, Nitrogen, Carbon, Particulate matter, Methane, Ammonia, Chlorofluorocarbons, Toxic metals etc.

Secondary pollutants

The Secondary Pollutants are not emitted directly. They are formed in the atmosphere when the primary pollutants react with themselves or with the other components of the atmosphere. Major secondary pollutants include photochemical oxidants and secondary particulate matter. Photochemical oxidants result from the photochemical reactions between sunlight and nitrogen oxides, sulphur dioxide, or volatile organic compounds. They mainly include acids, nitrogen dioxide, sulphur trioxide, and ozone. Ozone is considered as highly dangerous air pollutant. Exposure to ozone can cause many lung diseases such as asthma, emphysema, and bronchitis. Repeated and long exposures to ozone may even permanently scar the lung tissues.

Particulate Pollutant

Air quality at any location is determined by the level of pollutants present in the air and it depends on the types and amount of pollutants released into the air. The level of pollutants in the air can vary greatly from one location to the other and from one hour to the next. Particulate pollution is one of the most complicated forms of air pollution. The pollutant responsible for particulate pollution is called particulate pollutant & also known as particulate matter. It is an amalgamation of different particles both sold and liquid, that behave in a similar ways and are of similar size. Particulate matter is sub-divided into different categories based on particle size i.e.

PM10, PM2.5 and PM0.1. PM10 also known as coarse particles, is defined as all particles with an aerodynamic diameter of 10 µm or smaller. PM10 also contains PM2.5 and PM0.1. These particles can pose significant health threat as it can penetrate into our lungs. Once these particles get into our lungs, it can irritate the lung tissue and can prompt asthma attacks. It can also irritate our airways, nose, throat and eyes. Its sources may include construction site dust, road dust or natural dust storm, agricultural processes, plant, insects, pollen grains as well as non-combustible materials released during the burning of fossil fuels. PM2.5 also known as fine particles, is defined as all particles with an aerodynamics diameter of 2.5 µm or smaller. Fine particles can come from natural or human-made sources, like: vehicle exhaust, wildfires, power plant emissions and other combustion activities. Unlike PM10, PM2.5 can not only enter into our lungs but also permeate our bloodstream. PM10 particles get stuck up in our respiratory track and can't penetrate deep into our body, as PM2.5 does. PM2.5 can flow to other parts of our body like our brain and heart and can cause inflammation and damage. PM2.5 contributes to the same problems as PM10 and additional ones like, respiratory disease, reduced immune response, congenital disabilities. PM0.1 also known as ultrafine dust, is defined as all particles with an aerodynamics diameter of 0.1 µm or smaller. It is smaller than fine dust and originates from the similar sources as PM2.5. Research indicates that ultrafine dust poses a worse threat than PM2.5, as the smaller particle size can infiltrate into our body to an greater extent. Recent studies show that PM0.1 displays enhanced cardiovascular toxicity and greater potential for oxidative stress. Overall, ultrafine dust is to be taken seriously and additional research will shed light on the further differences between it and PM2.5. Emission of particulate matter can be controlled or removed from a polluted stream by a variety of physical processes. Common types of equipment for collecting particulate matter include Bag filters, cyclone separators, electrostatic precipitators, and scrubbers. Once collected, particulates adhere to eachother, forming agglomerates that can readily be removed from the equipment and disposed off, usually in a landfill.

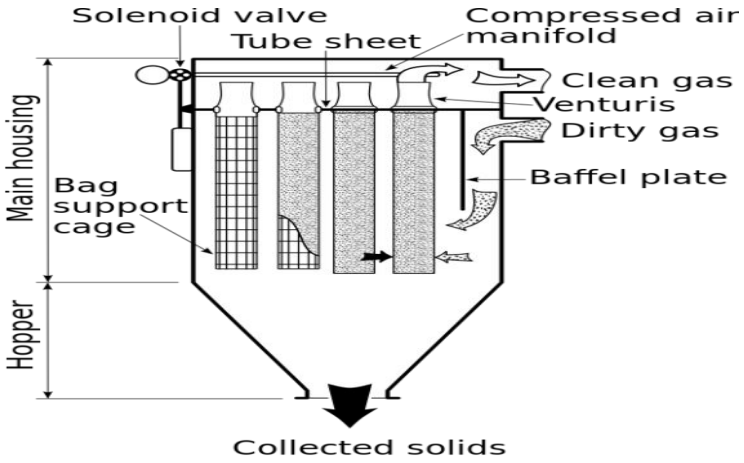
Bag filters

Bag filters, commonly known as baghouse or dust collector is an pollution control device used to remove particulate matter from the contaminated gas stream by depositing the particles on bag filters. 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. There are following three types of bag filters and they differ from each other in the method of cleaning the filter material.

1. Shaker bag filters
2. Reverse air bag filters
3. Pulse jet type bag filters

Shaker bag filters

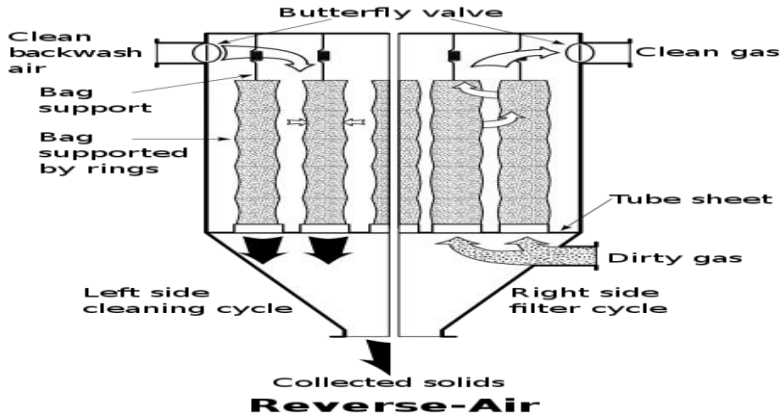
The shaker bag filters consists of vertical casing made up of cylindrical bags, bottom hopper and a tube sheet between the vertical casing and the hopper. The cylindrical bags are closed at the top. At the top of the casing, a shaking machanism is attached.



The contaminated gas stream enters into the hopper flows through the holes of the vertical sheet and inside the vertical bags, leaving the dust cake on the inside surface of the bag filters. Periodically, the gas flow is stopped and bags are shaken to clean them. The dislodged dust cake falls into the hopper and finally removed from the collector.

Reverse air bag filter

These filters are similar to the shaker bag filters. The contaminated gas stream enters from the hopper, f lows into and through the bags. The gas stream leaves out the dust cake on the inside bag surface.



For cleaning the bags, the flow of contaminated gas stream is stopped and another clean gas flow is introduced which flows in the reverse direction. This gas flow is usually taken from the cleaned gas stream discharged from the bag filters. The dust cake, dislodged by the reverse airflow falls into the hopper and finally removed from the collector.

Pulse Jet Type Bag Filters

The pulse jet type bag filters has a tube sheet located near top of the vertical casing, and the filter bags are hanged from the tube sheet. A wire mesh cage is fixed inside the bags to support and prevent them from collapsing. The contaminated gas stream enters through the hopper, flows into the bags and up through the tube sheet, leaving the dust cake on the bag surface. These bag surfaces are cleaned by applying short duration pulses of compressed air. The dust cake dislodged by the compressed air pulses falls into the hopper and finally removed from the collector.

Cyclone Separators

Cyclone separators or simply cyclones are separation device used for removing the particulate matter from air or other gas stream. It works in the principle of inertia to remove particulate matter. The size of the cyclone may vary from 1.2 meters to 9 meters depending upon

the volume of air or other gas stream to be filtered. Cyclone separators are basically centrifugal separators and work much like a centrifuge. It consists of an upper cylindrical part referred to as the barrel and a lower conical part referred to as cone. A vortex is generated in the cyclone body which simply transform the inertia force of flowing gas or air particle to a centrifugal force. The particle laden air stream enters tangentially at the top of the barrel and travels downward into the cone forming an outer vortex. The increasing air velocity in the outer vortex results in a centrifugal force on the particles separating them from the air stream.

When the air reaches the bottom of the cone, it begins to flow radially inwards, reaches at the top and comes out as clean air/gas while the particulate matter fall into the dust collection chamber attached to the bottom of the cyclone.

Most cyclones are built to control and remove particulate matter that is larger than 10µm. However, high efficiency cyclones are also available that are designed to remove the particles as small as 2.5µm. Out of all of the particulate-control devices, cyclone separators are the least expensive device. They are often used as a pre-treatment before the contaminated gas enters more effective pollution control devices. Therefore, cyclone separators can be seen as "rough separators" before the air/ gas reaches the fine filtration stages. Cyclone separators are generally able to remove somewhere between 50-99% of particulate matter presents in the air/gas.

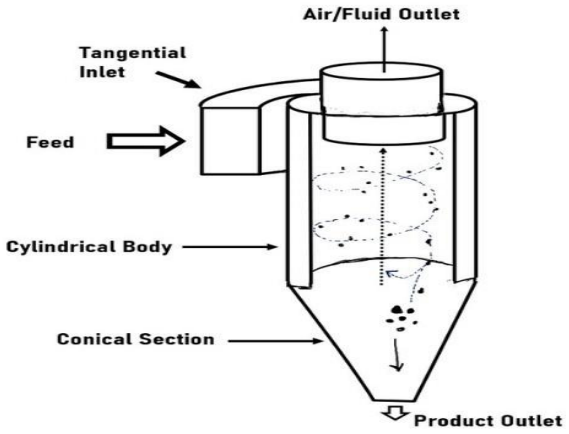
There are several advantages associated with the cyclone separators such as

(i) Less installation and maintenance cost

(ii) Occupy very little space

(iii) Separated particulate matter is collected in dry condition which makes it easier to disposed of.

However, there are few disadvantage also, like standard models are not available to remove particulate matter smaller than 10µm effectively and also the equipment are unable to handle sticky materials.



