Environment Engineering

1. Introduction

Deals with issue effecting lives of living organisms. It helps in protecting environment by finding solution to human degrading activities and protecting human from various disastrous solution.

Environment is interaction of living organism with each other and non living things.

1.1 Ecosystem

- An ecosystem includes *all of the living things* (plants, animals and organisms) *in a given area*, *interacting with each other, and also with their non-living environments* (weather, earth, sun, soil, climate, and atmosphere).
- Ecosystems are the foundations of the Biosphere and they determine the health of the entire earth system.
- Ecosystem is an open system and material can exchange from one ecosystem to another ecosystem. For ex. Frog move from the pond to the land and vice-versa.
- The ecosystem can be classified based on size, nature and duration;
    - ***Nature***: On the basis of nature, it can be natural or artificial.
        - Natural Ecosystem: This ecosystem forms naturally without interference of human. Example include are pond, river, forest, village, hill etc.
        - Artificial Ecosystem: This ecosystem is developed and maintained by human. Example include are flowerbed, backyard, aquarium etc.
    - ***Duration***: On the basis of duration, ecosystem can be classified as temporary or permanent.
        - Temporary ecosystem: it is short lived and manmade or natural. Example include rain fed pond.
        - Permanent ecosystem: it is long lived and self-supported natural ecosystem for very long period. Example includes forest, river etc.
    - ***Size:*** Ecosystem is classified as small or large ecosystem.
        - Small: it is small and also known as micro ecosystem. It can be temporary or permanent. For ex. Pond, flowerpot etc.
        - Large: It is large in size and also known as macro ecosystem. It is always permanent and mostly natural. For ex. Ocean, river, forest and desert.

1.2 Type of Environments:

Two type:

a) *Natural Ecosystem*: Are self-sustaining and require no human interference. These type of eco system are more genetically diverse.

b) *Artificial Ecosystem*: Are maintained by human. And require constant human interference for existence. Compared to natural ecosystem, these are less diverse.

1.3 Component of Ecosystem/ Structure of Ecosystem

Broadly speaking, two type:

a) Biotic Component: Living Organism example: Plant, animals etc.

b) Abiotic Component: Physical environment component.

a) Biotic Component:

The living organisms present in an ecosystem form the biotic component. They are connected through food. In this series, few organisms are producing food whereas others are consuming the food.

Depending upon the role of living organism in an ecosystem, the biotic component can further be classified as:

i. *Producers*:

- Photoautotrophs: These are green plants which can trap sun light to form carbohydrate, simple sugar from carbon di-oxide and water. This process is known as photosynthesis and these organisms are called as photoautotrophs.
- Chemoautotrophs: Few bacteria such as sulfur bacteria, nitrifying bacteria, can be able to utilize free energy released from the chemical reactions to prepare organic food with it. They are called chemoautotrophs and the process is known as chemosynthesis.

ii. *Consumers:*

These are mainly the animals. They are unable synthesize their own food and depends on producers. They utilizes the oxygen being released from the producers as well. Several consumers doesn't get the food from the producers but they are depended on consumers it self. As a result, consumers are related to each other through multiple food chains. Consumers are animals of an ecological food chain that consumes other organisms.

Consumers consist of four categories:

- Primary Consumers- these animals and insects eat primary producers, they are also called Herbivores they feed on plants and fungus, organisms who receive their food and energy through the process of photosynthesis.
- Secondary Consumers- these organisms eat Primary consumers, there are two types: Carnivores and Omnivores.
- Tertiary Consumers- they eat secondary consumers, sometimes both secondary and primary consumers. They are also known as the apex predator because it is at the top of the food chain. They consume energy from all other levels.

iii. *Decomposers.*

These are mainly bacteria and fungi. Their primary purpose in the ecosystem is to decompose the complex organic material into the simple inorganic material so that it can be use for producers to prepare food.

b) Abiotic Components: These factors include the non-living physiochemical factors of the environment. Abiotic factors are as follows:

(i) Inorganic substances: Inorganic substances like carbon, nitrogen, oxygen, water, carbon di-oxide, calcium, phosphorus and their inorganic compounds. These are available as free form or dissolved in water and may be adsorbed on the soil particles.

(ii) Organic compounds: These are carbohydrates, proteins, lipids, nuceltic acids etc. This material is present in dead organic matter. These are broken into the simple compounds by decomposers in ecosystem for recycling of matter.

(iii) Climatic factors: These are factors present in the environment such as temperature, humidity, light, wind, rainfall an atmospheric gaseous etc. Study of specific Ecosystem: Let's take a example of fresh water pond to understand the function of individual components.

1.3.1 Basis of Species

Species are identifies on the basis of different characteristics features they exhibit. A species is group of organism that can reproduce and create offspring.

1.3.2 Concept of Ecology

Few technical widely used while studying ecology are

a) *Biosphere/ecosphere* is the part of the earth and atmosphere inhabited by living organisms.

b) *The habitat* is a specific locality with a particular set of conditions where organisms live. Habitats are categorized into Terrestrial (Land) and aquatic(Water).

c*) An ecological niche* is the position that animal occupies in a habitat. It includes physical space where the organism is found and its role in that habitat in terms of feeding relationships and other interactions with other species.

d) *Population* refers to all members of a given species in a particular habitat, at a particular time.

e) *Community* refers to all organisms belonging to different species that interact in the same habitat. A community therefore is made up of populations.

f)*An ecosystem* is a natural unit composed of abiotic and biotic factors whose interactions leads to self-sustaining system e.g a small bond or a large ecosystem such as tropical forest.

g) *Biomass* is the total dry weight of living organisms at a particular tropic level or per unit area e.g total weight of maize crop per hectare.

h) *Carrying Capacity* is the maximum number of organisms an area can comfortably support without depletion of the available resources.

1.4 Structure of Ecosystem:

Each and every ecosystem has several components to sustain it for long duration. It needs matter (water, oxygen, mineral, and carbon dioxide), different types of organisms and continuous recycling of energy. These requirements are met by two important components present in ecosystem; biotic components and abiotic components.

Thus, a food chain is formed which can be written as follows:

Marsh grass → grasshopper → bird → hawk

A food chain is a linear sequence of organisms through which nutrients and energy pass as one organism eats another. In a food chain, each organism occupies a different trophic level, defined by how many energy transfers separate it from the basic input of the chain.

Food chain in any ecosystem runs directly in which green plants are eaten by herbivores, herbivores are eaten by carnivores and carnivores are eaten by top carnivores. Man forms the terrestrial links of many food chains.

Food chains are of three types:

1. Grazing food chain

2. Parasitic food chain

3. Saprophytic or detritus food chain

1. Grazing food chain:

The grazing food chain starts from green plants and from autotrophs it goes to herbivores (primary consumers) to primary carnivores (secondary consumers) and then to secondary carnivores (tertiary consumers) and so on. The gross production of a green plant in an ecosystem may meet three fates—it may be oxidized in respiration, it may be eaten by herbivorous animals and after the death and decay of producers it may be utilized by decomposers and converters and finally released into the environment. In herbivores the assimilated food can be stored as carbohydrates, proteins and fats, and transformed into much more complex organic molecules.

The energy for these transformations is supplied through respiration. As in autotrophs, the energy in herbivores also meets three routes respiration, decay of organic matter by microbes and consumption by the carnivores. Likewise, when the secondary carnivores or tertiary consumers eat primary carnivores, the total energy assimilated by primary carnivores or gross tertiary production follows the

same course and its disposition into respiration, decay and further consumption by other carnivores is entirely similar to that of herbivores.

2. Parasitic food chain:

It goes from large organisms to smaller ones without outright killing as in the case of predator.

3. Detritus food chain:

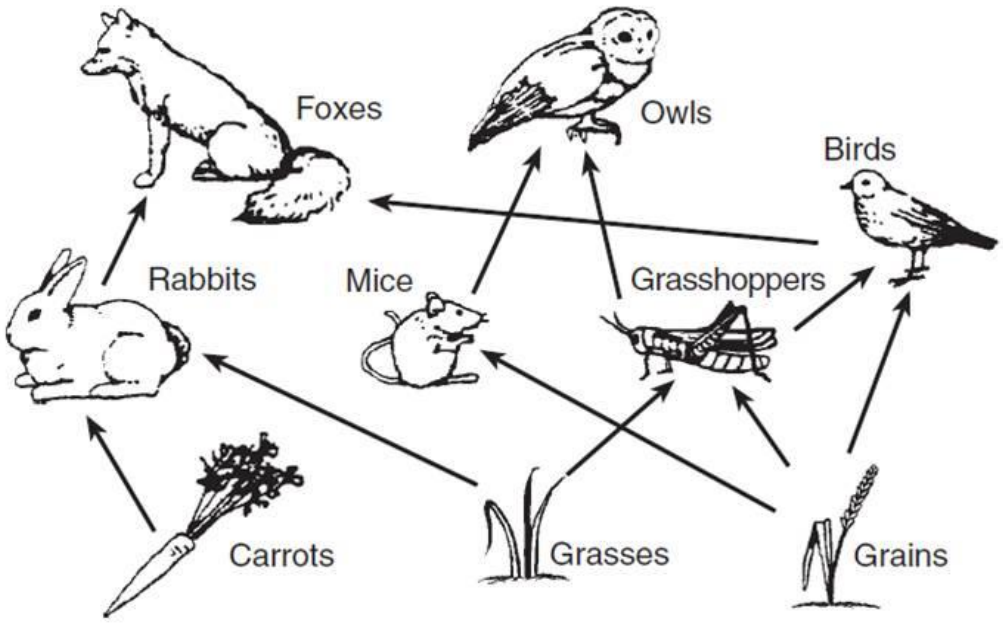
The dead organic remains including metabolic wastes and exudates derived from grazing food chain are generally termed detritus. The energy contained in detritus is not lost in ecosystem as a whole, rather it serves as a source of energy for a group of organisms called detritivores that are separate from the grazing food chain. The food chain so formed is called detritus food chain.

1.4.1 Trophic level:

The producers and consumers in ecosystem can be arranged into several feeding groups, each known as trophic level (feeding level). In any ecosystem, producers represent the first trophic level, herbivores present the second trophic level, primary carnivores represent the third trophic level and top carnivores represent the last level.

1.4.2 Food Web

A food web (or food cycle) is a natural interconnection of food chain. It is an important conceptual tool for illustrating the feeding relationships among species within a community, revealing species interactions and community structure, and understanding the dynamics of energy transfer in an ecosystem.



1.4.3 Ecological Pyramid

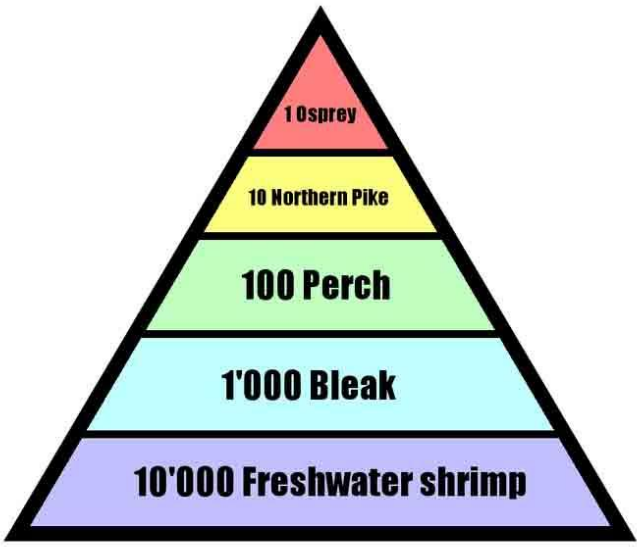
An ecological pyramid is a graphical representation of the relationship between different organisms in an *ecosystem*

Each of the bars that make up the pyramid represents a different *trophic level*, and their order, which is based on who eats whom, represents the flow of energy. Energy moves up the pyramid, starting with the *primary producers*, or *autotrophs*, such as plants and algae at the very bottom, followed by the *primary consumers*, which feed on these plants, then *secondary consumers*, which feed on the primary consumers, and so on. The height of the bars should all be the same, but the width of each bar is based on the quantity of the aspect being measured.

1.5 Types of Ecological Pyramids

1.5.1 Pyramid of numbers

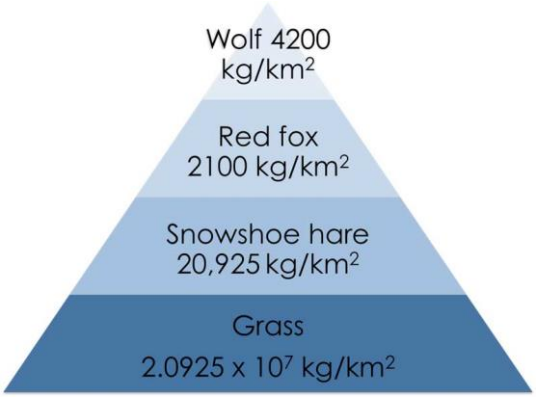
This shows the number of organisms in each trophic level without any consideration for their size. This type of pyramid can be convenient, as counting is often a simple task and can be done over the years to observe the changes in a particular ecosystem. However, some types of organisms are difficult to count, especially when it comes to some juvenile forms. Unit: number of organisms.



1.5.2 Pyramid of biomass

This indicates the total mass of organisms at each trophic level. Usually, this type of pyramid is largest at the bottom and gets smaller going up, but exceptions do exist. The biomass of one trophic level is calculated by multiplying the number of individuals in the trophic level by the average mass of one individual in a particular area. This type of ecological pyramid solves some problems of the pyramid of numbers, as it shows a more accurate representation of the amount of energy contained in each trophic level, but it has its own limitations. For example, the time of year when the data are gathered is very important, since different species have different breeding seasons. Also, since it's usually

impossible to measure the mass of every single organism, only a sample is taken, possibly leading to inaccuracies. Unit: g m^{-2} or Kg m^{-2}.



