Ecology

Ecology is the branch of biology concerned with the relations of organisms to one another (energy flow and mineral cycling) and to their physical surroundings (environment).

The term ecology was derived from two Greek words ‘Oikos’ meaning home and ‘logos’ meaning study

Levels of Organisations in Ecology

Ecology encompasses the study of individuals, organisms, population, community, ecosystem, biome and biosphere which form the various levels of ecological organisation.

Individual and Species

- Organism is an individual living being that has the ability to act or function independently.
- Species are a group of living organisms consisting of similar individuals capable of exchanging genes or of interbreeding.
- They are considered as the basic unit of taxonomy and are denoted by a Latin binomial, e.g. Homo sapiens.

Population

- Population is a community of interbreeding organisms(same species), occupying a defined area during a specific time.
- Population growth rate can be positive due to birth and/or immigration or negative due to death and/or emigration.

Population Attributes

- Birth rate- Total number of individuals born in a given period of time.
- Death rates- Total number of deaths in a period of time.
- Sex Ratio- Total number of females and males per 1000 individuals.
- Age pyramid: A plot of age distribution.

Population Growth

Population growth is one of the major concerns of the present world as the human population is not a static factor. Rather, it is growing at a very alarming rate. In spite of the increasing world population, the resources of the earth remain constant. Thus, the ability to maintain sustainable development is becoming a major challenge to mankind today.

Factors that Influence Population Fluctuation

The fluctuations in the population in a given area are influenced by four major factors, which include the following:

- Natality – It is the number of births in a given period of time in a population
- Mortality – It is defined as the number of deaths that takes place in a population at a given period of time.
- Immigration – It is defined as the number of individuals which come from another population and add to the population in consideration during a period of time.
- Emigration – It is defined as the number of individuals from a population who leave the habitat and go to a different habitat at a given period of time.

Thus, it is clearly visible, that Natality (N) and Immigration (I) add to a population, thus increasing population whereas, Mortality (M) and Emigration (E) decrease the population.

The population density (Pt) at a given point of time can be given as:

Pt =P0 + (N + I) – (M + E)

where, P0 is the initial population density.

We have two growth models which describe the basic growth trend in a population. These are:

Exponential growth

In an ideal condition where there is an unlimited supply of food and resources, the population growth will follow an exponential order. Consider a population of size N and birth rate be represented as b, death rate as d, Rate of change of N can be given by the equation
dN/dt = (b-d) x N

If, (b – d) = r,

dN/dt = rN

Where, r = intrinsic rate of natural increase

This equation can be represented with a graph which has a J shaped curve. According to calculus

Nt=N0ert

Where, Nt = Population density at time t

N0= Population density at time zero

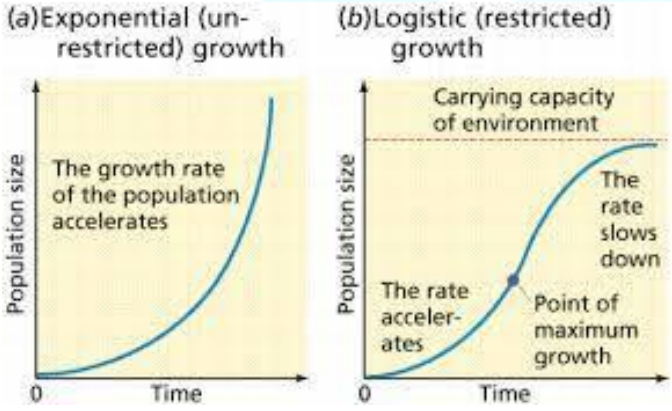
r = intrinsic rate of natural increase

e = base of natural logarithms

Logistic growth

This model defines the concept of ‘survival of the fittest’. Thus, it considers the fact that resources in nature are exhaustible. The term ‘Carrying capacity’ defines the limit of the resources beyond which it cannot support any number of organisms. Let this carrying capacity be represented as K.
The availability of limited resources cannot show exponential growth. As a result, the graph will have a lag phase, followed by an exponential phase, then a declining phase and ultimately an asymptote. This is known as Verhulst-Pearl Logistic Growth and is represented using the equation:

dN/dt = rN((K-N) /K)



Population Interaction in the Ecosystem

The environment consists of both abiotic (physical) and biotic (biological) factors. Nutrients in the soil, carbon dioxide, water, temperature, atmospheric pressure, wind and osmotic balances are some of the physical aspects required for a living being.