Electrostatic Precipitators

Electrostatic Precipitators are used to remove the fine particles like smoke and dust from the flowing gas. It is a commonly used device for air pollution control and mostly used in steel plants, thermal power plants etc. The operation of electrostatic precipitators is quite simple. It uses an electric charge to remove particulate matter either in the form of solid or liquid droplets from air or other gasses in smokestacks or other flues. The precipitators consists of a row of thin vertical wires and a stack of large vertical metal plates. The plates are spaced from 1 cm to 17 cm apart depending

on the type of application. One of the electrode is charged with a high negative voltage whereas second electrode charged with high positive charge. The gas stream flows horizontally between the wires and through the stack of plates. The particulates present in the gas stream are charged with the negative charge as they pass through the negatively charged electrodes. The particulates thus charged with the negative charge are pulled towards the positive electrode (plate) and deposited on plates or other collection devices. The treated gas steam then passes out of the precipitators and through a stack to the atmosphere. When sufficient quantity of particles are accumulated on the collector devices, they are shaken off mechanically from the collectors. The particulates which can be dry or wet, fall into a hopper at the bottom of the unit and are transported to the disposal or recycling site through belt conveyeor. The soot or ash collected from coal burning power plants in this manner is referred to as fly ash. Electrostatic precipitators are very important tool in the process of cleaning up contaminated gases. They are extremely effective and are capable of removing more than 99% of particulate matter of size smaller than 10 μm size. However, this level of effectiveness comes at a very high cost – about 2-4% of a power plant's electrical energy output.

GASEOUS POLLUTION CONTROL

Gaseous pollution is created by; primary and secondary pollutants. Primary gaseous pollutants include Sulphur and Nitrogen dioxide, Nitrogen oxide, Carbon monoxide and VoCs etc., whereas secondary gaseous pollutants include Ozone and other photochemical oxidants, Sulphuric acid etc. These gaseous pollutants are removed by means of three basic techniques; Absorption, Adsorption and Incineration or combustion. Here, two methods namely, Absorber and Catalytic converter which comes under combustion method are discussed.

Absorber

Absorber is a process of removing gaseous pollutants by dissolving it into a solvent media. Most commonly used solvent media is a liquid phase, but it can also be a dry bulk solid in certain cases. The material that absorbs is called the solvent, and the gas that is to be absorbed is called solute. The common form of absorption is wet scrubbing. The types of scrubber include cross flow scrubber, bubble, plate and tray scrubbers, packed-bed counter flow scrubber etc. The most common type of wet scrubber is a packed-bed counter flow scrubber. The gas stream con taining the pollutant enters from the bottom of the scrubber and moves upwards towards the exhaust provided at the top of the scrubber. The liquid scrubbing media or solvent enters from the top of the scrubber and gets distributed over the random packing. The gas stream also passes through the random packing which provides necessary surface area and facilitate contact between the two media. The liquid media absorbs the pollutants from the gas stream which are collected in the sump of the scrubber. Before exiting the gas stream passes through a mist eliminator and disperse to the atmosphere. Water is commonly used scrubbing fluids, but there are many processes or pollutants that require different fluids or solvent materials.

Catalytic converter

There is enormous number of cars on the road in India especially in big cities like Mumbai, Kolkata, Bangalore, Pune etc. and each one is source of air pollution. To overcome this problem, an interesting device called a catalytic converter was invented by Eugene Houndry, a French mechanical engineer and expert in catalytic oil refining in mid 1950s. The car emissions contain harmful toxic by-products like nitrogen oxides, carbon monoxide and hydrocarbons. A catalytic converter is a simple device that uses oxidation and reduction reactions to covert these harmful fumes to less harmful fumes. It is composed of a metal housing with a ceramic honeycomb interior with insulating layers. This honeycomb interior is coated with precious metals like platinum, rhodium, and palladium. It is

located near front portion of the car. There are mainly two types of catalysts used in the catalytic converter

(i) Reduction catalyst (ii) Oxidation catalyst

Reduction catalyst: It reduces nitrogen oxide pollution by removing oxygen. Nitrogen oxides are bro ken up into nitrogen and oxygen gases which are harmless.

Oxidation catalyst: It converts carbon monoxide into carbon dioxide and hydrocarbons into carbon dioxide and water. Based on the type of catalyst used, the converter is categorized into two categories:

Two-way type catalytic converter: In this type of converter, only oxidation catalysts are used, which converts carbon monoxide to carbon dioxide and hydrocarbons to carbon dioxide and water by oxidation process.

$$CO + O2 \rightarrow CO2$$

$$CxH4x + 2xO2 \rightarrow xCO2 + 2xH2O$$

Three-way type catalytic converter: In this converter, the catalysts, oxidation & reduction are used. Hence, it performs similar to the two-way converter with the addition of a reduction catalyst which reduces nitrogen oxide to nitrogen and oxygen gases by reduction process.

$$NOx \rightarrow Nx + Ox$$

Effects of air pollution due to Refrigerants, I.C., Boiler

Refrigerants are used in various electronic equipment such as refrigerator, air-conditioner etc. With the advancement of technology, there has been an immense change in the life style of people around the world. Specially, air-conditioner have become indispensable due to their existence almost everywhere be it home, office, school, railway station, airport etc. Initially, chlorofluorocarbons more widely known as CFCs were used as most common refrigerant. But after CFCs were found to be depleting the ozone layer, there was a worldwide effort to phase them out. The effort to get rid of CFCs resulted in two groups of chemicals but with a different problem, hydro fluorocarbons (HFCs) and hydro chlorofluorocarbons. These refrigerants break down Ozone molecules far less, but extremely potent greenhouse gasses. This is because HFCs and HCFCs along with CFCs absorb infrared radiation, trapping heat inside the atmosphere rather than allowing it to escape into space, creating a greenhouse effect that warms the planet.

I.C. 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 pollutant (HAPs), particle pollutant and volatile organic compounds. Some of the pollutants emitted are Nitrogen oxide, Sulphur 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 human and other organism. The sound is typically described in terms of loudness and it is measured in logarithmic units called decibels (dB). Not all sound is considered as noise pollution. According to World Health Organisation (WHO), noise above 65 dB can be considered as noise pollution. To be very precious, noise becomes harmful when it exceeds 75 dB and painful above 120 db.

Sources of noise pollution

Like any other pollution, the noise pollution is caused mainly due to industrialization, urbanization and modern civilization. The source of noise pollution can be categorised into two categories: Industrial sources and Non-industrial sources. Industrial sources include noise from

various industries and big machines working at very high speed and with very high noise intensity. Non-industrial sources include noise created by transport/vehicular traffic, loudspeaker, radio etc. However, the major source of noise pollution may be categorized as follows:

Industrial sources: The industries such as textile mills, engineering establishments, 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. It is therefore advisable to keep industrial zone away from the residential zone and they may be separated by a sufficiently wide green belt.

Transport vehicles: Automobile revolution in urban areas turned out to be a big source of noise pollution. In the recent past, there is an enormous growth in traffic volume due to increase in number of vehicles such as busses, trains; trucks etc. resulting in increased noise pollution. Airport located in the vicinity of residential areas creates lots of noise pollution as the airplanes passes over the residential areas during its landing and taking off. Heavy trucks, busses, trains, motor bikes, mopeds etc. are 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 type's machinery and equipment such as tractors, thrashers, tube wells, powered tillers, harvesters etc. are being used in many agricultural farms. This machinery may create noise pollution of level more than 90 dB to 98 db.

Defence equipment: A lot of noise pollution is created by artillery, tanks, explosions, shooting practices etc. by defence personnel. Noise created by jet engines and sonic booms have been known to shatter the window panes and old dilapidated buildings and also it has deafening impact on the ears.

Miscellaneous sources: The construction site, blasting, stone crusher etc. are some of the other sources of noise pollution.

Measurement of noise pollution level: The sound can be described physically as well as physiologically. Physically, sound is a mechanical disturbance propagated as a wave motion in air or other media such as water, steel etc. Physiologically, sound is an auditory sensation or perception evoked by this physical phenomenon. The physical properties and perception of sound or noise are expressed and measured in different concepts and units. Sound pressure is used as the fundamental measure of sound (amplitude) as it can be measured directly by instruments. The weakest sound pressure disturbance that can be detected by an average person at 1000 Hz has been found to be 20 μN/m2 and the largest sound pressure perceived without discomfort is of the order of 10^7 μN/m2. Because of such a wide range, the use of a linear pressure scale has been found to be impractical. It has been found convenient to employ sound pressure level, a quantity, which is proportional to the logarithm of sound pressure. By this, the sound pressure range of interest is compressed between 0 to 130, a range convenient to use. The sound pressure level is expressed in the unit of decibel (dB).

Sound pressure level is defined as:

$$LP = 10 \text{ Log}10 (P/Pr) 2$$

Where LP = sound pressure level, dB

P = root mean square sound pressure, usually in µN/m2

Pr = reference sound pressure

L og10 = Logarithm to the base 10

The reference sound pressure, PR has an internationally agreed value of 20 µN/m2. Sound is measured with a sound level meter which is usually a portable, self-contained instrument incorporating a microphone, amplifier, a voltmeter and attenuators, the whole of which is calibrated to read sound pressure levels directly.

Effects of Noise pollution

Noise is more than a mere nuisance. Noise pollution may have deleterious effects on human health, wild life and environmental quality. Some of the major effects of noise pollution is discussed below:

Hearing problems: Our ears can take certain range of sounds without getting damaged. Constant exposure to loud levels of noise may result in loss of hearing. It may also reduce our sensitivity to sounds that our ear picks up unconsciously in our day-to-day life.

Psychological issues: Our psychological health may get 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 issue 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 the time. The study reveals that the school children residing near railway station or airport have problems in learning.

Sleeping disorders: High level of noise 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 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 class room, laboratories and workshops.

Effect on wildlife: Noise pollution affects wildlife more than the humans as they are more dependent on sound. Animals have better sense of hearing than humans as their survival depends on it. Animals get disoriented more easily and face many behavioural problems. They 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 ambient noise levels in public places from various sources, inter-alia, industrial activity, construction activity, fire crackers, sound producing instruments, generator sets, loud speakers, public address systems, music systems, vehicular horns and other mechanical devices have deleterious 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 the 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 S.O.1046(E), dated 22.11.2000,

S.O.1088(E), dated 11.10.2002, S.O.1569(E), dated 19.9.2006 and S.O.50(E), dated 11.01.2010 under the Environment (Protection) Act, 1986.

The main features of the Noise Pollution (Regulation and Control) Rules, 2000 is described under the sub-headings:

1. Short-title and commencement.
2. Definitions .
3. Ambient air quality standards in respect of noise for different areas/zones.
4. Responsibility as to enforcement of noise pollution control measures.
5. Restrictions on the use of loud speakers/public address system and sound producing instruments (5A) Restriction on the use of horns, sound emitting construction equipment and bursting of fire crackers.
6. Consequences of any violation in silence zone/area.
7. Complaints to be made to the authority.
8. Power to prohibit etc. continuance of music sound or noise.