1.5.3 Pyramid of Energy/Productivity

The pyramid of productivity looks at the total amount of energy present at each trophic level, as well as the loss of energy between trophic levels.

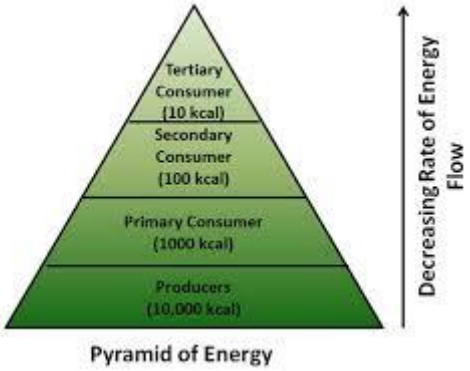
Since this type of representation takes into account the fact that the majority of the energy present at one trophic level will not be available for the next one, it is more accurate than the other two pyramids.

It's an important type of ecological pyramid because it examines the flow of energy in an ecosystem over time

This idea is based on Lindeman's Ten Percent Law, which states that only about 10% of the energy in a trophic level will go towards creating biomass. In other words, only about 10% of the energy will go into making tissue, such as stems, leaves, muscles, etc. in the next trophic level. The rest is used in respiration, hunting, and other activities, or is lost to the surroundings as heat. What's interesting, however, is that toxins are passed up the pyramid very efficiently, which means that as we go up the ecological pyramid, the amount of harmful chemicals is more and more concentrated in the organisms' bodies. This is what we call *biomagnification*.

The pyramid of productivity is the most widely used type of ecological pyramid, and, unlike the two other types, can never be largest at the apex and smallest at the bottom.. Unit: J m^{-2} yr^{-1}, where Joule is the unit for energy, which can be interchanged by other units of energy such as Kilojoule, Kilocalorie, and calorie.

While a productivity pyramid always takes an upright pyramid shape, number pyramids are sometimes inverted, or don't take the shape of an actual pyramid at all.



Pyramid of Energy

1.5.4 Function of Ecological Pyramid

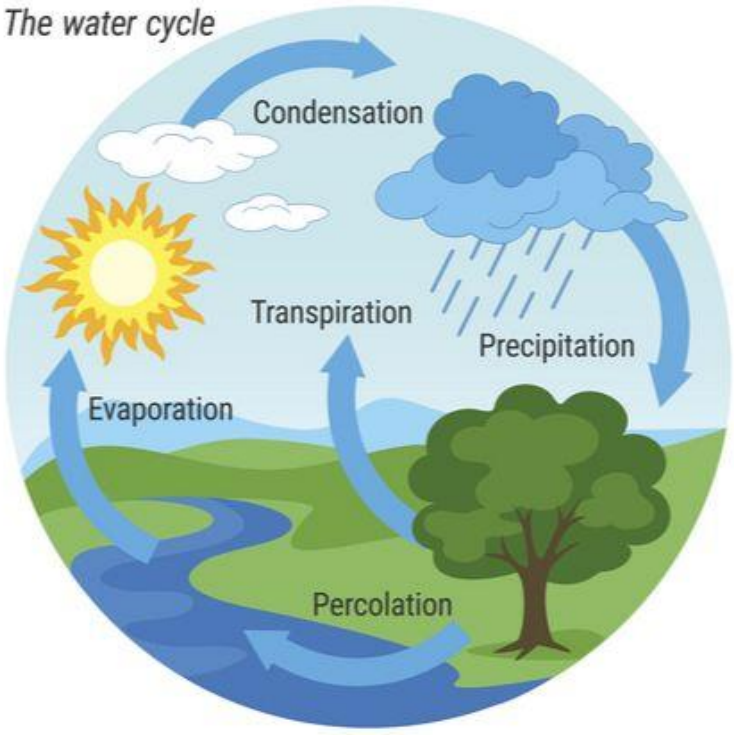
An ecological pyramid not only shows us the feeding patterns of organisms in different ecosystems, but can also give us an insight into how inefficient energy transfer is, and show the influence that a change in numbers at one trophic level can have on the trophic levels above and below it. Also, when data are collected over the years, the effects of the changes that take place in the environment on the organisms can be studied by comparing the data. If an ecosystem's conditions are found to be worsening over the years because of pollution or overhunting by humans, action can be taken to prevent further damage and possibly reverse some of the present damage.

1.6 HYDROLOGIC CYCLE

It is a process that describes the storage and movement of water between biospheres. Atmosphere, lithosphere, and hydrosphere.

Or

The pathway of water as it moves in its various phases to the atmosphere, to the earth, over and through the land, to the ocean and back to the atmosphere. This cycle has no beginning or end and water is present in all the three states (solid, liquid, and gas).



The hydrologic cycle begins with the evaporation of water from the surface of the ocean. As moist air is lifted, it cools and water vapor condenses to form clouds. Moisture is transported around the globe until it returns to the surface as precipitation. Once the water reaches the ground, one of two processes may occur; 1) some of the water may evaporate back into the atmosphere or 2) the water may penetrate the surface and become groundwater. Groundwater either seeps its way to into the oceans, rivers, and streams, or is released back into the atmosphere through transpiration. The balance of water that remains on the earth's surface is runoff, which empties into lakes, rivers and streams and is carried back to the oceans, where the cycle begins again

1.6.1 Components of Hydrological cycle

i. *Condensation*: Cooling of water vapor until it become liquid
ii. *Precipitation*: Moisture that fall from atmosphere as rain, snow, sleet or hail.
iii. *Evaporation*: Phase where liquid change to vapor. ***Evapotranspiration*** is combination of evaporation and transpiration. Transpiration is process by which plant return moisture to air. Plant take water from roots and loose some water form pores in leaves. ***Potential evapotranspiration*** is the amount of water that would be evaporated under optimal set of condition, most important is unlimited supply of water.
iv. *Infiltration and percolation:* Precipitation that is cooled by leaves is called interception. Percolation is downward movement of water through soil and rocks. Occur beneath the root zone.
v. *Runoff:* movement of water usually from precipitation across the earth surface.

1.7 Chemical Cycles

1.7.1 Carbon Cycle

The series of processes by which carbon compounds are interconverted in the environment, involving the incorporation of carbon dioxide into living tissue by photosynthesis and its return to the atmosphere through respiration, the decay of dead organisms, and the burning of fossil fuels. All living things are made of carbon. Carbon is also a part of the ocean, air, and even rocks. Because the Earth is a dynamic place, carbon does not stay still. It is on the move!

In the atmosphere, carbon is attached to some oxygen in a gas called carbon dioxide.

Plants use carbon dioxide and sunlight to make their own food and grow. The carbon becomes part of the plant. Plants that die and are buried may turn into fossil fuels made of carbon like coal and oil over millions of years. When humans burn fossil fuels, most of the carbon quickly enters the atmosphere as carbon dioxide.

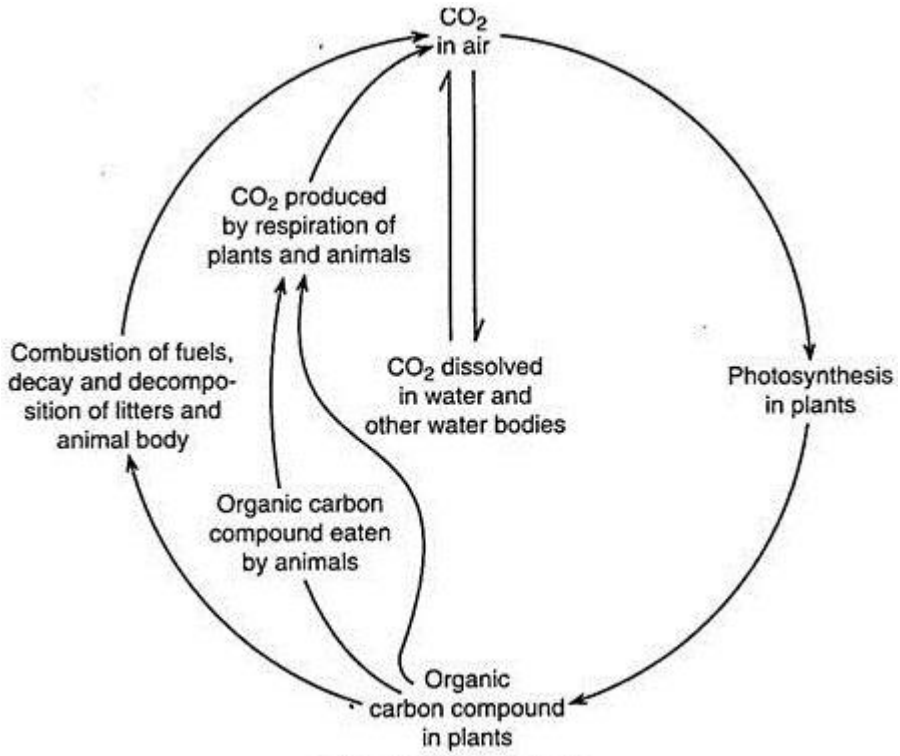


Fig. 2.33 : Carbon cycle

1.7.2 Nitrogen Cycle

It is the series of processes by which nitrogen and its compounds are interconverted in the environment and in living organisms, including nitrogen fixation and decomposition.

Nitrogen, a component of proteins and nucleic acids, is essential to life on Earth. Although 78 percent by volume of the atmosphere is nitrogen gas, this abundant reservoir exists in a form unusable by most organisms.

Through a series of microbial transformations, however, nitrogen is made available to plants, which in turn ultimately sustain all animal life. The steps, which are not altogether sequential, fall into the following classifications: nitrogen fixation (conversion of nitrogen gas into inorganic nitrogen

compounds) nitrogen assimilation (absorption of nitrogen for energy production), ammonification, nitrification, and denitrification.

Nitrates and ammonia resulting from nitrogen fixation are absorbed into the specific tissue compounds of algae and higher plants. Animals then ingest these algae and plants, converting them into their own body compounds.

The remains of all living things—and their waste products—are decomposed by microorganisms in the process of ammonification, which yields ammonia (NH3) and ammonium (NH_4^+). (Under anaerobic, or oxygen-free, conditions, foul-smelling putrefactive products may appear, but they too are converted to ammonia in time.) Ammonia can leave the soil or be converted into other nitrogen compounds, depending in part on soil conditions.

Nitrification, a process carried out by nitrifying bacteria, transforms soil ammonia into nitrates (NO3−), which plants can incorporate into their own tissues.

Nitrates also are metabolized by denitrifying bacteria, which are especially active in water-logged anaerobic soils. The action of these bacteria tends to deplete soil nitrates, forming free atmospheric nitrogen.

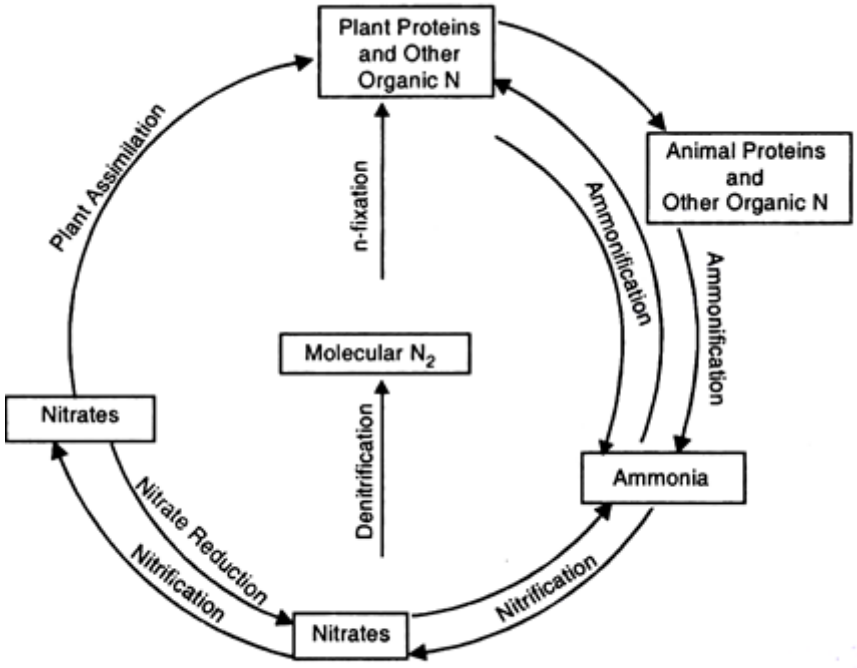
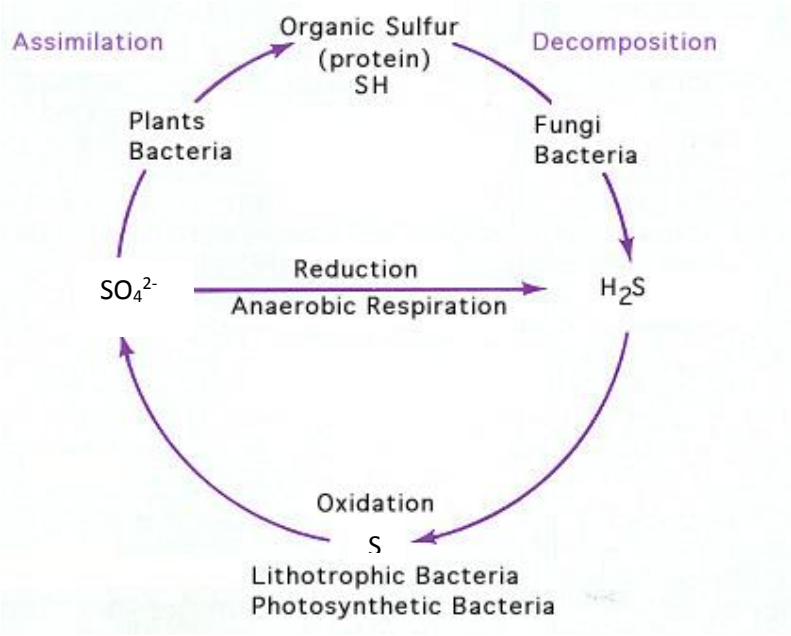


Fig. 12.11. Nitrogen cycle in ecosystem.