Along with these abiotic factors of the ecosystem, the population can be very much affected by their interactions.

Following are the main modes of interaction between populations.

Competition

As the name suggests, it is a relationship when two or more species compete for the same limited resources at the same time, which may be food, water, light, or any prey. All these things are crucial for any organism's growth and survival.

Predation

This is a relationship where one species depends entirely on the other for its food and survival. The species which feeds on other species is called predator whereas the one that is fed upon is called the prey. This entire relationship is called Predation.

Predator is usually stronger than the prey, and hence it consumes prey during its entire life cycle. In some food chains and food webs, a predator can also fall prey as all living organisms develop a kind of defence mechanism after a certain period of time.

The words 'predator' and 'prey' are not always limited to animals. They are implied on the relationship between animals and plants as well. For example – rabbit feeding on carrot, bear eating berry and grasshopper and leaf.

Camouflage

Camouflage literally means 'to disguise'. It is the phenomenon where an organism or a species develops structural adaptation that helps them to blend with their surroundings is known as camouflage. This helps them avoid getting detected by predators.

Symbiosis

It is a Greek term which means "living together." In various relationships among two or more species or organisms, both the parties depend on each other for food and survival. It is a relationship where one organism lives on another with mutual stereotypic behaviour.

There are three types of Symbiosis:

- Mutualism – where both species are benefitted.
- Commensalism – where one species benefits without harming the other.
- Parasitism – where one species benefits by harming the other.

Mutualism

It is the ecological interaction between two or more species where each species is benefitted from the other. It is the most common type of ecological interaction and describes that mutual dependence is necessary for social well-being. It is dominant in most of the communities worldwide.

Examples Of Mutualism

Humans and Plants

Humans require oxygen for life and plants use carbon dioxide for photosynthesis. Here both humans and plants are mutually benefited. Humans use the oxygen given by the plants. In return, plants use carbon dioxide, which is exhaled by the Humans.

Oxpeckers and Rhinos

The bird oxpecker lives on the rhino and removes all bugs and parasites on the animal skin by eating them. The Rhino provides the bird with food and in return, the bugs are removed from the skin of the rhino. Both rhino and the oxpecker benefited.

Commensalism

This is a type of ecological interaction where one organism is benefited from the other organism without harming or benefiting it. For eg., cattle egrets and livestock, birds following army ants, barnacles and whales, etc. all exhibit commensalism.

Parasitism

Parasitism is a one-sided symbiosis, where one organism lives on or in another organism. The one that feeds on the other organism is called the parasite whereas the one that is fed upon is called the host. The parasite survives and multiplies using the host cell machinery and therefore, harms the host.

Examples of Parasitism

Parasitism in Humans

The organisms that parasitize humans include fungi, leeches, lice, viruses, protozoa, tapeworm, etc. Few organisms such as Helminthes live inside the intestine of the host and cause several infectious diseases, such as jaundice, malnutrition, diarrhoea, etc. All the infections are caused by viruses and bacteria.

Parasitism in Plants

Small green insects called aphids, parasitize plants by eating their sap. Several types of fungi parasitize crops and spoil fruits, vegetables and food grains. The parasitic plants contain modified roots called haustoria which connect to the host xylem or phloem and drain it of nutrients and water.

Parasitism in Insects

Parasitism is very common in insects. Entomophagous parasites attack larva and young insects. A few insects deposit their eggs within the body of the larva of other insect species. When the eggs hatch, the young one eats the larva and derives nutrition from it

Ecosystem

An ecosystem is a community of organisms interacting with each other and with their environment such that energy is exchanged and system-level processes, such as the cycling of elements, emerge.