CHAPTER-3
WATER AND SOIL POLLUTION

Introduction

Pollution is the introduction of harmful materials into the environment. These harmful materials are called pollutants. Pollutants can be natural, such as volcanic ash. They can also be created by human activity, such as trash or runoff produced by factories. Pollutants damage the quality of air, water, and land.

Water pollution

Water pollution (or aquatic pollution) is the contamination of water bodies, with a negative impact on their uses. It is usually a result of human activities. Water bodies include lakes, rivers, oceans, aquifers, reservoirs and groundwater.

Sources of water pollution

Water pollution can come from many sources, including sewage, industrial waste, agriculture, and mining.

- Sewage

  Sewage from households and factories is a major cause of water pollution.

  Sewage can lead to water-related illnesses like diarrhea.

- Industrial waste

  Industries like dye factories discharge untreated waste into water bodies.

  Industrial waste can contain toxic chemicals and heavy metals.

- Agriculture

  Agricultural runoff from farms and livestock can include fertilizers, pesticides, and nutrient. Livestock waste, crop residues, and packaging materials can also contribute to water pollution.

- Mining

  Mining activities can leak heavy metals, sulfides, and other dangerous compounds into water bodies.

- Turbidity

  It is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air.The measurement of turbidity is a key test of both water clarity and water quality.

Types of water pollutants

The various types of water pollutants can be classified in to following major categories:

(1) Organic pollutants
(2) Pathogens
(3) Nutrients and agriculture runoff
(4) Suspended solids and sediments (organic and inorganic)
(5) Inorganic pollutants (salts and metals)
(6) Thermal Pollution
(7) Radioactive

Characteristics of water pollutants

- Oil spills

  Oil spills can harm marine life like fish, birds, and sea otters.

- Suspended matter

Large objects like cans and straws that don't dissolve in water can block oxygen from reaching the water.

- Industrial waste

  Toxic chemicals from factories can pollute water and decrease oxygen levels.

- Nutrients

  High levels of nutrients from wastewater, fertilizers, and sewage can promote the growth of algae and weeds.

- Toxic waste

  Waste that is poisonous, radioactive, explosive, or carcinogenic can pollute water.

- Agricultural runoff

  Pesticides used to protect crops can seep into groundwater and harm animals, plants, and humans.

- Oxygen depletion

  When oxygen levels are too low, life that relies on oxygen for respiration will die off.

Turbidity

- Fluids can contain suspended solid matter consisting of particles of many different sizes. While some suspended material will be large enough and heavy enough to settle rapidly to the bottom of the container if a liquid sample is left to stand (the settable solids), very small particles will settle only very slowly or not at all if the sample is regularly agitated or the particles are colloidal. These small solid particles cause the liquid to appear turbid.

Causes

- Turbidity in open water may be caused by growth of phytoplankton.
- Human activities that disturb land, such as construction, mining and agriculture, can lead to high sediment levels entering water bodies during rain storms due to storm water runoff.
- Areas prone to high bank erosion rates as well as urbanized areas also contribute large amounts of turbidity to nearby waters, through storm water pollution from paved surfaces such as roads, bridges, parking lots and airports.[
- Some industries such as quarrying, mining and coal recovery can generate very high levels of turbidity from colloidal rock particles.

Effect

- In water bodies such as lakes, rivers and reservoirs, high turbidity levels can reduce the amount of light reaching lower depths, which can inhibit growth of submerged aquatic plants and consequently affect species which are dependent on them, such as fish .
- High turbidity levels can also affect the ability of fish gills to absorb dissolved oxygen.
  Measurement
- The measurement of turbidity is a key test of both water clarity and water quality. There are two standard units for reporting turbidity: Formazin Nephelometric Units (FNU) and Nephelometric Turbidity Units (NTU).

PH (Potential of hydrogen)

- The pH scale is a commonly used scale to measure the acidity or the basicity of a substance.
- The possible values on the pH scale range from 0 to 14.
- Acidic substances have pH values ranging from 1 to 7 (1 being the most acidic point on the pH scale), and alkaline or basic substances have pH values ranging from 7 to 14.

- A perfectly neutral substance will have a pH of exactly 7.
- pH, which is an abbreviation of the 'potential for hydrogen' or 'power of hydrogen' of a substance

Total suspended solids (TSS)

- Total Suspended Solids (TSS) refers to the weight of all solid particles, like soil, silt, algae, and organic matter, that are suspended in a water sample and can be captured by a filter, essentially measuring the level of suspended material in a water body, impacting its clarity and often indicating pollution levels.
- High TSS can harm aquatic life by blocking sunlight, settling on gills, and disrupting habitats, with sources including erosion, wastewater discharge, and urban runoff.
- TSS is quantified by filtering a water sample through a standardized filter, then drying and weighing the captured solids, typically expressed in milligrams per liter (mg/L).
- High TSS levels can reduce water clarity, impair photosynthesis by blocking sunlight, and disrupt aquatic ecosystems by smothering organisms on the bottom.

Total solids BOD and COD

Total solids, BOD and COD are all parameters that can be used to measure water quality and the amount of organic pollution in water

Total solids

"Total solids" refers to the entire weight of dissolved and suspended particles in a water sample, calculated by drying a sample and weighing the remaining solids.

BOD (Biological Oxygen Demand)

- It is the amount of oxygen the microbes require to decompose the organic matter under aerobic conditions.
- It can be determined by putting a sealed water sample under specific temperature conditions for five days.
- Lower than COD
- It is used to waste loadings in treatment plants.
- Evaluation of BOD removal efficiency of the waste plants.

COD (Chemical Oxygen Demand)

- It is the total amount of oxygen required to break down the organic matter by chemical oxidation.
- It can be determined by placing a water sample with a strong oxidising agent under specific temperature conditions for a short period.
- Higher than BOD.
- To quantify the amount of oxidisable pollutants found in water bodies.
- It provides a measurement on how an effluent will affect the water body.

Waste water treatment

Wastewater treatment is the process of removing contaminants from wastewater so it can be safely returned to the environment. It can also be reused.

1. Primary method

Sedimentation and froth flotation methods are the primary method of waste water treatment

(a) Sedimentation

Primary sedimentation is a waste water treatment method that uses sedimentation tanks to remove suspended solids.

Purpose

Primary sedimentation is the first step in waste water treatment providing a basic level of purification.

Process

Sewage flows through large tanks, where contaminants separate as they pass through.

Effectiveness

Primary sedimentation can remove 25-50% of BOD, 65% of oil and 50-70% of TSS.

(b) Froth flotation

Froth flotation is a waste water treatment process that uses air bubbles to separate hydrophobic materials from hydrophilic materials.

Air bubbles

Compressed air is dissolved into water and then released at atmospheric pressure in a flotation tank. This creates air bubbles that trap foreign materials.

Separation

The bubbles move towards the water surface, carrying the hydrophobic materials with them

N.B

Hydrophilic

It means "water loving " that is hydrophilic substances are attracted to water and dissolve in it.

Hydrophobic

It means "water fearing" that is hydrophobic substances resist water and do not dissolve in it.

2. Secondary method

Activated sludge and trickling filters are both secondary waste water treatment methods that use biological processes to break down organic matter and pollutants.

Activated sludge

A common method that uses microorganisms to break down organic matter and reduce pathogens. The process involves a series of ventilation basins that aerate waste the growth of microorganisms. The waste water then goes to a clarifier where the solids settle out.

Trickling filters

- A biological filter that uses microorganisms attached to supporting materials like water and promotes rocks or plastic to break down organic matter.
- The filter may be supplied with oxygen through natural ventilation.
- The settled sewage is collected in a reservoir at the centre of the filter.

Bioreactor

A bioreactor is any manufactured device or system that supports a biologically active environment.

In one case, a bioreactor is a vessel in which a chemical process is carried out which involves organisms or biochemically active substances derived from such organisms. This process can either be aerobic or anaerobic.

3. Tertiary method

Tertiary method is a waste water treatment process that removes remaining contaminants after secondary treatment.

Membrane separation method

A membrane is a thin sheet of natural or synthetic material that covers a surface and is permeable to a certain component in the solution. The main membrane separation technologies include microfiltration, ultrafiltration, reverse osmosis and Nano filtration, electro dialysis, gas-separation and evaporation.

Works

A pressure difference is applied across the membrane smaller molecules pass through the pores, while larger molecules are blocked. The type of membrane separation process depends on the size of the molecules, separation efficiency, temperature, pH levels, and concentration.

Examples of membrane separation methods

Ultrafiltration: Separates molecules larger than the pores of the membrane

Nano filtration: Separates components based on their molecular weights

Reverse osmosis: Separates components based on their molecular weights

Microfiltration: Rejects physical solids and small materials from entering

Membrane distillation: A thermal process that only allows steam molecules to pass through the membrane

Gas separation membrane: Selectively separates gas molecules contained in a feed gas mixture

Evaporation: Combines the selective separation and transfer of a component across the membrane and its evaporation.

Reverse osmosis:

Reverse osmosis is one of the oldest and most popular separation techniques used mainly for the purification of water. The process was mainly adopted for the desalination of seawater in the year 1950 when the whole process was relatively slow and limited to certain laboratories. However, after a lot of research and advancements in technology, there were significant developments, especially in the field of polymers and the production of efficient membranes.

Reverse osmosis principle

To break down the process further, due to the presence of a membrane, large molecules of the solute are not able to cross through it and they remain on the pressurised side. The pure solvent, on the other hand, is allowed to pass through the membrane. When this happens the molecules of the solute start becoming concentrated on one side while the other side of the membrane becomes dilute. Furthermore, the levels of solutions also change to some degree. In essence, reverse osmosis takes place when the solvent passes through the membrane against the concentration gradient. It basically moves from a higher concentration to a lower concentration.

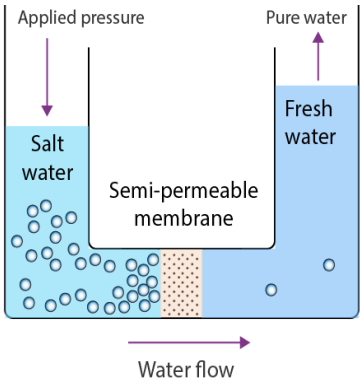
Reverse Osmosis Process

Osmotic pressure is the minimum pressure required to stop solvent flow through the semipermeable membrane. Therefore, when the solution side (the side where the solute concentration is high) is subjected to a pressure greater than the osmotic pressure, the solvent particles on the solution side move through the semipermeable membrane to the region where the solute concentration is low.