1.7.3 Sulphur Cycle

Within the terrestrial portion, the cycle begins with the weathering of rocks, releasing the stored sulfur. The sulfur then comes into contact with air where it is converted into sulfate (SO_4^{2-}). The sulfate is taken up by plants and microorganisms and is converted into organic forms; animals then consume these organic forms through foods they eat, thereby moving the sulfur through the food chain. As organisms die and decompose, some of the sulfur is again released as a sulfate and some enters the tissues of microorganisms. There are also a variety of natural sources that emit sulfur directly into the atmosphere, including volcanic eruptions, the breakdown of organic matter in swamps and tidal flats, and the evaporation of water.



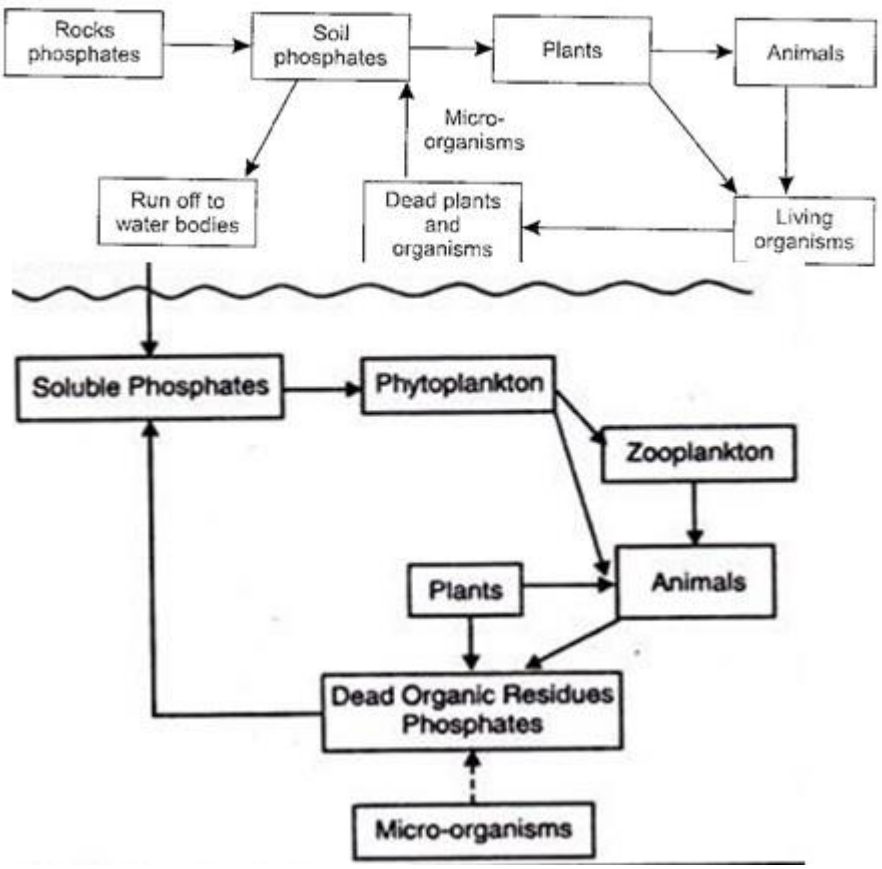
1.7.4 Phosphorous Cycle

The phosphorus cycle is the process by which phosphorus moves through the lithosphere, hydrosphere, and biosphere. Phosphorus is essential for plant and animal growth, as well as the health of microbes inhabiting the soil, but is gradually depleted from the soil over time.

The phosphorus cycle is an extremely slow process, as various weather conditions (e.g., rain and erosion) help to wash the phosphorus found in rocks into the soil. In the soil, the organic matter (e.g., plants and fungi) absorb the phosphorus to be used for various biological processes.

Once in the soil, plants, fungi, and microorganisms are able to absorb phosphorus and grow. In addition, phosphorus can also be washed into the local water systems. Plants can also directly absorb phosphorus from the water and grow. In addition to plants, animals also obtain phosphorus from drinking water and eating plants.

When plants and animals die, decomposition results in the return of phosphorus back to the environment via the water or soil. Plants and animals in these environments can then use this phosphorus, and the cycle is repeated.



1.8 Biodiversity

- It is the *variability among living organisms* from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems.

- *Biodiversity includes all ecosystems*—managed or unmanaged. Unmanaged ecosystems, such as wildlands, nature preserves, or national parks.. Managed systems—be they plantations, farms, croplands, aquaculture sites, rangelands, or even urban parks and urban ecosystems—have their own biodiversity.

1.8.1 Importance of Biodiversity.

Biodiversity has a number of functions on the Earth. These are as follows:

a) **Maintaining balance of the ecosystem:** Recycling and storage of nutrients, combating pollution, and stabilizing climate, protecting water resources, forming and protecting soil and maintaining Eco balance.

b) **Provision of biological resources**: Provision of medicines and pharmaceuticals, food for the human population and animals, ornamental plants, wood products, breeding stock and diversity of species, ecosystems and genes.

c) **Social benefits**: Recreation and tourism, cultural value and education and research.
The role of biodiversity in the following areas will help make clear the importance of biodiversity in human life:

d) **Biodiversity and food**: 80% of human food supply comes from 20 kinds of plants. But humans use 40,000 species for food, clothing and shelter. Biodiversity provides for variety of foods for the planet.

e) **Biodiversity and human health**: The shortage of drinking water is expected to create a major global crisis. Biodiversity also plays an important role in drug discovery and medicinal resources. Medicines from nature account for usage by 80% of the world's population.

f) **Biodiversity and industry**: Biological sources provide many industrial materials. These include fiber, oil, dyes, rubber, water, timber, paper and food.

g) **Biodiversity and culture**: Biodiversity enhances recreational activities like bird watching, fishing, trekking etc. It inspires musicians and artists.

1.8.2 Threat to Biodiversity

a) *Invasion of Exotic Species*: The introduction of non-native species into an ecosystem can threaten existing biodiversity.
b) *Deforestation:* Deforestation is a direct cause of extinction and loss of biodiversity. Deforestation causes loss of habitat which leads to migration or extinction of species.
c) *Hunting and Poaching*: Hunting is also a major threat to biodiversity. Excessive hunting activities and poaching of animals leads to disturbance of food chain which lead to loss to biodiversity
d) *Pollution*: Contamination of soil, water and air is another major threat to biodiversity. Pollution of natural resources leads to relocation or death of species, causing decline of biodiversity of region
e) *Climate Change*: Changes in climate throughout our planet's history have, of course, altered life on Earth in the long run — ecosystems have come and gone and species routinely go extinct.
But rapid, manmade climate change speeds up the process, without affording ecosystems and species the time to adapt. For example, rising ocean temperatures and diminishing Arctic sea ice affects marine biodiversity and can shift vegetation zones, having global implications.

1.8.3 Solution/Conservation of Biodiversity

The aim of the convention is to save species and plants from extinction and their habitats from destruction.
This can be achieved in following ways:

a) Spreading Awareness: People should be made aware of the activities that are leading to loss to biodiversity and what steps can be taken to avoid such activities.
b) Establishing special provision and care for endangered species.
c) Strict laws against poaching and hunting.
d) Protecting vegetation and planting more trees.

1.9 Environment Pollution

Environment pollution occurs when natural environment can not destroy element without creating damage and harm to itself. The elements are not produced by nature and their destroying process may vary from few days to thousands of years.

Following are the type of environment pollution

1.9.1 Air pollution

Air pollution means the presence of chemicals or compounds in the **air** which are usually not present and which lower the quality of the **air** or cause detrimental changes to the quality of life (such as the damaging of the ozone layer or causing global warming).

Air pollutant can be categorized into two types:

a) *Primary Air Pollutant:*

➔A **primary pollutant** is an air pollutant emitted directly from a source. The source can be natural (e.g.: volcanic eruption) or artificial (e.g.: Industries).

➔ Examples of primary pollutants are sulfure dioxide (SO_2), carbon monoxide (CO), nitrogen oxides (NOX), and particulate matter (PM).

Sulfur dioxide (SO_2)

Sulfur dioxide is an invisible gas with a strong odor. Its main sources are anthropogenic, resulting from the combustion of fuels and the processing of mineral ores containing sulfur. Humans and animals exposed to sulfur dioxide display severe respiratory problems. Sulfur dioxide can interact with water in the atmosphere to form harmful acid rain.

Carbon monoxide (CO)

Carbon monoxide is an odorless gas emitted by the incomplete combustion of fuel. The main sources for atmospheric carbon monoxide are gasoline or diesel-powered engines and biomass burning (forest fires and biomass fuels). Carbon monoxide is very toxic and is linked to an increased risk of heart

disease. Exposure to high levels of CO may lead to unconsciousness or even death.

Nitrogen oxides (NOX)

Fossil fuel combustion (gasoline and diesel engines) is the main source for nitrogen oxides in urban areas, while microbial activity in the soil and agricultural practices such as the use of synthetic fertilizers are its main sources in rural areas. Exposure to nitric oxides may cause an inflammation of the respiratory tracts.

Particulate matter (PM)

Particulate matter is a term referring to solid particles and liquid droplets found in the atmospheric air. Primary particles may be natural, originating from soil dust and sea spray. They can be industrial and transportation-related as well when their sources are metallurgical processes or exhausts and tire breaks.

b) Secondary Air Pollutant:

A **secondary pollutant** is not directly emitted as such, but forms when other pollutants (primary pollutants) react in the atmosphere.

Major examples of secondary pollutants are photochemical oxidants and secondary particulate matter.

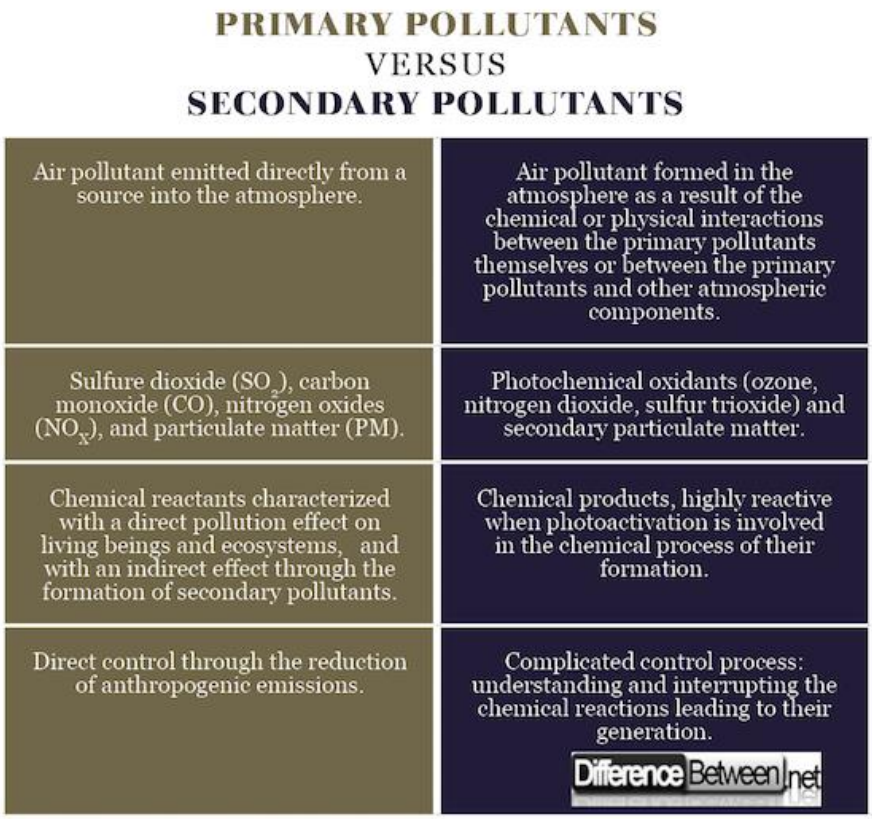
Photochemical oxidants

Photochemical oxidants result from the photochemical reactions involving sunlight with nitrogen oxides, sulfur dioxide, or volatile organic compounds. They include acids, nitrogen dioxide, sulfur trioxide, and ozone. Ozone is considered a 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 tissue.

Secondary particulate matter

Secondary particles are the result of the condensation of gases, the chemical reactions involving primary particles with gases, and the coagulation of various primary particles. The main primary pollutants involved in the formation of secondary particulate matter are sulfur dioxide and nitrogen oxides.