Biotic and Abiotic Factors

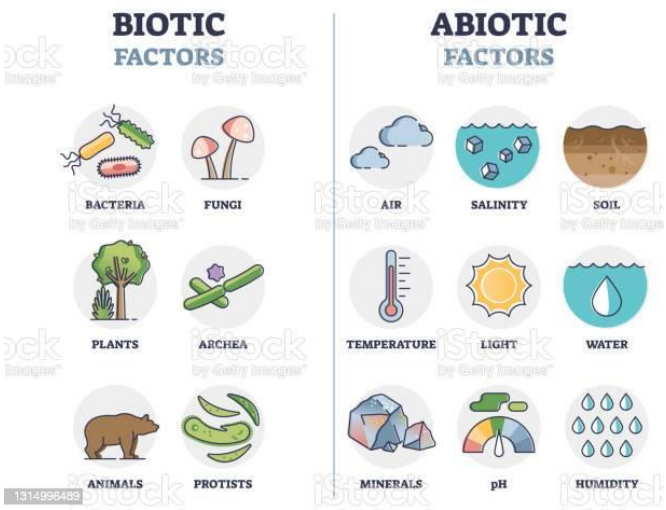
The main aim of ecology is to understand the distribution of biotic and abiotic factors of living things in the environment. The biotic and abiotic factors include the living and nonliving factors and their interaction with the environment.

Biotic components

Biotic components are living factors of an ecosystem. A few examples of biotic components include bacteria, animals, birds, fungi, plants, etc.

Abiotic components

Abiotic components are non-living chemical and physical factors of an ecosystem. These components could be acquired from the atmosphere, lithosphere and hydrosphere. A few examples of abiotic components include sunlight, soil, air, moisture minerals and more.



Living organisms are grouped into biotic components, whereas non-living components like sunlight, water, topography are listed under abiotic components.

Habitat

A habitat is a place or area where a species grows, lives or thrives.
Habitat of a species describes the totality of abiotic factors to which the species is exposed in the area.
Examples of habitat include desert, ponds, freshwater lake, ocean, mountains, grassland, forest, etc.

Niche

Niche is defined as a functional role played by an organism in its ecosystem.

Joseph Grinnel coined the term “Niche”. He described a niche as the distributional unit specific to each species. He emphasised that no two species living in the same territory can occupy the same ecological niche for long.

The ecological niche not only involves the physical space occupied by an organism but it also describes the functional role or place of a species in its community structure. This includes everything related to how it influences a community, i.e. what it eats, where it lives, what it does, the trophic position occupied, etc. Niche describes how a species contributes to the energy flow of the system, how it gains energy and supplies it further in an ecosystem.

There are three aspects of an ecological niche:

1.Spatial or habitat niche:

It accounts for the physical space occupied by an organism. This explains the different microhabitat owned by several species having identical general habitat.E.g. seven species of millipedes reside in the same general habitat of the forest floor of a maple oak forest and all are decomposers, i.e. occupy the same trophic level but predominate in their specific microhabitat that is created by several gradients in the decomposition stage.

2.Trophic Niche:

It tells about the functional role or trophic position occupied by a species. It explains how different species share the same habitat but occupy different trophic niches.E.g. Darwin's finches of Galapagos islands. These birds belong to the same genera and live in the same general habitat but differ in their eating habits, i.e. trophic position. One species is vegetarian feeding on buds and fruits and others are insect eaters, feeding on insects of different sizes. There is a woodpecker finch, which has a wood-pecking beak.

3.Hypervolume or multidimensional niche:

It represents the position of a species in the environmental gradient. There are a large number of environmental factors, both abiotic and biotic, that affect the population. This is the fundamental niche of the species and refers to the totality of abiotic and biotic factors to which a given species is uniquely adapted.
Niche is specific to a particular species, no two species can fill the same niche. The two similar niches can overlap but there must be distinct differences to avoid competition for the same resources.