Such inverse solvent movement through the semipermeable membrane is called reverse osmosis. It is important to note that the pressure applied to the solution side must be higher than the osmotic pressure for the reverse osmosis process to proceed. Osmotic pressure is a colligative property, which depends on the concentration of the solution. In water purification, the reverse osmosis process is very important. Many water purifiers used today use reverse osmosis in the purification process as one of the steps.

Reverse osmosis work

An easy experiment can be conducted by taking some freshwater and a concentrated aqueous solution. The solutions should be kept on opposite sides with a semipermeable membrane placed in between to separate the two solutions. Pressure should be applied on the side with the concentrated solution. Now this will result in water molecules moving through the membrane to the freshwater side. This basically sums up the process of reverse osmosis.



Advantages of Reverse Osmosis

- Bacteria, viruses and pyrogen materials are rejected by the intact membrane. In this respect, RO water approaches distilled water in quality.
- Available units are relatively compact and require little space. They are well suited to home dialysis.
- In average use, the membrane has a life of a little more than one to two years before replacement is necessary.
- Periodic complete sterilization of the RO system with formalin or other sterilant is practical.

Disadvantages of Reverse Osmosis

- Cellulose acetate membranes have limited pH tolerance. They degrade at temperatures greater than 35°C. They are vulnerable to bacteria. They eventually hydrolyze.
- Polyamide membranes are intolerant of temperatures greater than 35oC. They have poor tolerance for free chlorine.
- Thin-film composites are intolerant of chlorine. High flux polysulfide's require softening or deionization of feed water to function properly.

Soil Pollution

- Soil pollution refers to the contamination of soil with anomalous concentrations of toxic substances.
- It is a serious environmental concern since it harbours many health hazards. For example, exposure to soil containing high concentrations of benzene increases the risk of contracting leukaemia.

- An image detailing the discolouration of soil due to soil pollution is provided below.
- It is important to understand that all soils contain compounds that are harmful/toxic to human beings and other living organisms. However, the concentration of such substances in unpolluted soil is low enough that they do not pose any threat to the surrounding ecosystem. When the concentration of one or more such toxic substances is high enough to cause damage to living organisms, the soil is said to be contaminated.

Cause Soil Pollution

Soil pollution can be broadly classified into two categories –

- Naturally caused soil pollution
- Anthropogenic soil pollution (caused by human activity)

Natural Pollution of Soil

In some extremely rare processes, some pollutants are naturally accumulated in soils. This can occur due to the differential deposition of soil by the atmosphere. Another manner in which this type of soil pollution can occur is via the transportation of soil pollutants with precipitation water.

An example of natural soil pollution is the accumulation of compounds containing the perchlorate anion (ClO_4^-) in some dry, arid ecosystems. It is important to note that some contaminants can be naturally produced in the soil under the effect of certain environmental conditions. For example, perchlorates can be formed in soils containing chlorine and certain metals during a thunderstorm.

Anthropogenic Soil Pollution

- The demolition of old buildings can involve the contamination of nearby soil with asbestos.
- Usage of lead-based paint during construction activities can also pollute the soil with hazardous concentrations of lead.
- Spillage of petrol and diesel during transportation can contaminate soils with the hydrocarbons found in petroleum.
- Activities associated with metal casting factories (foundries) often cause the dispersion of metallic contaminants into the nearby soils.
- Underground mining activities can cause the contamination of land with heavy metals.
- Improper disposal of highly toxic industrial/chemical waste can severely pollute the soil. For example, the storage of toxic wastes in landfills can result in the seepage of the waste into the soil. This waste can go on to pollute groundwater as well.
- Chemical pesticides contain several hazardous substances. Excessive and inefficient use of chemical pesticides can result in severe soil pollution.
- Sewage produced in urbanized areas can also contaminate soil (if not disposed of correctly). These wastes may also contain several carcinogenic substances.

Effect of Soil Pollution

Soil pollution harbours a broad spectrum of negative consequences that affect plants, animals, humans, and the ecosystem as a whole. Since children are more susceptible to diseases, polluted soil poses a greater threat to them. Some important effects of soil pollution are detailed in this subsection.

Effects on Human Beings

Soil contaminants can exist in all three phases (solid, liquid, and gaseous). Therefore, these contaminants can find their way into the human body via several channels such as direct contact with the skin or through the inhalation of contaminated soil dust.

The short term effects of human exposure to polluted soil include

- Headaches, nausea, and vomiting.
- Coughing, pain in the chest, and wheezing.
- Irritation of the skin and the eyes.
- Fatigue and weakness.

A variety of long-term ailments have been linked to soil pollution. Some such diseases are listed below.

- Exposure to high levels of lead can result in permanent damage to the nervous system. Children are particularly vulnerable to lead.
- Depression of the CNS (Central Nervous System).
- Damage to vital organs such as the kidney and the liver.
- Higher risk of developing cancer.

It can be noted that many soil pollutants such as petroleum hydrocarbons and industrial solvents have been linked to congenital disorders in humans. Thus, soil pollution can have several negative effects on human health.

Effects on Plants and Animals

Since soil pollution is often accompanied by a decrease in the availability of nutrients, plant life ceases to thrive in such soils. Soils contaminated with inorganic aluminium can prove toxic to plants. Also, this type of pollution often increases the salinity of the soil, making it inhospitable for the growth of plant life.

Plants that are grown in polluted soil may accumulate high concentrations of soil pollutants through a process known as bioaccumulation. When these plants are consumed by herbivores, all the accumulated pollutants are passed up the food chain. This can result in the loss/extinction of many desirable animal species. Also, these pollutants can eventually make their way to the top of the food chain and manifest as diseases in human beings.

Effects on the Ecosystem

- Since the volatile contaminants in the soil can be carried away into the atmosphere by winds or can seep into underground water reserves, soil pollution can be a direct contributor to air and water pollution.
- It can also contribute to acid rain (by releasing huge quantities of ammonia into the atmosphere).
- Acidic soils are inhospitable to several microorganisms that improve soil texture and help in the decomposition of organic matter. Thus, the negative effects of soil pollution also impact soil quality and texture.
- Crop yield is greatly affected by this form of pollution. In China, over 12 million tons of grain (worth approximately 2.6 billion USD) is found to be unfit for human consumption due to contamination with heavy metals (as per studies conducted by the China Dialogue).

Controlled of soil pollution

- Several technologies have been developed to tackle soil remediation. Some important strategies followed for the decontamination of polluted soil are listed below.
- Excavation and subsequent transportation of polluted soils to remote, uninhabited locations.
- Extraction of pollutants via thermal remediation – the temperature is raised in order to force the contaminants into the vapour phase, after which they can be collected through vapour extraction.

- Bioremediation or phytoremediation involves the use of microorganisms and plants for the decontamination of soil.
- Mycoremediation involves the use of fungi for the accumulation of heavy metal contaminants.

Fertilizer

Fertilizer natural or artificial substance containing the chemical elements that improve growth and productiveness of plants. Fertilizers enhance the natural fertility of the soil or replace chemical elements taken from the soil by previous crops.

Excessive use of fertilizer

Chemical fertiliser over use can contribute to soil acidification and soil crust, thereby reducing the content of organic matter, humus content, beneficial species, stunting plant growth, altering the pH of the soil, growing pests, and even leading to the release of greenhouse gases.

Pesticides

Pesticides are a class of chemicals designed to kill pests (rodents, insects, or plants) that may affect agricultural crops or carry diseases like malaria.

- Insecticides
- Herbicides
- Fungicides
- Rodenticides

Insecticides

Insecticides are substances that are in use to kill insects. Insecticides include ovicides and larvicides. These are in use against insect eggs and larvae. Insecticides are in use in the field of agriculture, medicine, industry and consumers.

Examples

Aldrin,Chlordane.Chlordecone.DDT.

Irrigation

- It is the practice of applying controlled amounts of water to land to help grow crops, landscape plants, and lawns.
- Irrigation has been a key aspect of agriculture for over 5,000 years and has been developed by many cultures around the world.
- Nutrients may also be provided to the crops through irrigation.
- The various sources of water for irrigation are wells, ponds, lakes, canals, tube-wells and even dams.
- It helps to grow crops, maintain landscapes, and revegetate disturbed soils in dry areas and during times of below-average rainfall.

E-waste

When an electronic product is thrown away after its useful life is over, it produces electronic trash, or e-waste. E-waste is produced in vast quantities as a result of the consumption-driven society and the quick development of technology.

Types of electronic waste

- Fridges, freezers and other cooling equipment.
- Computers and telecommunications equipment.
- Consumer electronic devices and solar panels.
- TVs, monitors and screens.

CHAPTER -4

Renewable Sources of Energy

INTRODUCTION

"I have no doubt that we will be successful in harnessing the Sun's energy. If sunbeams were weapon of war, we would have had solar energy centuries ago."

George Porter, Noble Prize Winner in Chemistry, 1967 Usage of renewable sources of energy became unavoidable to protect our environment from hazardous impact of fossil fuels. These sources are available in nature in various forms such as solar energy, wind energy, hydrogen energy, ocean energy, biomass etc. The usage of renewable source of energy has many advantages over traditional forms of energy; such as, it emits no or low greenhouse gases, no or low air pollutants, low cost, accessible to all, creates job etc. In this unit, different methodology of harnessing of solar energy, wind energy, biomass, application of new sources of energy; hydrogen and ocean energy including their advantages are discussed in detail.

SOLAR ENERGY

We receive a pure, non-polluting, and inexhaustible form of energy from the sun. This energy comes in the form of radiant light and heat and known as solar energy. Although the sun is 150 million km away from us, but still an enormous amount of solar energy falls on the earth. The energy what we get from Sun in one hour is more than the energy consumed by everyone in the entire world in one year energy is our most reliable source of energy and is source of most of the other forms of energy on our planet. Historically, people have been using solar energy for heating buildings, creating fire and driving industrial processes etc. Solar energy is a powerful source of energy, however, only a small portion of it can be Solar mainly used to/for:

• Generate electricity

• Heating and cooling

• Cooking and

• Water desalination

Flat Plate Collector (liquid and air)

The flat plate collector is the most fundamental solar power collector. It is mainly used for domestic hot water system. The typical flat-plate collector includes following features:

• Black plate surface – to absorb incident solar radiation

• Glass cover – a transparent layer of glass 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

In the plate collector, 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. The thermal insulation in the bottom and sides of the collector, and the glass screen above the plate prevents heat loss during transfer of heat. The flat-plate systems normally operate within the temperature range from 30° to 80° C. However, advanced collectors that employ vacuum insulation and selective coatings can achieve temperature up to 200° C. Some of the advantages of flat plate collector includes; easy to manufacture, low manufacturing cost, little maintenance etc. For transfer of heat, either a medium, liquid or air can be used in the flat plate collectors. For liquid, water is one of the common options due to its accessibility and good thermal properties.