1.9.1.1 Difference between Primary Pollutants and Secondary Pollutants



1.9.1.2 Harmful Effect of Air pollution

a) ***Acidification***: Chemical reactions involving air pollutants can create acidic compounds which can cause harm to vegetation and buildings. Sometimes, when an air pollutant, such as sulfuric acid combines with the water droplets that make up clouds, the water droplets become acidic, forming acid rain. When acid rain falls over an area, it can kill trees and harm animals, fish, and other wildlife.
Acid rain destroys the leaves of plants. When acid rain infiltrates into soils, it changes the chemistry of the soil making it unfit for many living things that depend on the soil as a habitat or for nutrition. Acid rain also changes the chemistry of the lakes and streams that the rainwater flows into, harming fish and other aquatic life.

b) ***Ground-level ozone***:
Chemical reactions involving air pollutants create a poisonous gas ozone (O3). Gas Ozone can affect people's health and can damage vegetation types and some animal life too

c) ***Respiratory and Heart Problems***: With the increased rate of air pollution there has been a trend of rising problems and various health issues pertaining to respiratory diseases and heart problems. These have had a serious impact and also a noticeable increase in the death toll for this reason. The effects have been pretty alarming. There have been instances where several

respiratory and heart conditions have developed. Children are observed to contract pneumonia and asthma due to increased exposure to pollutants.

d) ***Global Warming*** : Increased air pollution is directly related to the cause of global warming which is increasing the temperature worldwide. The rising sea levels, thermal expansion of sea water, melting ice bergs, displacement of living beings from their habitats and even loss of habitats with serious signals of impending disasters. These things can only be mitigated if proper actions are undertaken.

1.9.1.3 Control to Air Pollution

a) Afforestation: Planting trees and sowing seeds is the best way to control air pollution.
b) Source Correction Methods: Industries and automobile are the major source of air pollution. By careful investigation pollution can be controlled from source by eliminating, substituting or modifying air pollution causing stages. For example low sulphur fuel can be used instead of high sulphur fuels in automobiles, smoke, carbon-monoxide and fumes can be reduced if open hearth furnaces are replaced with controlled basic oxygen furnaces or electric furnaces.
c) Using pollution controlling equipment's like cyclone separator, electrostatic precipitator etc.
d) Changing Habits: Air pollution can be greatly reduced by making few changes in daily habits. For example: Not using automobiles for short distances, Using public transport instead of private vehicle as much as possible, Regular pollution control check of vehicles and keeping vehicles in good condition.

1.9.2 Noise pollution

Noise pollution is generally defined as regular exposure to elevated sound levels that may lead to adverse effects in humans or other living organisms. According to the World Health Organization, sound levels less than 70 dB are not damaging to living organisms, regardless of how long or consistent the exposure is. Exposure for more than 8 hours to constant noise beyond 85 dB may be hazardous.

1.9.2.1 Harmful Effect of Noise Pollution:

Human Diseases Caused by Noise Pollution

Whether we realize we are subjected to it or not, noise pollution can be hazardous to our health in various ways.

a) ***Hypertension*** Prolonged exposure to high pitch noise leads to elevated blood levels.

b) ***Hearing loss*** can be directly caused by noise pollution, whether listening to loud music in your headphones or being exposed to loud drilling noises at work, heavy air or land traffic, or separate incidents in which noise levels reach dangerous intervals, such as around140 dB for adult or 120 dB for children.

c) ***Sleep disturbances*** are usually caused by constant air or land traffic at night, and they are a serious condition in that they can affect everyday performance and lead to serious diseases.

d) ***Child development****:* Children appear to be more sensitive to noise pollution, and a number of noise-pollution-related diseases and dysfunctions are known to affect children, from hearing impairment to psychological and physical effects. Also, children who regularly use music players at high volumes are at risk of developing hearing dysfunctions. In 2001, it was estimated that 12.5% of American children between the ages of 6 to 19 years had impaired hearing in one or both ears

e) ***Various cardiovascular dysfunctions***. Elevated blood pressure caused by noise pollution, especially during the night, can lead to various cardiovascular diseases.

1.9.2.2 Effects of Noise Pollution on Wildlife and Marine Life

Thousands of oil drills, sonars, seismic survey devices, coastal recreational watercraft and shipping vessels produce a serious cause of noise pollution for marine life. Whales are among the most affected, as their hearing helps them orient themselves, feed and communicate. Noise pollution thus interferes with cetaceans' (whales and dolphins) feeding habits, reproductive patterns and migration routes, and can even cause hemorrhage and death.

Other than marine life, land animals are also affected by noise pollution in the form of traffic, firecrackers etc., and birds are especially affected by the increased air traffic.

1.9.2.3 Preventing Noise Pollution

a) Wear earplugs whenever exposed to elevated noise levels
b) Maintain a level of around 35 dB in bedroom at night, and around 40 dB in house during the day
c) If possible, choose your residential area as far removed from heavy traffic as you can
d) Avoid prolonged use of earphones, especially at elevated sound levels

1.9.3 Water pollution

Water pollution occurs when harmful substances—often chemicals or microorganisms—contaminate a stream, river, lake, ocean, aquifer, or other body of water, degrading water quality and rendering it toxic to humans or the environment.

1.9.3.1 Source of Water Pollution

a) Domestic Sewage: Include household waste like paper, vegetables, garbage etc. These when disposed in an unmanaged way end up in local water bodies causing water pollution.
b) Industrial Waste: Include hazardous chemicals, insecticides, pesticides etc. These are major pollution cause source and if unchecked cause severe contamination of water in short duration causing death of aquatic life.
c) Random source: Theses include unplanned source usually Accidents like oil spills, leaks in tanks etc.

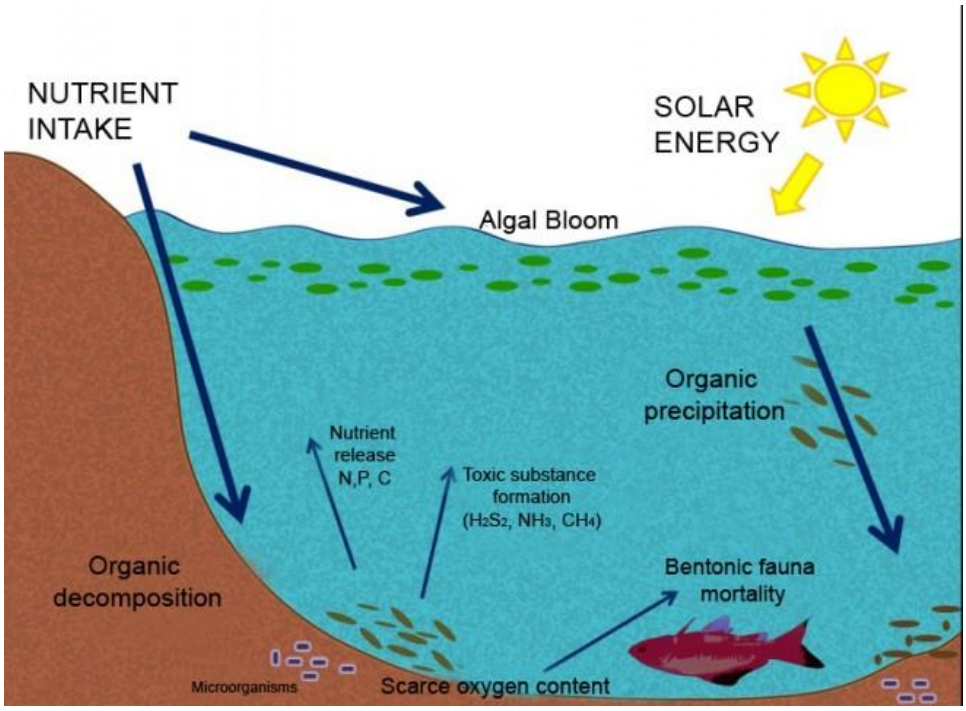
1.9.3.2 Effect of Water pollution:

i. *Diseases*: In humans, drinking or consuming polluted water in any way has many disastrous effects on our health. It causes typhoid, cholera, hepatitis and various other diseases.
ii. *Destruction of Ecosystems*: Ecosystems are extremely dynamic and respond to even small changes in the environment. Water pollution can cause an entire ecosystem to collapse if left unchecked.
iii. *Eutrophication*: Chemicals in a water body, encourage the growth of algae. These algae form a layer on top of the pond or lake. Bacteria feed on this algae and this decreases the amount of oxygen in the water body, severely affecting the aquatic life there.
iv. *Effects the food chain*: Disruption in food chains happens when toxins and pollutants in the water are consumed by aquatic animals (fish, shellfish etc) which are then consumed by humans.

1.9.3.3 Eutrophication

Eutrophication is characterized by a significant increase of algae (microscopic organisms similar to plants) due to the greater availability of one or more growth factors necessary for photosynthesis, such as sunlight, carbon dioxide and nutrients (nitrogen and phosphorus).

To destroy all the dead algae, the microorganism require an excessive consumption of oxygen. Thus, an anoxic (oxygen-free) environment is created at the bottom of the lake, leading to growth of organisms capable of living in the absence of oxygen (anaerobic), responsible for the degradation of the biomass.
The microorganisms, decomposing the organic substance in the absence of oxygen, liberates compounds that are toxic, such as ammonia and hydrogen sulphide (H_2S). The absence of oxygen reduces biodiversity which in extreme cases cause the death of animal and plant species. All this happens when the rate of degradation of the algae by microorganisms is greater than that of oxygen regeneration, which in summer is already present in low concentrations.



1.9.3.4 Effect

i. Abundance of organic substances gives the water bad odours or tastes.

ii. These substances, moreover, form complex chemical compounds that prevent normal purification processes and are deposited on the walls of the water purifier inlet tubes, accelerating corrosion and limiting the flow rate;

iii. Disappearance or significant reduction of quality fish with very negative effects on fishing (instead of quality species such as trout undesirable ones such as carp become established);

iv. Possible affirmation of toxic algae with potential damage to the population and animals drinking the affected water;

v. prohibition of touristic use of the lake and bathing, due to both the foul odour on the shores caused by the presence of certain algae, water become dangerous for health because certain algae cause skin irritation;

vi. Reduction of oxygen concentration, especially in the deeper layers of the lake at the end of summer and in autumn causing death of marine life.

1.9.5 Waste Water Treatment

The treatment of waste water proceeds in following stages:

1) Preliminary Treatment
2) Primary Treatment
3) Secondary Treatment
4) Tertiary Treatment

1. Preliminary Treatment

If the waste water contain excess amount of solid waste, then a preliminary treatment is given. In this stage, large solid particles and floating matters are removed. This is achieved by Screening Process.. The space of the perforation varies from 10-60mm. Based on perforation size, screen are classified as fine screens (size 10-20 mm) and coarse screens (size 20-60mm). The selection of screen size is dependent upon quality of solid waste present. Usually in preliminary treatment, coarse screen is used.

2. Primary treatment

Primary treatment removes material that will either float or readily settle out by gravity. It includes the physical processes of screening, comminution, grit removal, and sedimentation.

- Screens are made of long, closely spaced, narrow metal bars. They block floating debris such as wood, rags, and other bulky objects that could clog pipes or pumps. In modern plants the screens are cleaned mechanically, and the material is promptly disposed of by burial on the plant grounds.
- A comminutor may be used to grind and shred debris that passes through the screens. The shredded material is removed later by sedimentation or flotation processes.
- Grit chambers are long narrow tanks that are designed to slow down the flow so that solids such as sand, coffee grounds, and eggshells will settle out of the water. Grit causes excessive wear and tear on pumps and other plant equipment. Its removal is particularly important in cities with combined sewer systems, which carry a good deal of silt, sand, and gravel that wash off streets or land during a storm.

- Suspended solids that pass through screens and grit chambers are removed from the sewage in sedimentation tanks. These tanks, also called primary clarifiers, provide about two hours of detention time for gravity settling to take place. As the sewage flows through them slowly, the solids gradually sink to the bottom. The settled solids—known as raw or primary sludge—are moved along the tank bottom by mechanical scrapers. Sludge is collected in a hopper, where it is pumped out for removal. Mechanical surface-skimming devices remove grease and other floating materials.

Primary Treatment:

Prelimany Treatment➔Screening➔Comminutor➔Grit Chamber➔Sedimentation Tank

3. Secondary treatment

Secondary treatment *removes the soluble organic matter* that escapes primary treatment. It also removes more of the suspended solids. Removal is usually *accomplished by biological processes* in which microbes consume the organic impurities as food, converting them into carbon dioxide, water, and energy for their own growth and reproduction.

- Removal of soluble organic matter at the treatment plant helps to protect the dissolved oxygen balance of a receiving stream, river, or lake.

- There are three basic biological treatment methods: the trickling filter, the activated sludge process, and the oxidation pond. A fourth, less common method is the rotating biological contacter.