Water based flat plate collector

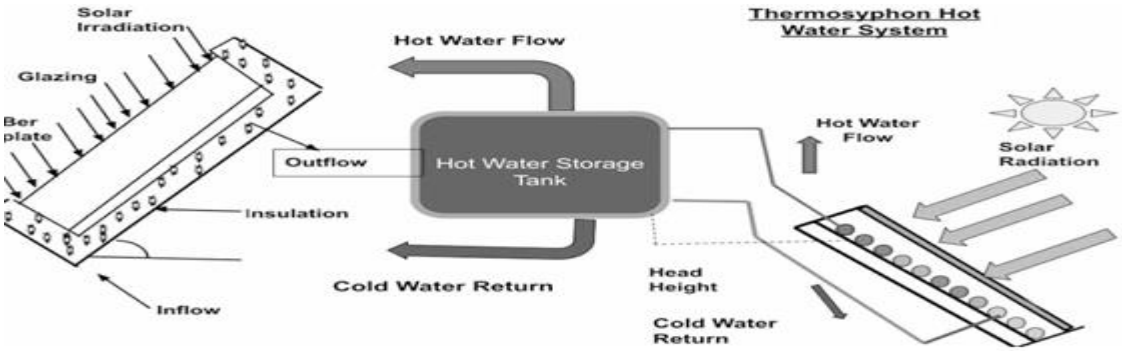
In this type, water is used as a medium of heat transfer. Water is most commonly used as liquid fluid because of its high volumetric heat capacity and high mass density, which allows using small tubes and pipes for the heat transfer. One disadvantage of water is that it freezes during winter, which can damage the collector or piping system. This can be managed by draining down the collector time-to-time.

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 collector is very simple. When a metal sheet is placed to solar radiation, 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.

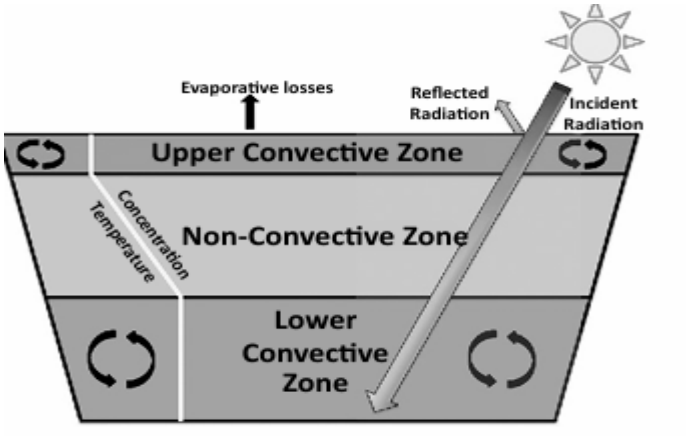


Solar pond, solar water heater, solar dryer and solar stills

The sun is the largest source of renewable energy and this energy is abundantly available in all parts of the earth. It is, in fact one of the best alternatives to the non-renewable sources of energy. There are many ways to harness solar energy for example through the use of solar ponds, solar water heater, solar dryer and solar stills.

Solar pond

It is a solar energy collector, fairly large in size and looks like a pond. The solar pond works on a very simple principle. We all know that when water or air is heated they become lighter and rise upward e.g., a hot air balloon. Similarly, 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. A solar pond mainly has three zones. The top zone is the surface zone called Upper Convective Zone, which is normally at atmospheric temperature and has very little salt content. 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. In between these two zones an important zone called as gradient zone or Non-Convective Zone exists. In this zone, the salt content increases with increase in the water depth and thereby creats a density gradient. If we consider a particular layer in this zone, water of 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. This gradient zone acts as a transparent insulator permitting sunlight to reach the bottom zone but also entrapping it there. Therefore, 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 800C. Finally, heated water from the bottom level is transferred to pipes, circulating through the pond to extract thermal energy.



Solar Water Heater

It is a device that helps in heating water utilising the radiation energy from the sun. Using this device, water can easily be heated up to the temperature 600C to 800C. A solar water heater (SWH) of capacity 100 to 300 litres are suitable for domestic use. Larger system can be used in restaurants, canteens, guest houses, hotels, hospitals etc. A 100 litres capacity SWH may save approximately 1500 units of electricity annually by replacing electric geysers for residential use. It can also prevent emission of 1.5 tons of car bon dioxide annually. The main components of solar water heater includes:

1. A collector to collect energy from solar radiation

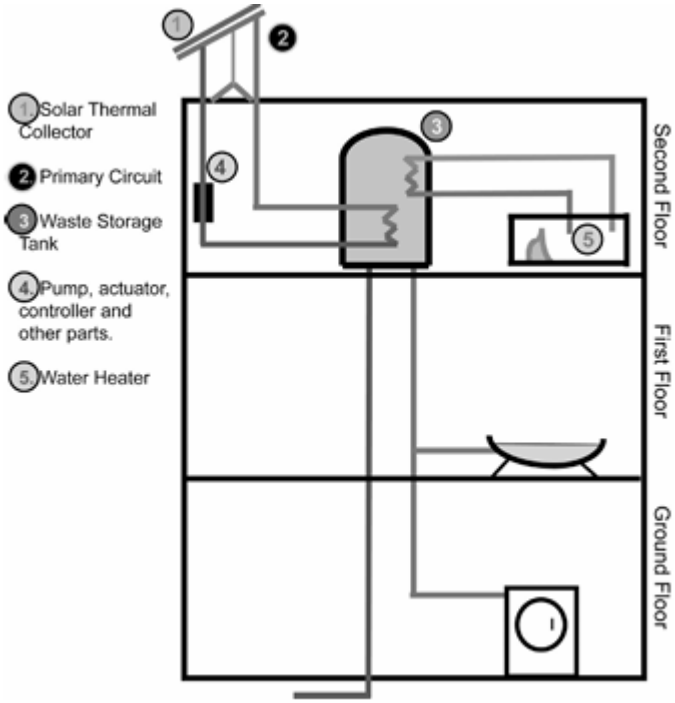
2. Insulated tank for storing heated water

3. Supporting arrangements

4. Connecting pipes and associated instrumentation

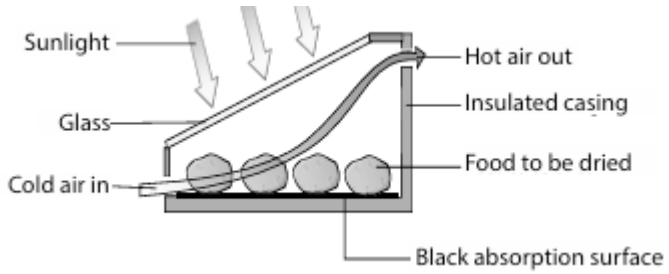
The sun rays fall on the collector plate and get absorbed by the black absorbing surface of the collector. The absorbed heat energy get transferred to the water flowing through it. The heated water is collected in a storage tank. The tank is insulated to prevent heat loss. Solar water heaters are one of the most cost-effective uses of solar energy. Every year, several thousands of new solar water heaters are installed world-wide. It can be used for homes, community centres, nursing homes, hotels, hostels, industry etc. Use of solar water heaters can curtail electricity bills considerably. A residence can save 70%-80% on electricity bill by replacing conventional water heater with solar water heater. Solar water heaters are the fastest repayment of investment in 2 to

4m years depending upon its usage.



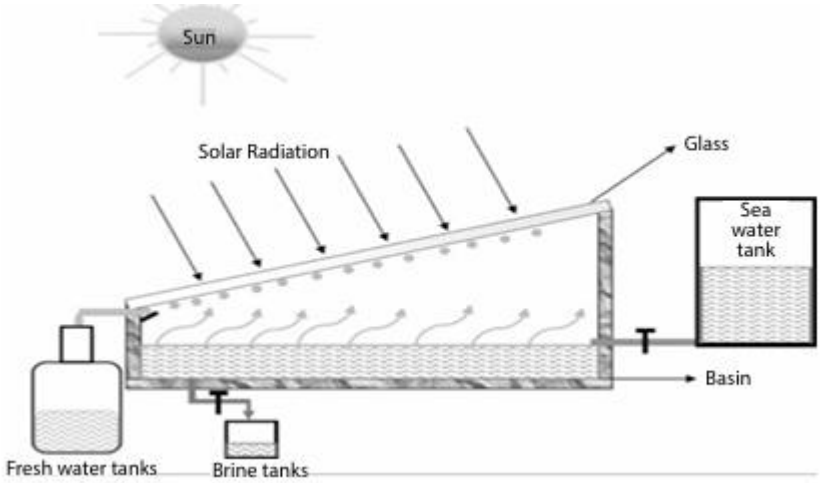
Solar Dryer

Solar energy has become a viable alternative energy and can be converted into heat energy for various applications such as heating water, power generation, food drying, drying of agricultural products particularly vegetables and fruits etc. In old days, the traditional method of food drying was to place the foodstuffs in the sun in the open air. Although, this method was effective for small quantity of food but the food may easily be contaminated as was kept in open air. In contrast to the sun drying, where the food is exposed directly to the sun, the solar drying uses indirect solar radiation. 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 dryer are suitable for drying large quantity of food products and for small scale farmers and food producers.



Solar Stills

A solar still is a green energy product that uses natural sun energy to purify water. Solar stills are able to supply pure water for drinking and cooking, even in the areas where there are no other source of energy, while still being friendly to the environment. It works on the principle of evaporation and condensation process. The still, consisting of a basin (where impure water is kept) is fully insulated along all its side and closed with the transparent glass cover to permit the solar energy. First, the water that needs to be purified is placed in the basin. The solar still is then allowed to sit in the sun, which allows the still to absorb the solar radiation. As the energy is absorbed, it starts to heat the water. As the temperature of the water rises, the liquid H2O is converted into steam and evaporates towards the glass ceiling, leaving impurities in the basin below. The second scientific principle on which a solar still acts is condensation. The water slowly condenses on the glass, forming pure water droplets. Since the glass is angled down toward the second basin, the water droplets roll down into clean water basin. Because none of the minerals, bacteria or other substances are able to evaporate with the pure H2O, the water droplets that end up in the second basin are simply purified, and safe for drinking and cooking. In most other sources of purification, such as commercial water-bottling plants etc. usually, the water is boiled as part of the purification process. As the water is boiled, its PH value drops drastically, causing flat-tasting water. Whereas in a solar still, the water is purified naturally, allowing the PH levels to stay balanced and hence, the test of water remains intact.