3.1 Trickling filter

- A trickling filter is simply a tank filled with a deep bed of stones. Settled sewage is sprayed continuously over the top of the stones and trickles to the bottom, where it is collected for further treatment.
- As the wastewater trickles down, bacteria gather and multiply on the stones. The steady flow of sewage over these growths allows the microbes to absorb the dissolved organics, thus

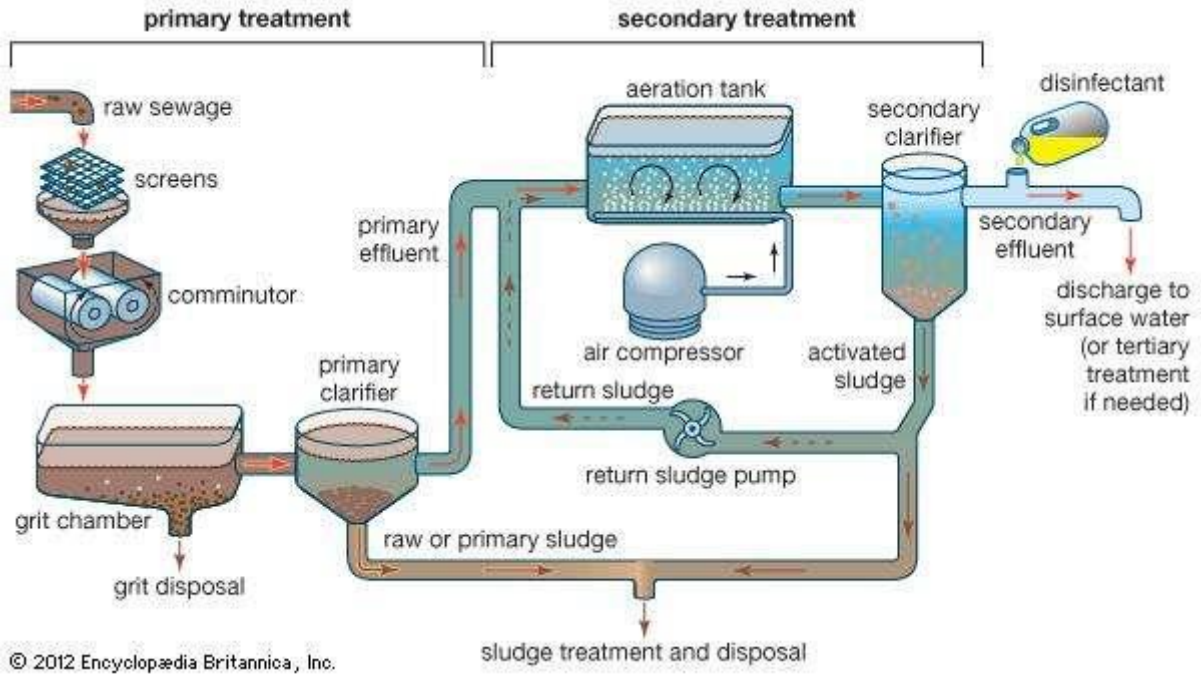
lowering the biochemical oxygen demand (BOD) of the sewage. Air circulating upward through the spaces among the stones provides sufficient oxygen for the metabolic processes.

- Settling tanks, called secondary clarifiers, follow the trickling filters. These clarifiers remove microbes that are washed off the rocks by the flow of wastewater. Two or more trickling filters may be connected in series, and sewage can be recirculated in order to increase treatment efficiencies.

3.2 Activated sludge

- The activated sludge treatment system consists of an aeration tank followed by a secondary clarifier. Settled sewage, mixed with fresh sludge that is recirculated from the secondary clarifier, is introduced into the aeration tank.
- Compressed air is then injected into the mixture through porous diffusers located at the bottom of the tank. As it bubbles to the surface, the diffused air provides oxygen and a rapid mixing action.
- Under such oxygenated conditions, microorganisms thrive, forming an active, healthy suspension of biological solids—mostly bacteria—called activated sludge. About six hours of detention is provided in the aeration tank. This gives the microbes enough time to absorb dissolved organics from the sewage, reducing the BOD.
- The mixture then flows from the aeration tank into the secondary clarifier, where activated sludge settles out by gravity. Clear water is seprated from the surface of the clarifier, disinfected, and discharged as secondary effluent. The sludge is pumped out from a hopper at the bottom of the tank.
- About 30 percent of the sludge is recirculated back into the aeration tank, where it is mixed with the primary effluent. This recirculation is a key feature of the activated sludge process. The recycled microbes are well acclimated to the sewage environment and readily metabolize the organic materials in the primary effluent. The remaining 70 percent of the secondary sludge must be treated and disposed of in an acceptable manner (see Sludge treatment and disposal).
- Variations of the activated sludge process include extended aeration, contact stabilization, and high-purity oxygen aeration. Extended aeration and contact stabilization systems omit the primary settling step. They are efficient for treating small sewage flows from motels, schools,

and other relatively isolated wastewater sources. Both of these treatments are usually provided in prefabricated steel tanks called package plants. Oxygen aeration systems mix pure oxygen with activated sludge. A richer concentration of oxygen allows the aeration time to be shortened from six to two hours, reducing the required tank volume.



4. Tertiary Treatment

Tertiary treatment is the next wastewater treatment process after secondary treatment. This treatment is sometimes called as the final or advanced treatment and consists of removing the organic load left after secondary treatment for removal of nutrients from sewage and particularly to kill the pathogenic bacteria.

The purpose of tertiary treatment is to removes different types of pollutants such as organic matter, SS, nutrients, pathogens, and heavy metals that secondary treatment is not able to remove. Wastewater effluent becomes even cleaner in this treatment process through the use of stronger and more advanced treatment systems

4.1 Need of Tertiary treatment

Tertiary treatment may be provided to the secondary effluent for one or more of the following

contaminant further.

1) To remove total suspended solids and organic matter those are present in effluents after

secondary treatment.

2) To remove specific organic and inorganic constituents from industrial effluent to make it suitable for reuse.
3) To make treated wastewater suitable for land application purpose or directly discharge it into the water bodies like rivers, lakes, etc.
4) To remove residual nutrients beyond what can be accomplished by earlier treatment methods.
5) To remove pathogens from the secondary treated effluents.
6) To reduce total dissolved solids (TDS) from the secondary treated effluent to meet reuse quality standards

4.2 Method of Tertiary Treatment

a. *Phosphorous Removal*
Can be removed either chemically or biologically. Chemical process is comparatively expansive, hence used only when concentration of phosphorous is extremely high and required removal rate is fast.
- In Chemical process effluent from secondary treatment is mixed with calcium oxide. Calcium oxide reacts to from insoluble calcium phospahate, which settels in bottom and is filtered out
- Biological treatment is carried out by introducing phosphorous consuming bacteria to the treatment unit. Once bacteria decompose all phosphorous, the biomass created during the process is removed and is used as fertilizer.

b. *Nitrogen Removal*
Done using nitrification-denitrification process. Two type of nitrogen reaction occur, in first stage, reaction is aerobica and nitrogen is converted to nitrates. Second stafe is anaerobic and nitrates is reduced to nitrogen gas which escapes out from treatment unit.

c. Disinfection: in this process pathogenic bacteria, virus, protozoa are removed via following process
a) *Boiling*: Simple and easy. Useful for small quantity of water
b) *Adding Bleaching Powder*. Very efficient method. Bleaching powder which is a mix of $Ca(OCl_2)$, $CaOCl_2$ and $CaCl_2$ upon addition of water converts into hypoclorus acid (HOCl) which is powerful germicide. Its disadvantage is that excess quantity increase hardness, provide bad taste and odor
c) *Chlorinatio*n: It is the most economical process. Chlorine is added in solid or gaseous form, which upon addition convert into hypochlorous acid which act as disinfectant. The disadvantage of this process is that addition in excess quantity produce bad taste and irritation to skin.
d) *Potassium per magnate*: It is the oldest disinfectant method. Upon the addition, water turns pink which become transparent upon the completion of disinfectant process. Most preferred method in rural areas.

1.9.4 Environment Regulations and Acts

The need for protection and conservation of environment and sustainable use of natural resources is reflected in the constitutional framework of India and also in the international commitments of India.

Part IVA of Indian constitution cast duty on every citizen of India to protect and improve natural environment and have compassion for living creatures.

Though many rules, regulations and legislation has been set up by Government of India to protect the environment, some main are:

1. **The Wildlife Protection Act, 1972**

Objective: Effectively protecting the wild life of this country and to control poaching, smuggling and illegal trade in wildlife and its derivatives. The Act was amended in January 2003

2. **The Water (Prevention and Control of Pollution) Act, 1974**

Objective: Prevention and control of water pollution and to maintain or restore wholesomeness of water in the country. The Water Act prohibits the discharge of pollutants into water bodies beyond a given standard, and lays down penalties for non-compliance. It empowers the Government to constitute Pollution Control Boards to maintain the wholesomeness of national water bodies. It enables Central and State Pollution Control Boards to prescribe standards and has provisions for monitoring & compliance and penal provisions against the violators of the Act. It provides the permit system i.e. "Consent" procedure to prevent and control of water pollution. The Act empowers State Boards to issue directions to the defaulters.

3. **The Forest Conservation Act, 1980**

Objective: To help conserve the country's forests. It strictly restricts and regulates the de-reservation of forests or use of forest land for non-forest purposes without the prior approval of Central Government.

4. **The Air (Prevention and Control of Pollution) Act, 1981 or the "Air Act"**

Objective: a)Combat air pollution by prohibiting the use of polluting fuels and substances, as well as by regulating appliances that give rise to air pollution

b) Counter the problems associated with air pollution, ambient air quality standards were established under the Air Act.

5. **The Environment Protection Act, 1986**

It is an umbrella legislation. It includes water, air and land as well as the interrelationship which exists between water, air and land, and human beings, other living creatures, plants, micro-organisms and property.The Environment Protection Act establishes the framework for studying, planning and implementing long-term requirements of environmental safety and laying down a system of speedy and adequate response to situations threatening the environment. Violation of this result in imprisonment and/or prison time.

6. **The Biological Diversity Act, 2002**

The Act aims at the conservation of biological resources and associated knowledge as well as facilitating access to them in a sustainable manner. It attempt to realize the objectives enshrined in the United Nations Convention on Biological Diversity (CBD), 1992 which recognizes the sovereign rights of states to use their own Biological Resources.

7. **The National Green Tribunal Act, 2010**

Objective: Setting up National green tribunal for effective and expeditious disposal of cases relating to environment protection and conservation of forests and other natural resources.

Hazardous Wastes Management Regulations

Hazardous waste means any waste which, by reason of any of its physical, chemical, reactive, toxic, flammable, explosive or corrosive characteristics, causes danger or is likely to cause danger to health or environment, whether alone or when in contact with other wastes or substances.

There are several legislations that directly or indirectly deal with hazardous waste management. Few relevant are:

Hazardous Wastes (Management, Handling and Transboundary) Rules, 2008, brought out a guide for manufacture, storage and import of hazardous chemicals and for management of hazardous wastes.

Biomedical Waste (Management and Handling) Rules, 1998, were formulated along parallel lines, for proper disposal, segregation, transport, etc, of infectious wastes.

Municipal Solid Wastes (Management and Handling) Rules, 2000, aim at enabling municipalities to dispose municipal solid waste in a scientific manner.

1.9.5 Rain Water Harvesting

It is a technique or strategy for the collection of rainwater and storing it in the right way for future use. The water can be collected from various surfaces and platforms and stored for later use. In most cases, the water is usually collected from rooftops and other hard surfaces. Rainwater harvesting is considered as a very reliable way to conserve water.

1.9.5.1 Advantages of Rainwater Harvesting

In both urban and rural setting, harvesting can be done by the use of infrastructure. One of the simplest ways of storing water from the collection is storage tanks. In most cases, the harvested water is usually redirected to storage tanks, cistern or reservoirs. The water is usually stored for later use. The roof of buildings is the best way to harvest rainwater. There are numerous advantages in doing so.

1. Easy to Maintain

The use of rainwater harvesting system provides ideal merits to any community. First and foremost, the collection offers a better and efficient utilization of energy resource. It is important because potable water is usually not renewable, thus reducing wastage. The systems used for water collection is based on simple techniques that are very easy to maintain. The overall expenses used in setting up harvesting methods are much cheaper compared to other purifying or pumping means. Also, its maintenance is feasible on the economic front as it does not require deep pockets.

2. Reducing Water Bills

Water that has been stored from harvesting water can be used for several non-drinking purposes. It will immediately reduce one's utility bills. It is ideal for both residential and commercial properties.

3. Suitable for Irrigation

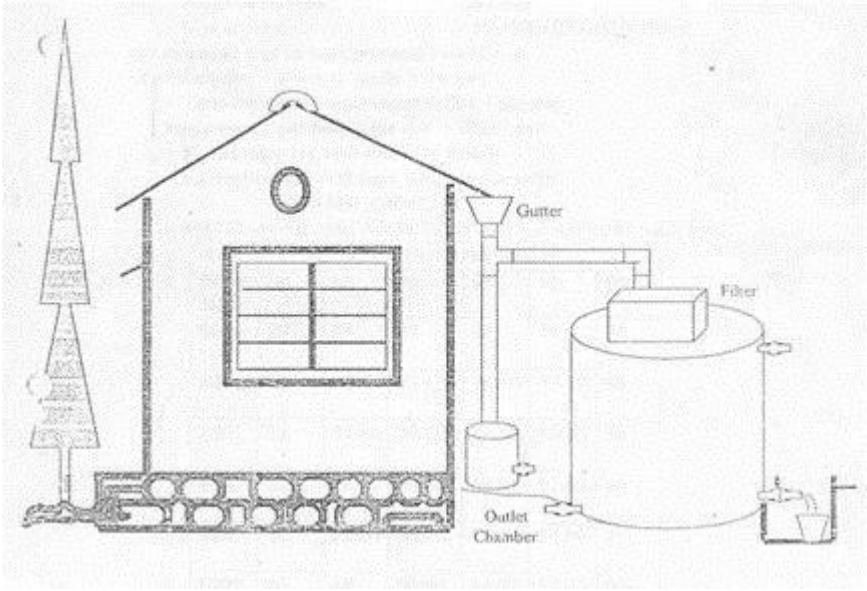
Harvesting allows the collection of large amounts of water. Most rooftops provide the necessary platform for collecting water. Rainwater is usually free from harmful chemicals, which makes it ideal for irrigation purposes.

4. Reduce demand on Ground Water

Another important advantage is that it reduces demand for potable water. It is important especially in areas with low water levels.