Biomass

Biomass refers to 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. Biomass is a source of renewable energy. It has been in use since people first began burning wood for cooking food and keeping warm the surroundings. Biomass has always been a major source of energy for mankind and estimated to contribute 10% to14% 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: Firewood, wood pellets, and wood chips, furniture mill sawdust and waste, and black liquor from pulp and paper mills.

2. Agricultural crops and waste materials: Various types of agricultural crops such as corn, soybeans, sugar cane, switchgrass, woody plants, and algae, including crop and food processing residues.

3. Municipal solid wastes: It includes, paper, cotton, wool products, food and wood wastes.

4. Animal manure and sewage waters.

Biomass contains energy which is first derived from the sun. Plants absorb the sun's energy through photosynthesis, and convert carbon dioxide and water into nutrients (carbohydrates). This energy from these organism can be transformed into usable energy. Biomass can be burned to create heat, converted into electricity or it may be processed into biofuel.

Thermal characteristics of biomass as fuel

If you plan to use biomass for fuel, it is necessary to understand it's thermal characteristics in order to avoid possible problems and utilize biomass effectively. 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:

Amount of heat available in a fuel (kJ/kg) denotes its heat value. It is one of the most important characteristics of a fuel as it indicates the total amount of energy available in a particular fuel. The heat value in a given fuel type is mostly a function of the fuel's 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. Generally, the HHV is used for biomass combustors. The heat content of a fuel, usually do not have the fixed value. It can vary significantly depending on the climate and soil in which the fuel is grown. 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 fouls equipment or can even contribute to an explosion hazard. The moisture content in a

fuel can be calculated either on wet basis or dry basis. In wet basis calculations, the moisture content is equal to the mass of water in the fuel divided by the total mass of the fuel. In the case of dry-basis calculations, the moisture content is equal to the mass of water in the fuel divided by the mass of the dry portion of the fuel. Practically, the maximum required moisture level for combusting fuel is about 50 to 60 percent, calculated on wet basis.

Composition: In addition to heat and moisture content, composition of various biofuels affects its performance. The main compositional properties includes; 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. In most of the time, ash remains in a powdery form, however, 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). It is observed that the high mineral content as well as dirt in the fuel may 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 combusting. 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 is also one of the 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 matter such as animal manure, food wastes, wastewater bio solids etc. is broken down by microorganisms (bacteria) in the absent of oxygen. Anaerobic digestion process results in generation of biogas and bio-fertiliser. 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 collected by removing carbon dioxide and other gases and may be used as a fuel for cooking or heating or to generate electricity. Anaerobic digestion process is also used in the municipal waste water treatment. The quantity of solids produced from waste water treatment can be reduced through anaerobic digestion process thereby reducing its disposal cost. When a good number of animals stay in one farm, the resulting manure and wastewater can have significant environmental impacts if they are simply allowed to run over open land, storm sewars etc. Such environmental pollution 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. In addition to the animal waste, 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 a wet mixture which is usually separated into a solid and a liquid form. 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. The biggest role in the biogas production process is played by microbes feeding on the biomass. 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.Biogas production starts from the arrival of bio wastes .

2. After that, it is crushed to make its consistency as even as possible. In this step, any unwanted

Non-biodegradable waste is separated from the mixture.

3. The crushed bio waste is made in slurry form by adding liquid to prepare it for the anaerobic digestion process.

4. Biomass is then delivered in the form of slurry to the biogas plant and pumped into the pre-digester tank where enzymes secreted by bacteria break down the biomass into an even finer consistency.

5. In the next step, the biomass is sanatized by heating the mixure at 700 C and above for minimum one hour. During this process any harmfull bacteria present in the biomass is removed.

6. After sanitization process, the mass is pumped into the main biomass reactor in which biogas production takes place.

7. In the biogas reactor, microbial action begins and the biomass enters into a gradual process of fermentation. 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. Most of the organic matter is broken down into biogas which is mainly a mixture of methane and carbon dioxide , water vapour and other gases, approximately in three weeks duration.

9. The biogas thus generated is collected in a spherical gas holder placed at the top of the biogas reactors.

Utilization and storage of biogas

Biogas generated from anaerobic digestion processes is an environmental friendly renewable fuel. But it is important to clean or upgrade it before using, mainly to increase its heating value and to make it useable in some gas appliances such as engines, boilers etc. Biogas mainly contains 50% to 70% methane (CH4), 25% to 30% carbon dioxide (CO2), traces of other gases and fractions of water vapor. It is about 20% lighter than air and has an ignition temperature in the range of 6500C to 7500C. It is an odourless and colourless gas that burns with a clear blue flame similar to that of natural gas.

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. Communities and enterprises across the country use biogas to:

• Produce mechanical power, heat and/or electricity

• Fuel boilers and furnaces, hot water systems, air heaters;

• To run fuel vehicles;

• 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. It can be used in vehicles that have been adjusted for using natural gas. Most vehicles in this category a digestate is the material that is left over following the anaerobic digestion process. Digestate can be made into products like, Flower pots, Soil treatment and Fertilizers. re retro-fitted with a gas tank and a gas supply system in addition to the normal petrol fuel system. However, dedicated vehicles (using only biogas) are more efficient than these retro-fits vehicles.

Digestate:

It is the material that is left over following the anaerobic digestion process. Digestate can be made into products like, Flower pots, 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. A biogas storage system also takes care of fluctuations in the production and consumption of biogas.

There are two broad categories of biogas storage system:

(i) Internal biogas storage tanks that are integrated with the anaerobic digester and
(ii) (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 systems used for on site 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 makes them more costly. To prevent corrosion of the tank components and to ensure safe operation, the biogas must first be cleaned by removing H2S. Biogas that has been upgraded to bio-methane by removing H2 S, moisture, and CO2 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

At present, renewable energy became the first choice for alternative energy source. It is mainly due to the pollution generated by traditional source of energy i.e. burning of fossil fuels. The fossil fuels are not renewable source hence; it may get completely exhausted due to its continuous usage. Therefore, renewable source of energy become the obvious choice. Out all the available renewable sources, wind and solar energy contributes about 90% world-wide. Wind energy is the kinetic energy associated with the movement of atmospheric air. It captures the natural wind in our environment and converts the air's motion into mechanical energy. This is transformed into electrical energy by using wind turbines or wind energy conversion system. 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 produced 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

Wind power technology is one of the fastest growing renewable energy technologies. 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 and in 2016, wind energy accounted for 16% of the electricity generated by all other renewable energy source. Word wide 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.

Wind energy in India

India's wind energy sector is progressing consistently. It is led by indigenous wind power industry. Continuous progress and expansion of the wind power industry in India resulted in protection of ecosystem. 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%. The Government is promoting wind power projects in the entire country through private sector investment. 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 need to be commissioned by March, 2022.

3. With an objective to provide a frame work 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.

Environmental benefits and problem of wind energy

The Environmental benefits of wind energy are more apparent than the problem. The main Environmental benefits 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.

• Unlike other types of power plants, it does not emit air pollutants or greenhouse gases. The wind turbines harmlessly generate electricity utilizing the kinetic energy of passing by wind.

• Wind energy is far more eco-friendly than the burning of fossil fuels for generating electricity.

• Once the turbines and energy centres are installed, 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.

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 animals. Many birds and bats have been killed by flying into the rotors.

• 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.

NEW ENERGY SOURCES

Fossil fuel (coal, oil and natural gas) are our most traditional source of power generation. Therefore, 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. That means no more oil, natural gas and even coal. Also, burning fossil fuel in power plants has much adverse impact on our environment. Entire ecosystem gets destructed due to the various types 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 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 because naturally occurring continual renewal makes them inexhaustible. There are new energy sources which falls under non-renewable category; e.g., nuclear energy source.

The material used in nuclear power plants to create nuclear fusion is typically a rare type of uranium, which is non-renewable.There are eight (08) most commonly 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.

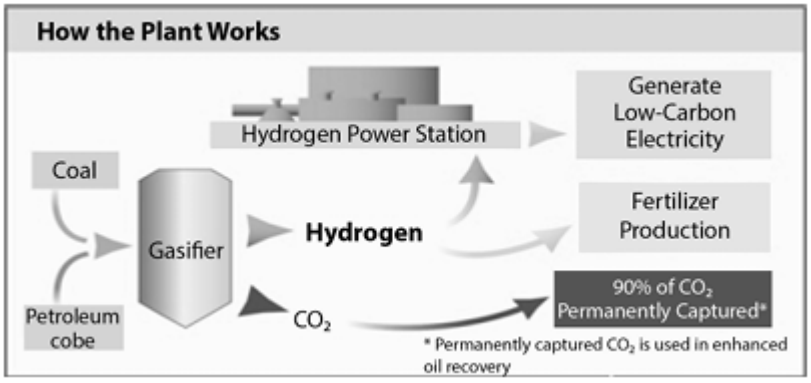
7. Hydrogen energy: Hydrogen is used as clean burning fuel as it generates fewer pollutants leading to cleaner environment.

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 with one proton and one electron, is the most simplest and abundant element on earth. But it does not exist by itself in nature and produced from the sources that contain it such as biomass, solar energy, wind energy, natural gas etc. Hydrogen is not a energy source rather it is an energy carrier and can store or deliver a tremendous amount of energy. It can be used in fuel cell

to generate electricity, or power and heat. Hydrogen is a clean fuel and produces only electricity, heat and water when used in fuel cell. Hydrogen and fuel cell together have the broad range of applications almost in all the sectors such as transportation, industrial, residential etc. In addition, it may provide power for trucks, aircraft, rail, ships, cars, busses etc. Hydrogen and fuel cells have the potential to reduce greenhouse gas emission in many applications.