1.9.5.2 Techniques of Rainwater Harvesting

The collection of rainwater can be done in various methods depending on a few factors. A few common methods include the following:



1. Rain barrels

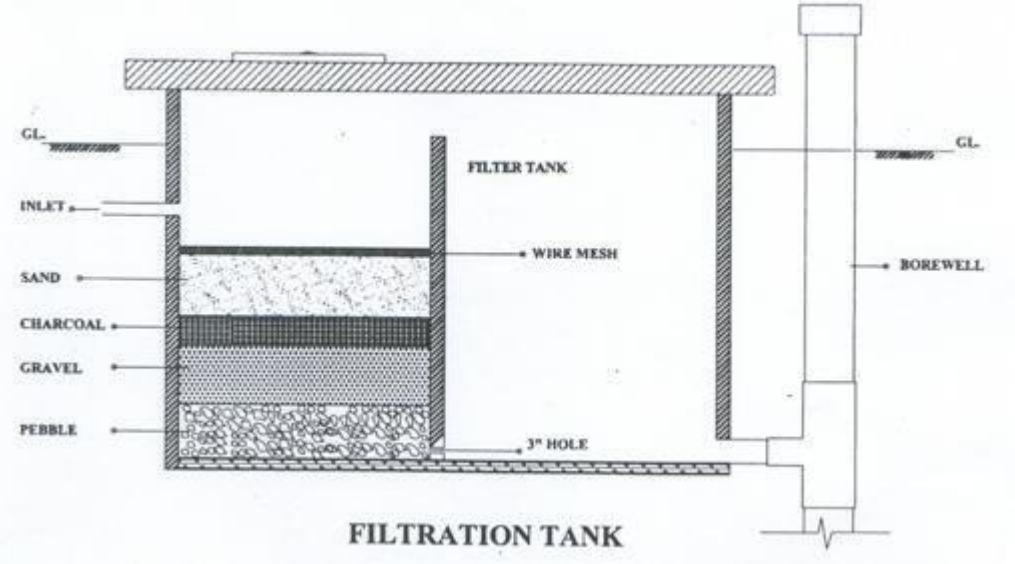
It is the easiest and affordable method of rainwater harvesting, especially at home. It is where barrels or water tanks installed below the downspouts of the rooftops guttering system. The water is then funneled/directed into the tanks. The tank can be connected to provide backup water to your current plumbing system, or it can be attached to a pipe for drip irrigation. The use of barrels or tanks is ideal since it can store significant amounts of water.

2. Ground water aquifer recharge method

This is done by building various kind of underground structures like recharging bore wells, dug wells, pits, trenches and recharge shafts to ensure percolation of rainwater in ground instead of draining away on surface.

2.1 Recharge through bore wells

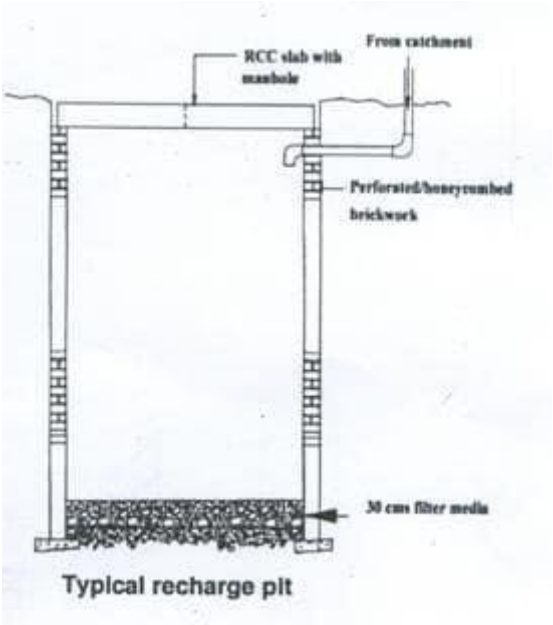
Rainwater from roof top is diverted into filtration tank from which it is diverted into bore wells to recharge deep aquifers.



FILTRATION TANK

2.2 Recharge pits

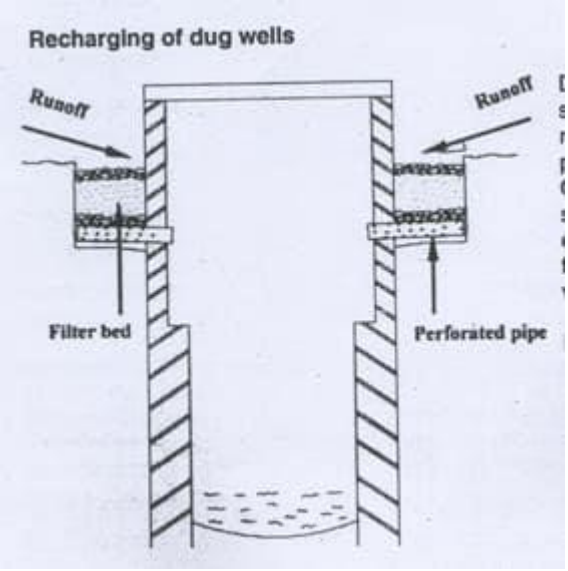
Small pits of is constructed using bricks masonry wall and top is covered with perforated cover or an RCC slab. The capacity of pit is as per catchment area (*the area from which rainfall flows into river or reservoir)* and rainfall intensity. These are suitable for small houses.



Typical recharge pit

2.3 Recharge through dough well

Dug well can be used as recharge structure. Rainwater from the rooftop is diverted to dug wells after passing it through filtration bed. Cleaning and desalting of dug well should be done regularly to enhance the recharge rate. The filtration method suggested for bore well recharging could be used



3. Green Roof

This method of harvesting does not need the use of storage tanks. Instead of storing the water in a reservoir, the water is channeled straight to the garden. The process will require installing a drainage system on a building's roof straight to the backyard. It is a very low maintenance method.

These are few of the standard rainwater harvesting methods, which are mainly done in many households

1.9.5.3 How Rainwater Harvesting Solves Water Shortage?

Harvesting and collection of rainwater is a proper way that can be used to address the problem of the water crisis in various parts of the world. This simple water conservation method can be used to put forward a remarkable solution in areas where there is enough rainfall but not enough supply of groundwater.

The collected rain water can be used for daily household purposes like sweeping, washing cloths and utensils, bathing etc.

The rainwater collected at pit can serve as water source for local birds and animal, conserving the extra quantity of water that would have otherwise been used for the same purpose.

Rain water can also be used to improve the groundwater level by allowing it to percolate into the ground surface instead of letting it go waste in the form of urban runoff.

Storing rainwater and directing it into the gardens, agriculture field and other vegetation rich area when required conserves a considerable amount of water and save vegetation form fading.

2.0 Solid Waste Management

Solid waste means any garbage, refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded materials including solid, liquid, semi-solid, or contained gaseous material, resulting from industrial, commercial, mining and agricultural operations, and from community activities, but does not include solid or dissolved materials in domestic sewage, or solid or dissolved materials.

Example of solid waste are: waste tires, scrap metal, discarded furniture and toys, garbage, oil and anti-freeze, paint cans and construction and demolition debris, asbestos.

Classification of solid waste

Solid waste can be categorized into following:

a) ***Source Based Classification***

(i) Residential: This refers to wastes from dwellings, apartments, etc., and consists of leftover food, vegetable peels, plastic, clothes, ashes, etc.

(ii) Commercial: This refers to wastes consisting of leftover food, glasses, metals, ashes, etc., generated from stores, restaurants, markets, hotels, motels, auto-repair shops, medical facilities, etc.

(iii) Institutional: This mainly consists of paper, plastic, glasses, etc., generated from educational, administrative and public buildings such as schools, colleges, offices, prisons, etc.

(iv) Municipal: This includes dust, leafy matter, building debris, treatment plant residual sludge, etc., generated from various municipal activities like construction and demolition, street cleaning, landscaping, etc.

(v) Industrial: This mainly consists of process wastes, ashes, demolition and construction wastes, hazardous wastes, etc., due to industrial activities.

(vi) Agricultural: This mainly consists of spoiled food grains and vegetables, agricultural remains, litter, etc., generated from fields, orchards, vineyards, farms, etc.

(vii) Open areas: this includes wastes from areas such as Streets, alleys, parks, vacant lots, playgrounds, beaches, highways, recreational areas, etc.

Type-based classification

Classification of wastes based on types, i.e., physical, chemical, and biological

A) PHYSICAL

(i) Garbage: This refers to animal and vegetable wastes resulting from the handling, sale, storage, preparation, cooking and serving of food. Garbage comprising these wastes contains putrescible (rotting) organic matter, which produces an obnoxious odour and attracts rats and other vermin. It, therefore, requires special attention in storage, handling and disposal.

(ii) Ashes and residues: These are substances remaining from the burning of wood, coal, charcoal, coke and other combustible materials for cooking and heating in houses, institutions and small industrial establishments.

(iiv) Bulky wastes: These include large household appliances such as refrigerators, washing machines, furniture, crates, vehicle parts, tyres, wood, trees and branches. Since these household wastes cannot be accommodated in normal storage containers, they require a special collection mechanism.

(iv) Street wastes: These refer to wastes that are collected from streets, walkways, alleys, parks and vacant plots, and include paper, cardboard, plastics, dirt, leaves and other vegetable matter. Littering in public places is indeed a widespread and acute problem in many countries including India, and a solid waste management system must address this menace appropriately.

B) CHEMICAL

(i) Combustible and non-combustible wastes: Waste that are flammable are combustible waste , material here incluse paper, cardboard, textile, rubber, garden trimmings, etc., non-combustible material consists of such items as glass, crockery, tin and aluminium cans, ferrous and non-ferrous material and dirt.

(ii) Hazardous wastes and Non Hazardous: Hazardous wastes are those defined as wastes of industrial, institutional or consumer origin that are potentially dangerous either immediately or over a period of time to human beings and the environment. This is due to their physical, chemical and biological or radioactive characteristics like ignitability, corrosivity, reactivity and toxicity. Typical examples of hazardous wastes are empty containers of solvents, paints and pesticides, which are frequently mixed with municipal wastes and become part of the urban waste stream. Certain hazardous wastes may cause explosions in incinerators and fires at landfill sites. Others such as pathological wastes from hospitals and radioactive wastes also require special handling. Effective management practices should ensure that hazardous wastes are stored, collected, transported and disposed of separately, preferably after suitable treatment to render them harmless.

C) BIOLOGICAL

Biodegradable and non-biodegradable wastes: Biodegradable wastes mainly refer to substances consisting of organic matter such as leftover food, vegetable and fruit peels, paper, textile, wood, etc., generated from various household and industrial activities. Because of the action of micro-organisms, these wastes are degraded from complex to simpler compounds. Non-biodegradable wastes consist of inorganic and recyclable materials such as plastic, glass, cans, metals, etc.

Table 5.8 Classification of Solid waste.

Types of solid waste	Description	Sources
Food waste (garbage)	Wastes from the preparation, cooking & serving of food. market reuse, waste from the handling storage, & sale of meat & vegetables	Households, institutions, & commercials such as hotels, stores, restaurants, markets etc.
Rubbish	Combustible (primary organic), paper, cardboard, cartons, wood, boxes, plastics, rags, cloth, bedding, leather, rubber, grass, yard trimmings. Noncombustible(inorganic) metals, tin cans, metal foils, dirt, stones, bricks, ceramics, crockery, glass bottles, other mineral reuse.	
Ashes & residues	Residue from fires used for cooking & for heating buildings, cinders, clinkers, and thermal power plants.	
Bulky wastes	Large auto parts, tyres, stoves, refrigerators, other large appliances, furniture, large crates, trees, branches, palm fronts, stumps, floatage.	
Street waste	Street sweepings, dirt, leaves, catch basin dirt, animal droppings, contents of litter receptacles, dead animals.	Streets, side walks, alleys, vacant lots etc.
Dead animals	Small animals: cats, dogs, poultry, etc. large animals: horses, cows etc.	
Construction & demolition waste	Lumber, roofing & sheathing scraps, crop residues, broken concrete, rubble, plaster, conduit, pipe, wire, insulation etc.	Construction & demolision sites, remodeling, repairing sites
Industrial waste & sludge	Solid waste resulting from industry processes & manufacturing operations, such as food processing wastes, boiler house cinders, wood, plastic & metal scraps & shaving etc. effluent treatment plant sludge of industries & sewage treatment plant sludges, coarse screening, grit & septic tank.	Factories, power plants, treatment plants, etc.
Hazardous wastes	Hazardous wastes, pathological wastes, explosives, radioactive materials, toxic wastes etc.	Households, hospitals, institutions, stores, industry etc.

1.9 Solid Waste Management

Solid waste management (SWM) is associated with the control of waste generation, its storage, collection, transfer and transport, processing and disposal in a manner that is in accordance with the best principles of public health, economics, engineering, conservation, aesthetics, public attitude and other environmental considerations.

Purpose of solid waste management is:

i. Protection of environmental health.
ii. Promotion of environmental quality.
iii. Supporting the efficiency and productivity of the economy.
iv. Generation of employment and income.

1.9.1 Solid Waste Management System:

A SWM system refers to a combination of various functional elements associated with the management of solid wastes. The system, when put in place, facilitates the collection and disposal of solid wastes in the community at minimal costs,

The functional elements that constitute the system are:

(i) ***Waste generation***: Wastes are generated at the start of any process, and thereafter, at every stage as raw materials are converted into goods for consumption. The type of waste generated determines its disposal activity. For example a biodegradable solid waste like paper can be disposed in landfill.

(ii) Waste storage: Storage is a key functional element because collection of wastes never takes place at the source or at the time of their generation. Onsite storage is of primary importance due to aesthetic consideration, public health and economics involved. Some of the options for storage are plastic containers, conventional dustbins (of households), used oil drums, large storage bins (for institutions and commercial areas or servicing depots), etc.

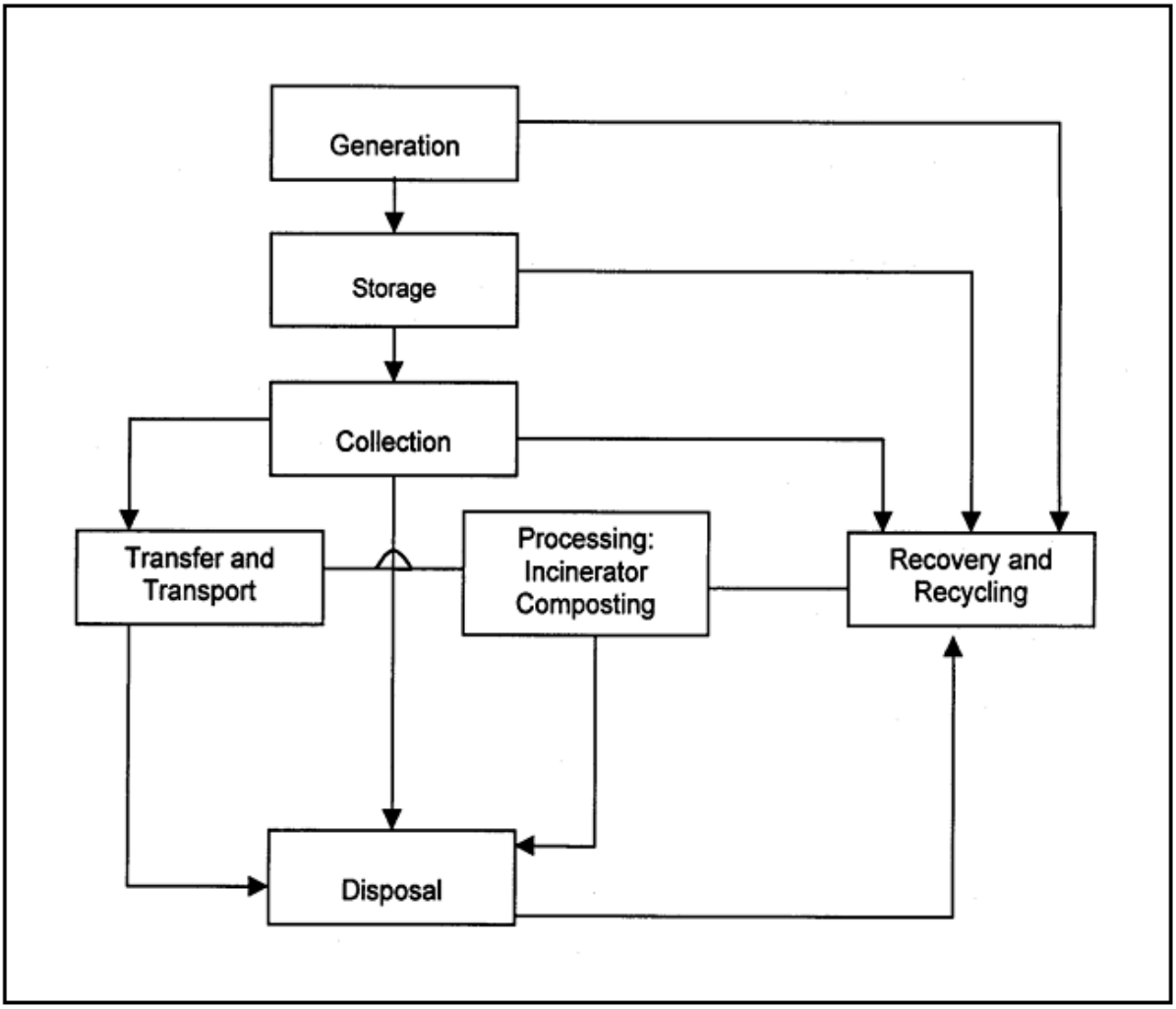
(iii) Waste collection: This includes gathering of wastes and hauling them to the location, where the collection vehicle is emptied, which may be a transfer station (i.e., intermediate station where wastes from smaller vehicles are transferred to larger ones and also segregated), a processing plant or a disposal site. Collection depends on the number of containers, frequency of collection, types of collection services and routes. Typically, collection is provided under various management arrangements, ranging from municipal services to franchised services, and under various forms of contracts.

(iv) Transfer and transport: This functional element involves the transfer of wastes from smaller collection vehicles, where necessary to overcome the problem of narrow access lanes, to larger ones at transfer stations; the subsequent transport of the wastes, usually over long distances, to disposal sites. The factors that contribute to the designing of a transfer station include the type of transfer operation, capacity, equipment, accessories and environmental requirements.

(v) Processing: Processing is required to alter the physical and chemical characteristics of wastes for energy and resource recovery and recycling. The important processing techniques include compaction, thermal volume reduction, manual separation of waste components, incineration and composting.

(vi) Recovery and recycling: This includes various techniques, equipment and facilities used to improve both the efficiency of disposal system and recovery of usable material and energy. Recovery involves the separation of valuable resources from the mixed solid wastes, delivered at transfer stations or processing plants. It also involves size reduction and density separation by air classifier, magnetic device for iron and screens for glass. The selection of any recovery process is a function of economics, i.e., costs of separation versus the recovered-material products. Certain recovered materials like glass, plastics, paper, etc., can be recycled as they have economic value.

(vii) Waste disposal: Disposal is the ultimate fate of all solid wastes, be they residential wastes, semi-solid wastes from municipal and industrial treatment



2.0 DISPOSAL OF SOLID WASTE

a) Open Dumping

Here an uncovered area is used to dump solid waste. This type of disposal practice is highly unhygienic as untreated, uncovered waste produce foul smell and become breeding ground for pest, flies and rodents. Also, during rain, waste get transported to far distance causing clogging and foul odours.

b) Incirnation

- Burning is a very effective method of reducing the volume and weight of solid waste. In modern incinerators the waste is burned inside a properly designed furnace under very carefully controlled conditions. The combustible portion of the waste combines with oxygen, releasing mostly carbon dioxide, water vapour, and heat.
- Advantage: Incineration can reduce the volume of uncompacted waste by more than 90 percent, leaving an inert residue of ash, glass, metal, and other solid materials called bottom ash.
- Disadvantage: The gaseous by-products of incomplete combustion, along with finely divided particulate material called fly ash, are carried along in the incinerator airstream. If the ash is found to contain toxic metals, it must be managed as a hazardous waste. Also, if not proceeded carefully, fire may become uncontrollable and destroy every thing.

c) Composting

Another method of treating municipal solid waste is composting, a biological process in which the organic portion of refuse is allowed to decompose under carefully controlled conditions. Microbes metabolize the organic waste material and reduce its volume by as much as 50 percent. The stabilized product is called compost or humus. It resembles potting soil in texture and odour and may be used as a soil conditioner or mulch.

Composting offers a method of processing and recycling both garbage and sewage sludge in one operation. As more stringent environmental rules and siting constraints limit the use of solid-waste incineration and landfill options, the application of composting is likely to increase. The steps involved in the process include sorting and separating, size reduction, and digestion of the refuse.

d) Landfilling

In this method a pit is dug in ground and is used to dump garbage from various sources. After regular time interval, the garbage is compressed using heavy machinery and covered with soil to avoid breeding of flies and rats. This process is continued till the pit is completely filled with garbage.

Drawback: Leaching of decomposed liquid waste into the soil take place, contaminating soil and ground water table. Since the layer is compacted and sealed with soil, upon long term decomposition, generation of harmful gases like methane causes serious health hazard. Methane is poisonous and explosive when diluted in the air, and it can flow long distances through porous layers of soil. If it is allowed to collect in basements or other confined areas, dangerous conditions may arise

e) Sanitary landfill

Sanitary landfill eliminates drawback attached to landfill disposal. One of the most important factors relating to landfilling is that the buried waste never comes in contact with surface water or groundwater. Sanitary landfills are required to have an impermeable liner or barrier at the bottom, as well as a system of groundwater-monitoring wells. Completed landfill sections must be capped with an impermeable cover to keep precipitation or surface runoff away from the buried waste. Bottom and cap liners may be made of flexible plastic membranes, layers of clay soil, or a combination of both. Also, an exhaust pipe is provide to ensure safe exhaust of generated gases, In modern landfills, methane movement is controlled by impermeable barriers and by gas-venting systems.

2.1 ON SITE SENETATION

Sanitation is a broad term which includes safe disposal of human wastes, waste water management, solid wastes management, water supply, control of vectors of diseases, domestic and personal hygiene, food, housing, etc

2.1.1 Impacts of good sanitation:

Good sanitation has the following impacts on individuals and

on community:

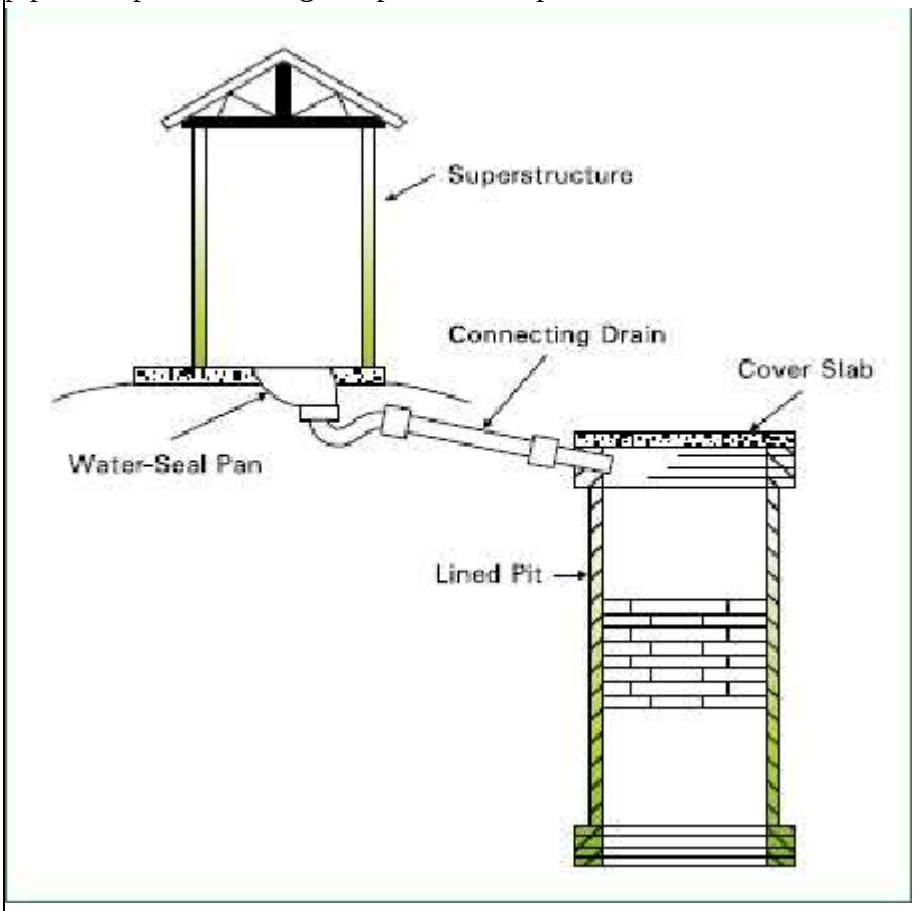
- Improves health
- Decrease in morbidity and mortality
- Improves man-days
- Improves productivity
- Poverty alleviation
- Improves water quality
- Minimizes incidence of drop-out in school particularly girl students

2.1.2 on Site Sanitation Techniques

a) Single off-site Pit Water Seal Toilet

Single Offset Pit Water Seal Toilet' consists of a superstructure connected to pit with help of drains. The wall of the pit has honey combs that help percolate effluent from pit into soil. There is no vent

pipe with pit latrine as gases produced in pits are diffused in soil.