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:

The interaction of sun-moon-earth system causes tides. Tides rise and fall is the product of the gravitational and centrifugal forces, of primarily the moon with the earth. The

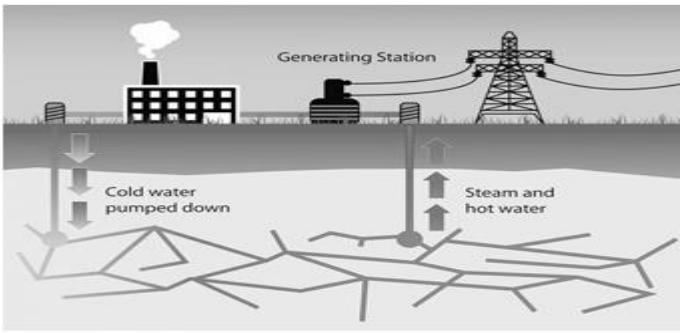
difference of level between low and high tide is used to produce electricity. The technology is similar to the one used in the traditional hydroelectric power plants. The use of tidal energy requires a barrage (dam) across a shallow area, where the difference in the level of low and high tide should 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 theme 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 and 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. Majority of earth's heat is constantly generated by the decay of radioactive isotopes. Temperature of the core is more than 50000C. Radiating heat from core is warming rocks, water, gas and other geological materials. If underground rock formations are heated to temperature about 7000C-13000C they get partly melted and become magma. Magma heats nearby rocks and underground aquifers. From this heated aquifers, hot water can be released through geysers, 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 power plant, 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

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 and the first one was built at Italy in 1904. These plants require highest temperature and can only be used where underground temperature is quite high. Steam technology is still effective today and is currently in use at The Geysers in northern California, the world's largest source of geothermal power.

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 1800C. 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. It can also be used for some other heating purposes.

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.

CHAPTER-5

Solid Waste Management, ISO 14000 & Environmental Management

INTRODUCTION

"Refuse what you do not need; reduce what you do need; reuse what you consume; recycle what you cannot reuse, reduce, or reuse; and rot (compost) the rest".

'Bea Johnson' Due to exponential growth in human activities, solid waste generation has increased many folds that need to be managed properly. We are producing much more waste than nature can handle. It is however, better to prevent waste generation than to produce waste and then try to manage it. We cannot simply through away waste, because what we dispose of, remains in the ecosystem and creates some form of pollution. To save our environment from the pollution created by solid wastes, it is very much essential to manage these wastes properly.

SOLID WASTE GENERATION

In our daily life, we generate lots of used materials and throw them away. The used and discarded materials are termed as wastes. The waste materials may be in gaseous form (e.g., automobile exhaust, smoke from chimney etc.), in liquid form (e.g., sewage water, effluents from industry etc.), or in solid form (e.g., food waste, farm waste etc.). Solid waste is a complex mixture of diverse materials. The composition of waste varies from season to season, region to region and also within a particular region. It may be defined as the wastes which have been rejected and cannot be used further in the same form. 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:

Residential sources: Wastes from household and residential areas. These are the major sources of municipal solid wastes.

Institutional sources: Wastes from government and public institutions such as schools, colleges universities, government offices etc.

Commercial establishments: Wastes from business centers such as food and drink establishments, shops, banks etc.

Health facilities: Wastes from hospitals and other health facilities. Construction and demolition activities: Wastes from various types of construction and demolition activities such as construction of apartments, demolition of slums etc.

Industrial sources: Wastes from various types of industrial processes.

Agricultural sources: Wastes from agricultural activities.

Open areas: Wastes from Electronic and electrical roadside dustbins, street sweeping and other public places.

Electronics and electrical wastes (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 wastes is important for its proper management. The characteristics 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 following parameters:

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

For understanding the behavior of solid waste materials, the knowledge of its chemical composition is also important. Its chemical characteristics may include PH value, Nitrogen, Phosphorus, and potassium, total carbon etc. and bio-chemical characteristics may include carbohydrates, proteins, natural fiber etc. Heavy metals, pesticides, insecticides etc. may fall under toxicity characteristics.

Biodegradable and Non-biodegradable Solid Wastes

In our daily life, we produce different types of wastes and throw them away or discard them. These wastes may be of many forms; however, we can mainly divide them into two categories; biodegradable waste and non-biodegradable waste. We must know that everything we use in our daily life is either biodegradable or non-biodegradable.

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. are comes 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

The term "e-waste" is an abbreviation of "electronic and electrical waste". Electronic waste or e-waste is a popular, informal name for the electronic or electrical products nearing the end of their useful life and are discarded. Due to the revolution in IT sector, production of electrical and electronic equipment (EEE) became one of the fastest manufacturing activities. Due to rapid economic growth, the production and consumption of EEE has increased many folds. Therefore, e-waste is also growing exponentially because global consumer demand continues to increase. The Global E-Waste Monitor 2017 shows that e-waste has grown to 44.7 million metric tons annually. But only 20% of the e-waste generated is documented to be collected and recycled. The fate of 80% (35.76 million metric tons) is unknown, but likely to be dumped, stored, traded or recycled under inferior condition.

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. Presence of organic toxic and hazardous materials in e-waste separates it from the normal municipal waste.

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 (the flora, the fauna, the soil etc.) and human health (carcinogenic diseases, liver, kidney, brain damages etc.).

Non-Hazardous substances: The recycling of e-wastes helps to identify the non-hazardous 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 aluminum, 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 and Characteristics of Biomedical waste

Biomedical wastes can be defined as wastes that are generated in hospitals, biological activities, veterinarian clinics and health care units. These wastes consist of solids, liquids, laboratory wastes and sharp instruments used during the diagnosis, treatment, prevention or immunization of human beings, animals, or in research activities. Biomedical waste may be hazardous or non-hazardous. According to WHO (World Health Organization), about 85% of biomedical wastes falls under non-hazardous category, whereas 15% falls under hazardous category.

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 centers, transfusion centers, blood banks, clinical laboratories, research laboratories, mortuaries, veterinarians and nursing homes.

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

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 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 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.) inlarge 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, fetuses 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.
5. General Wastes: The waste generated at medical facilities is not very different from the general household or office waste. Waste like paper, plastics, liquids and all the waste which are not included in the above three wastes, falls under this category.

METALLIC WASTES AND NON-METALLIC WASTES

Several kinds of heavy metals such as alloy steel, aluminium, copper, zinc, lead etc. are used in industrial process everyday 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. Industrial wastes in the form of 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. According to the American Iron and Steel Institute (AISI), 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. In addition to the financial benefits, recycling also has environmental impact. The recycling of scrap metals, enables us to preserve 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 waste paper, 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.

Lubricant

It is a substance used to reduce the friction between various parts of the machinery and thereby extending the life by minimizing wear and tear which in-turn save energy and resources. A lubricant can be in liquid (oil, water etc.), gaseous (air), or even semisolid (grease) forms. Depending on its use, lubricants may be classified as automotive, industrial and marine oils. Used oils such as engine lubrication oil, hydraulic fluids, and gear oils which are used in cars, bikes, or lawnmowers 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.

Plastics

Most of us use plastic bags every day in our day to day activity. The thin plastic bags are used by almost every retailer we visit. Whenever we're shopping, you can almost guarantee that you'll be leaving the store with a plastic bag stuffed with full of your new goodies. As we all know, most of the plastics are non-biodegradable. Plastic pollution is a global catastrophe and sadly it is a man-made one. The marine ecosystem in particular is suffering immensely as a result of plastic pollution. There are few ways to reduce plastic is by using jute bags or paper bags or making our own eco-friendly bags. You will also feel proud that you are carrying around a bag that you have made yourself and are eco-friendly. Ever increasing mass of unmanaged plastic waste is causing significant damage to the global ecosystem. A few key regulations, as well as recycling technologies, are helping to curb the threat.

Rubber

Like any other polymer materials, rubber is also 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. Due to these properties, it is widely used in automobile sectors, healthcare, household etc. However, this unique property of rubber making it very difficult to degrade easily. As the demand of rubber products keep increasing, there is a constant increase of rubber waste and 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. Hence, it is very important to manage these rubber wastes in a sustainable manner through reuse, recycling, recovery and pyrolysis process. Reuse the worn rubber i.e., tyres simply by retreading and reuse back. Recycling of rubber waste includes utilizing the discarded rubber in various applications such as erosion control, back water and f loatation device, cement concrete, bitumen products etc. In recovery method, waste rubber is used as a fuel source for high temperature process such as steam production, cement kiln etc. Basic components of rubber wastes such as gas, oil etc are generated using pyrolysis process.

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 centres, 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, pro cessing and disposal of the solid wastes .

Collection of Municipal Solid Waste (MSW)

Solid waste collection is the first functional element of solid waste management. The collection of municipal solid waste is a public service and has great impact on the public health and appearance of towns and cities. 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 road kerbside/alley: In this system, waste generators place their waste containers or bags on the road kerbside or in the alley 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.

In Hauled-container 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.

In Stationary-container 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 environmemtal and human health issues. The wastes dumped on the road side, 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 principle of reducing waste, reusing and recycling resources and products is referred to as 3Rs. All 3Rs help us to cut down 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 you use the less waste you will produce.

Some of ways meantioned 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. Do not take a bag from the store unless you need one.

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. In addition to the recovery of energy, there are few additional benefits as mentioned below:

• The total quantity of waste gets reduced drastically depending upon the waste composition and the adopted technology.

• Demand for space for landfilling gets reduced. The cost of transportation of waste to far-away land f ill sites also gets reduced proportionately.

• Overall reduction in environmental pollution.

Hence, 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:

(iii) 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.

(iv) 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-de gradable 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 affects the recovery of Energy from Wastes (including MSW), includes: Quantity of waste, and its Physical and chemical characteristics (quality). The actual production of energy is also depending upon 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 at end of the working day or other suitable intervals. 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. When it is possible to excavate, trench method is used.

Hazardous waste

The wastes generated from industry, hospital, household containing toxic substances are known as Hazardous waste. 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. A hazardous waste because of its harmful property, cannot be disposed of by common means like other by-products of our everyday lives. 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. Historically, 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. Al though 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 you have anything extra and find it unusable, may be shared or donated to someone who need it. By sharing or donating, you will be able to reduce hazardous wastes generation.

AIR QUALITY ACT 2004

Air Quality Act, 2004 was notified in Government Gazette, volume 476 of Republic of South Africa on 24 February 2005 under the Act No. 39, 2004.

The Act:

To reform the law regulating air quality in order to protect the environment by providing reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development while promoting justifiable economic and social development; to provide for national norms and standards regulating air quality monitoring, management and control by all spheres of government; for specific air quality measures; and for matters incidental thereto.

Object of the Act:

(a) To protect the environment by providing reasonable measures for-

(i) The protection and enhancement of the quality of air in the Republic;

(ii) The prevention of air pollution and ecological degradation;

(iii) Securing ecologically sustainable development while promoting justifiable economic and social development;

(b) Generally to give effect to section 24(b) of the South Africa Constitution in order to enhance the quality of ambient air for the sake of securing an environment that is not harmful to the health and well-being of people.