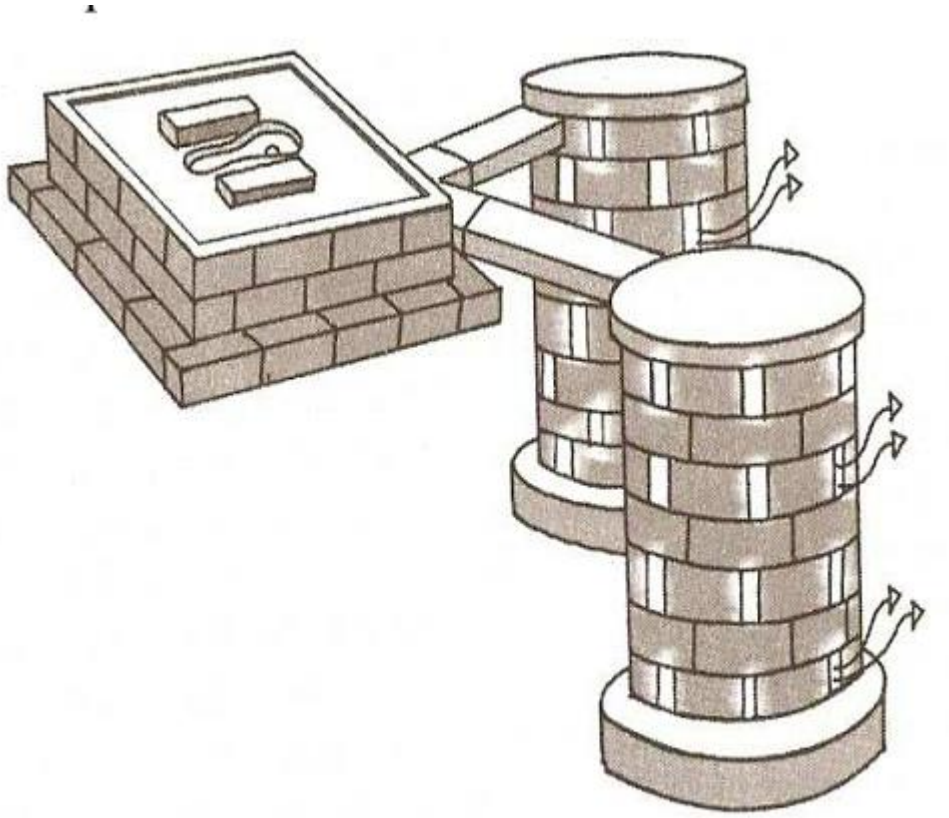


Disadvantages:

Major disadvantage of the single pit is its operational unsustainability. After the pit is filled, it can't be emptied as it contains fresh as well semi degraded excreta. Under such conditions, the only option left is to clean such pits manually by scavengers or dig another pit in neighboring area and used it for disposal purpose. Since manual scavenging is unsocial, unhealthy and against the Scavengers liberation Act of the Government of India and is a punishable offense, diging other pit is the only option which is time consuming and unsustainable.

b) Single pit toilet with provision of double pit.

To overcome the drawback of single pit toilet, a second pit is constructed at later stage, before the first pit is filled. Advantage of having a second pit at later stage just is that one time initial expenditure for construction of toilet is reduced. These two pits are used alternately. Capacity of each pit is for about 3 years. After first pit is filled, human waste is diverted to the second pit. Two years after blocking of the first pit, its contents turn into solid, odour free manure, suitable for use in agriculture and horticulture purposes.



2.1 Energy Recovery from Solid Waste

Numerous technology options are available to harness the energy from the available soild waste. Some are:

a) Thermo Chemical Conversion

In this process, combustible solid waste are separated, collected and fed into boiler chamber where they are burned. Boilers convert the heat of combustion into steam or hot water, thus allowing the energy content of the refuse to be recycled. Incinerators that recycle heat energy in this way are called waste-to-energy plants. The steam produced from burning the waste is used for electricity production. The process saves a huge amount of money that would have been invested to buy coal to generate heat. Also, burning the waste reduced the overall land requirement for waste disposal.

b) Biochemical Conversion

This include anaerobic digestion, fermentation of organic waste to produce compost and biogas. The compost is used as fertilizer in crops and garden, and biogas is as fuel for individual or local community.

c) Physico-Chemical Conversion:

Here, the waste is recycled and reused to produce another material. Widely used for metallic waste, where, the discarded metal are melted and used for production of material. This process saves huge amount of time, money and energy that is invested in production and processing of same metal from its raw material source.

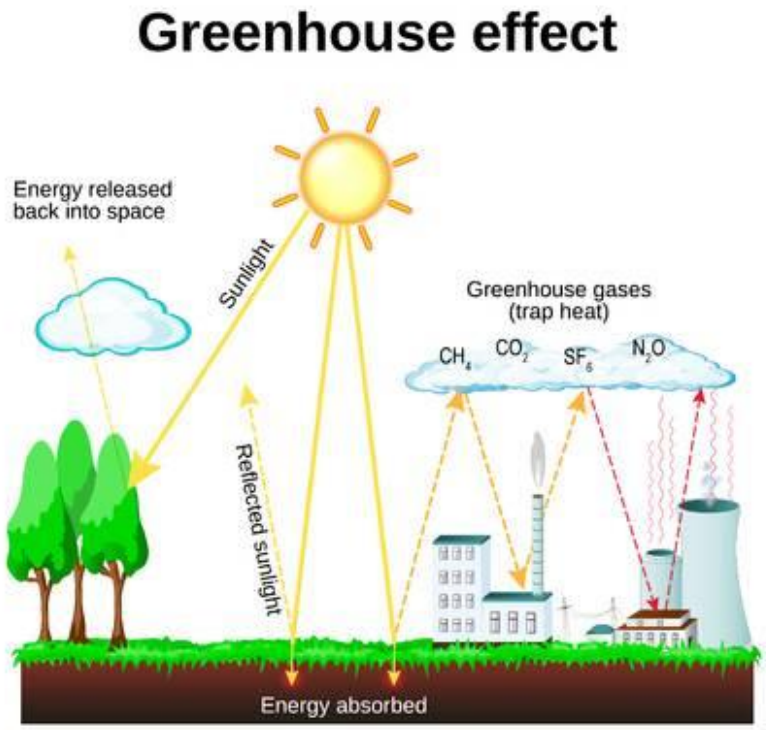
2.2 Importance in waste management

In communities where appropriate sites are available, sanitary landfills usually provide the most economical option for disposal of nonrecyclable refuse. However, it is becoming increasingly difficult to find sites that offer adequate capacity, accessibility, and environmental conditions. Nevertheless, landfills will always play a key role in solid-waste management. It is not possible to recycle all components of solid waste, and there will always be residues from incineration and other treatment processes that will eventually require disposal underground. In addition, landfills can actually improve poor-quality land. In some communities properly completed landfills are converted into recreational parks, playgrounds, or golf courses.

2.3 Green House Effect

The greenhouse effect is the process by which radiation from a planet's atmosphere warms the planet's surface to a temperature that cause sustenance of life. Gases in the atmosphere, like water vapor, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) act as a natural blanket by preventing the sun's heat energy from radiating back into space, much like a greenhouse traps the sun's energy to warm someone's plants even in the middle of winter. The natural greenhouse effect helps warm the Earth's surface by as much as 33°C, and without it, our planet would be too cold for humans to survive.

The major greenhouse gases (GHG) are water vapour (36-70%), CO_2 (9-26%) Methane (4-9%) and Ozone (3-7%). Other greenhouse gases include nitrous oxide, sulphur hexafluoride, hydro fluorocarbon, per fluorocarbons and chlorofluorocarbons.



2.4 GLOBAL WARMING

Global warming is the phenomenon of increasing average air temperatures near the surface of Earth over the past one to two centuries. The reason for global warming is the abrupt increase of overall percentage of greenhouse gases especially CO_2 in the atmosphere. The higher the concentration of GHG, more heat is reflected back to earth.

2.4.1 EFFECT OF GLOBAL WARMING

a) CLIMATE CHANGE: The most disastrous result of global warming has been on the climatic variable experienced in a defined spatial area. Rapid increase in temperature resulted in sudden change in geographical activities like melting of glaciers, change in wind speed etc. which resulted in either early onset or delay in several seasonal activities like rain, summer, snowfall etc.

The result od this phenomena are disastrous, most prominent are *(Following points can be used for both negative impact of climate change and negative impact of global warming):*

1. **Spread of Disease**: As northern countries become warm, migration of disease carrying insect to new area resulted into spread of diseases like malaria, typhoid and other diseases.

2. **Frequent Disaster Activities**: Global warming/Climate Change resulted in change in geographical activities. Due to increase in earth's surface temperature, wind flow pattern changed resulted in hurricanes, typhoons and cyclones in last few decades. Similarly, occurrence of drought, heat waves has become more prominent from last decade compare to early centuary.
3. **Polar Ice Caps Melting**: Rapid increase in surface temperature resulted in decrease in polar ice caps, resulting in threat to the biodiversity of the area. Most prominent in current time is threat to the existence of polar bears which are suffering from adverse effect of global warming/climate change.
4. **Economic Consequence**: Frequent disaster activities cause loss to huge infrastructure and life.

2.5 Ozone Layer Depletion

Ozone layer depletion is one of the most serious problems faced by our planet earth. It is also one of the prime reasons which are leading to global warming. Ozone is a colourless gas which is found in the stratosphere of our upper atmosphere. The layer of ozone gas is what which protects us from the harmful ultraviolet radiations of the sun. The ozone layer absorbs these harmful radiations and thus prevents these rays from entering the earth's atmosphere. Ultraviolet radiations are high energy electromagnetic waves emitted by the sun which if enters the earth's atmosphere can lead to various environmental issues including global warming, and also a number of health related issues for all living organisms. Ozone layer protects us from these harmful rays.

2.6 Causes of ozone layer depletion

Low temperatures, increase in the level of chlorine and bromine gases in the upper stratosphere are some of the reasons that leads to ozone layer depletion.

a) CFC gases

the one and the most important reason for ozone layer depletion is the production and emission of chlorofluorocarbons (CFCs). This is what which leads to almost 80 percent of the total ozone layer depletion. As CFC is emitted, molecule floats toward stratosphere, where in presence of UV light breaks it into free chlorine. This free chlorine react with ozone to form chlorine monoxide (ClO) and oxygen (O_2). This ClO is very destructive to ozone. A single ClO molecule can destruct 1,00,000 ozone molecules

Reactions

$CFCL_3$+UV radiation $\longrightarrow$ $CFCl_2$ +Cl

$Cl + O_3 \longrightarrow ClO + O_2$

$O_3 + UV\ radiation \longrightarrow O_2 + O$

$ClO + O \longrightarrow Cl + O_2$

$Cl + O_3 \longrightarrow ClO + O_2$

$O + O_3 \longrightarrow 2O_2$

There are many other substances that lead to ozone layer depletion such as Nitrogen and volatile organic compounds (VOCs).

b) Destruction by oxides of Nitrogen.

The source are chemicals and metal fabrication etc. Like CFC's Nitrogen oxide also convert O_3 molecule to O_2 . The free oxygen molecule are destroyed. The mechanism involved is as follows

$N2 + UV\ radiation \longrightarrow N2 + O$

$N_2O + O \longrightarrow 2NO$

$NO + O_3 \longrightarrow NO_2 + O_2$

$O_3 + UV \longrightarrow O_2 + O$

$NO_2 + O \longrightarrow NO + O_2$

NO act as catalyst and further breaks ozone into NO_2 and O molecules

c) Depletion by Volcanic Eruption

Hydrogen chloride released by volcanoes can cause drastic reductions in ozone if concentrations reach high levels. Volcanoes account for about 3% of chlorine in the stratosphere. Methyl chloride produces about 15% of the chlorine entering the stratosphere. The remaining 82% of stratospheric chlorine comes from man-made sources, mostly in the form of chlorofluorocarbons.

Although volcanic gases do not play a direct role in destroying ozone they may play a harmful indirect role. Scientists have found that particles, or aerosols, produced by major volcanic eruptions accelerate ozone destruction. The particles themselves do not directly destroy ozone but they do provide a surface upon which chemical reactions can take place. This enhances chlorine-driven ozone depletion. They interact with Clorine and bromine to form bromine oxide and clorine oxide resulting in destruction of ozone.

2.7) Effects of ozone depletion on environment

Ozone layer depletion leads to decrease in ozone in the stratosphere and increase in ozone present in the lower atmosphere. Presence of ozone in the lower atmosphere is considered as a pollutant and a greenhouse gas. Ozone in the lower atmosphere contributes to global warming and climate change. The depletion of ozone layer has trickle down effects in the form of global warming, which in turn leads to melting of polar ice, which will lead to rising sea levels and climatic changes around the world.

i) On Human

a) Skin Cancer: Exposure to UV rays from sun can lead to increased risk for developing of several types of skin cancers. Malignant melanoma, basal and squamous cell carcinoma are the most common cancers caused by exposure to UV rays.

b) Eye Damage: UV rays are harmful for our eyes too. Direct exposure to UV rays can lead to Cataract problems, and also Photokeratitis or snow blindness.

c) Damage to Immune system: our immune system is also highly vulnerable to UV rays. Increased exposure to UV rays can lead to weakening of the response of immune system and even impairment of the immune system in extreme cases.

d) Aging of skin: exposure to UV rays can lead to acceleration of the aging process of your skin. This will result in you looking older than what you actually are. It can also lead to photo allergy that result in outbreak of rashes in fair skinned people

Apart from these exposure to UV rays can also lead to difficulty in breathing, chest pain, and throat irritation and can even lead to hampering of lung function.

ii) On Plants and Animals

UV rays affect other life forms too. It adversely affects the different species of animals and is one of the prime reasons for the declining numbers species. It affects them in every stage of their life cycle; from hampering the growth and development in the larvae stage, deformities and decreases immunities in some species and to even retinal damage and blindness in some species.

UV rays also have adverse effect on the marine ecosystem. It adversely affects the planktons which plays a vital role in the food chain and oceanic carbon cycle. Affecting phytoplankton will in turn affect the whole ocean ecosystem.

UV rays will also affect the plants. UV radiations can alter the time of flowering in some plant species. It can also directly affect the plant growth by altering the physiological and developmental processes of the plants.

2.8 Ways to bring down ozone layer depletion

Ozone layer depletion is not something that affects any specific country or region. The whole world is vulnerable to its after effects. That makes it important for each and every one of us to take actions to

reduce ozone layer depletion. International agreements such as Montreal protocol in 1987 have helped in reducing and controlling industrial emission of Chlofluorocarbons. More and more of such international agreements between countries is necessary to bring down ozone layer depletion. At individual level each and everyone also can contribute towards reducing ozone layer depletion. Buying and using recycled products, saving of energy, using of public transport can do a lot in combating ozone layer depletion. The most important thing that we can do is spreading awareness. Our individual efforts will go a long way in saving the earth's blanket and keep our planet earth liveable for us and our future generations.