The sections of the act include total nine chapters. Chapter 1 discusses interpretation and fundamental principles; Chapter 2 is about national framework and national, provincial and local standards; Chapter 3 institutional and planning matters; air quality management measures are discussed in Chapter 4; Chapter 5 deals with licensing of listed activities; international air quality management is described in Chapter 6; Chapter 7 is about offences and penalties; general matters are discussed in Chapter 8 and chapter 9 deals with miscellaneous matters.

Air pollution control act 1981

The Act was passed under Article 253 of the Constitution of India and in pursuance of decisions of Stockholm Conference and was enacted by the parliament in the 32nd year of the republic of India with the aim to prevent, control and mitigate air pollution. It is also a comprehensive legislation with more than fifty sections. Objectives:

1. To establish central and State Boards and empower them 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 Air (Prevention and Control of Pollution) Act was enacted in 1981 and amended in 1987 to provide for the prevention, control and abatement of air pollution in India. 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 wholesomeness of water in the country. The Act was amended in 1988. The Water (Prevention and Control of Pollution) Cess Act was enacted in 1977, to provide for the levy and collection of a Cess on water consumed by persons operating and carrying on certain types of industrial activities. This Cess is collected with a view to augment the resources of the Central Board and the State Boards for the prevention and control of water pollution constituted under the Water (Prevention and Control of Pollution) Act, 1974. The Act was last amended in 2003. This Act provides authority for the prevention and control of water pollution and the maintenance/ restoration of the wholesomeness of water; and aids in the establishment of a board, which possesses the powers and functions of conducting activities and interventions in the context of prevention and control of water pollution. According to the Article 51 A (g) it is the fundamental duty of every citizen of India to protect and improve the natural environment included Forest, Lakes, Rivers and Wildlife and to have compassion for living creatures. Water Act is enacted with the aim of prevention and control of Water Pollution in India.

Objectives

- To provide for the prevention, control and abatement of water pollution.
- The Act sets out the establishment of Central and State Boards and prescribes how these Boards should be established.
- 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 AND STATE 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. CPCB was entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981. It serves as a field formation and also provides technical services to the Ministry of Environment and Forests for the provisions of the Environment (Protection) Act, 1986.

Organisational structure of Central Pollution Control Board

The Central Board consists of the following members:

1. A full time chairman having knowledge or practical experience in matters related to environmental protection to be nominated by the central government.

2. One full time 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 government.

Functions of the Central Board at the National Level

Functions of Central Board is mentioned below:

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

• Plan a nation-wide programme for the prevention, control or abatement of water and air pollution.

• Co-ordinate the activities of the State Board and resolve disputes among them.

• 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.

• Plan and organise training of persons engaged in programme on the prevention, control or abatement of water and air pollution.

• Organise through mass media, a comprehensive mass awareness programme on the prevention, control or abatement of water and air pollution.

Structure and Role of State Pollution Control Board

Every State has its own Pollution Control Board (PCB) or Pollution Control Committee (PCC). It is established to implement Environmental laws and rules within the concerned state's jurisdiction. The main function of every PCB/PCC 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 Board: The primary motive of SPCB is to assist the industries and entrepreneurs to discharge their responsibilities to safe guard 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

• Issue of consent under provisions of section 25/26 of the Water Pollution Act 1974.

• 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.

Laws Applicable to SPCB:

Following laws are applicable SPCB for their functioning:

- Air (Prevention and Control of Pollution) Act, 1981.
- Water (Prevention and Control of Pollution) Cess Act, 1977.
- Environmental Protection Act, 1986.
- Water (Prevention and Control of Pollution) Act, 1974.

Functions of the Central Board as State Boards for Union Territories

No separate State Boards are constituted for a Union territory and in relation to a Union territory. As per the policy decision of the Government of India, the CPCB has delegated its powers and functions under the Water (Prevention and Control of Pollution) Act, 1974, the Water (Prevention and Control of Pollution) Cess Act, 1977 and the Air (Prevention and Control of Pollution) Act, 1981 with respect to Union Territories to the respective local administrations. CPCB along with its counterparts State Pollution Control Boards (SPCBs) are responsible for implementation of legislations relating to prevention and control of environmental pollution for Union Territories.

Functions: Functions of the Central Board as State Boards for the Union Territories is summarized below:

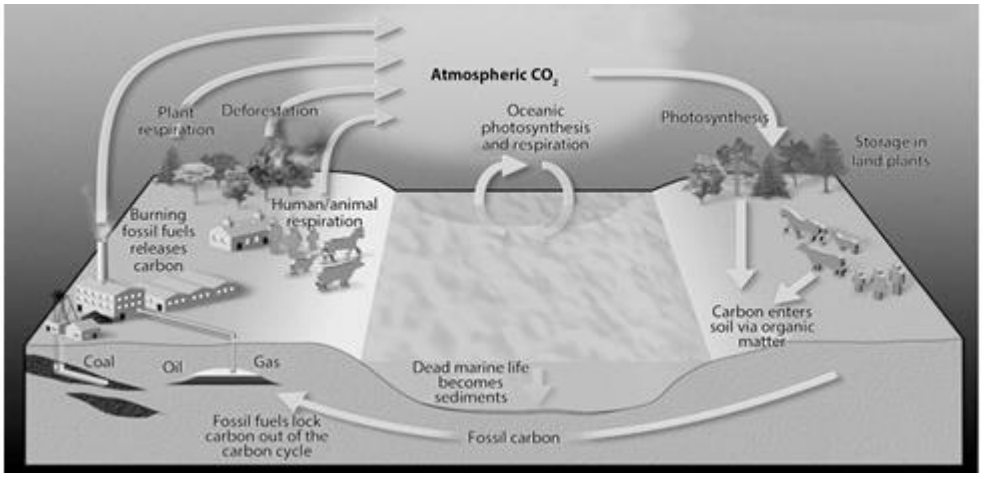
- Advise the Governments of Union Territories with respect to the suitability of any premises or location for carrying on any industry which is likely to pollute a stream or well or cause air pollution.
- Lay down standards for treatment of sewage and trade effluents and for emissions from automobiles, industrial plants, and any other polluting source.
- Evolve efficient methods for disposal of sewage and trade effluents on land.
- Develop reliable and economically viable methods of treatment of sewage, trade effluent and air pollution control equipment.
- Identify any area or areas within Union Territories as air pollution control area or areas to be notified under the Air (Prevention and Control of Pollution) Act, 1981.
- Assess the quality of ambient water and air, and inspect wastewater treatment installations, air pollution control equipment, industrial plants or manufacturing process to evaluate their performance and to take steps for the prevention, control and abatement of air and water pollution.

CONCEPT OF CARBON CREDIT, CARBON FOOTPRINT

The concept of carbon foot print has come from older idea of ecological foot print, a concept invented by Canadian ecologist William Rees and Swiss-born regional planner Mathis Wackernagel at the university of British Columbia. The main cause of greenhouse gas emissions [GHG] are the human activities. This effects/results in the change of climate and global warming. The climate change is due to the dependency of human on usage of electricity, fossil fuels, deforestation etc. Carbon-dioxide [CO2], methane [CH4] nitrous acid [N2O] and fluorinated gases are the common GHGs. A carbon footprint is the amount of greenhouse gases, primarily carbon dioxide released into the atmosphere by action of an individual, a family, an event, an organization, or even an entire nation. It is usually measured as tons of CO2 emitted per year. Among all the greenhouse gases, why is the carbon foot print is all about CO2 It is because impact of each greenhouse differs, their total impacts need to measure in a common way. For example, one ton of methane is far more harmful to the climate than one ton of CO2. To make the communication easier, all greenhouses are measured in CO2 equivalents. The number represents how much pure CO2 would have the same effect on the climate, as mix of gases that was actually emitted. Carbon footprint is just like one normal foot print and the mark which we leave in our environment, but it is not due to our footwear, but it is due to

every action of ours that release carbon. The harmful gases such as CO2, which is released by burning fossil fuels like oil, gas etc. More the fuel you use the bigger will be your footprint. For example, if you drive a vehicle the CO2 released by the vehicle is not only responsible for carbon footprint but also the manufacturing of the vehicle. The energy needed to extract the oil from the ground, purification of the fuel, transportation of the fuel also has their own carbon footprint. Everything a human owns has a carbon footprint. The book we read, the food we eat etc. Imagine an apple which we get in our nearby market also has its own carbon footprint, because it travels miles to reach a market nearby you. It is not possible to leave any carbon footprint behind but it can be reduced by our actions. Let us think about our actions and choices. We can try to predict the carbon footprint during the process of manufacturing or when the process is being planned/ designed. Carbon emissions can be of two types:

1. **Direct Carbon Emission** – The carbon emission which come directly from the sources like from the Industry by burning of fuel, personal vehicles, burning of gas stoves etc. can be termed as direct carbon emission.
2. **Indirect Carbon Emission** – The carbon emissions which are indirectly related to sources such as purchased electricity, transportation of materials, treatments, selling of product etc. can be termed as indirect carbon emission. We can reduce carbon footprints through the development of alternative energy resources such as solar and wind power energy which are renewable resources. Also by changing our everyday life styles, we can reduce our energy consumption such as lowering our dependency on air conditioners, use of CFL light bulbs, buying ENERGY STAR appliances, recycling, using a vehicle which is fuel efficient. Also by creating awareness and encouragement to turn off light and fan whenever it is not required.



Carbon Credit

Carbon credit came into existence to enhance awareness towards the need for controlling the emissions of GHGs. It is a generic term for any tradable certificate or permit representing the right to emit one ton of CO2 or the equivalent amount of GHG. One carbon credit is equal to one ton of CO2. The main goal for the creation of carbon credit is the reduction of emissions of CO2 or other green house gases from industrial activities to reduce the effects of global warming. Carbon credit creates a market for reducing greenhouse emissions by giving a monetary value to the cost of polluting air. Methane and nitrous oxide have approximately 21 times and 310 times respectively,

the heat trapping capacity of CO2. Reducing methane by 1 ton is equivalent to reducing CO2 by 21 tons.

ENVIRONMENTAL MANAGEMENT IN THE FABRICATION INDUSTRY

An environmental management system, often called an 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 regardless of its activity and sector 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.

The expected outcomes of an EMS include:

- Enhancement of environmental performance.
- Fulfilment of compliance obligations .
- Achievement of environmental objectives.

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 series of standards was introduced in 1996 by the International Organisation of Standards and most recently revised in 2015. 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, some of them being;

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. which in turn help to protect human health, maintain the quality of environment, meet customers' environmental expectations, establish public and community relations, etc. The ISO 14000 provisions helps to take benefits from the natural resources and conserve the environment for the future civilization.