Difference between Habitat and Niche

The table below shows the main difference between habitat and niche

Habitat	Niche
A habitat is a particular place where organisms live, i.e. address	A niche defines a particular role played by organisms in an ecosystem, i.e. profession
Habitat is not species-specific and many species can occupy the same habitat	Niche is species-specific and it supports only a single species
Habitat consists of several niches	Niche is specific to a particular species, which may overlap with a similar niche but must have distinct differences

Habitat is a superset of niche	Niche is a subset of habitat
Examples: desert, ocean, mountains, grassland, forest, etc.	Examples: different trophic position occupied by Darwin's finches

Structure of the Ecosystem

The structure of an ecosystem is characterised by the organisation of both biotic and abiotic components. This includes the distribution of energy in our environment. It also includes the climatic conditions prevailing in that particular environment.

The structure of an ecosystem can be split into two main components, namely:

1. **Biotic Components**
2. **Abiotic Components**

Biotic Components

Biotic components refer to all living components in an ecosystem. Based on nutrition, biotic components can be categorised into autotrophs, heterotrophs and saprotrophs (or decomposers).

- **Producers** include all autotrophs such as plants. They are called autotrophs as they can produce food through the process of photosynthesis. Consequently, all other organisms higher up on the food chain rely on producers for food.
- **Consumers or heterotrophs** are organisms that depend on other organisms for food. Consumers are further classified into primary consumers, secondary consumers and tertiary consumers.

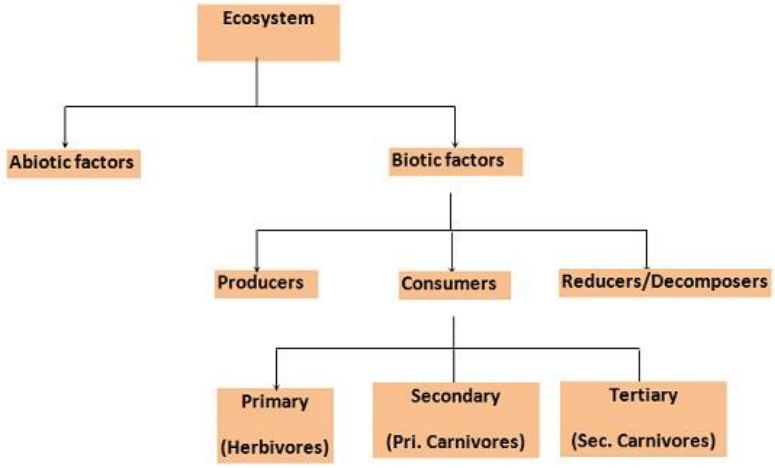
1. **Primary consumers** are always herbivores as they rely on producers for food.
2. **Secondary consumers** depend on primary consumers for energy. They can either be carnivores or omnivores.
3. **Tertiary consumers** are organisms that depend on secondary consumers for food. Tertiary consumers can also be carnivores or omnivores.
4. **Quaternary consumers** are present in some food chains. These organisms prey on tertiary consumers for energy. Furthermore, they are usually at the top of a food chain as they have no natural predators.

- **Decomposers** include saprophytes such as fungi and bacteria. They directly thrive on the dead and decaying organic matter. Decomposers are essential for the ecosystem as they help in recycling nutrients to be reused by plants.

Abiotic Components

Abiotic components are the non-living component of an ecosystem. It includes air, water, soil, minerals, sunlight, temperature, nutrients, wind, altitude, turbidity, etc.

The biotic and abiotic components are interrelated in an ecosystem. It is an open system where the energy and components can flow throughout the boundaries.



Functions of Ecosystem

The functions of the ecosystem are as follows:

- It regulates the essential ecological processes, supports life systems and renders stability.
- It is also responsible for the cycling of nutrients between biotic and abiotic components.
- It maintains a balance among the various trophic levels in the ecosystem.
- It cycles the minerals through the biosphere.
- The abiotic components help in the synthesis of organic components that involve the exchange of energy.

So the functional units of an ecosystem or functional components that work together in an ecosystem are:

1. **Productivity** – It refers to the rate of biomass production.
2. **Energy flow** – It is the sequential process through which energy flows from one trophic level to another. The energy captured from the sun flows from producers to consumers and then to decomposers and finally back to the environment.

3. **Decomposition** – It is the process of breakdown of dead organic material. The top-soil is the major site for decomposition.
4. **Nutrient cycling** – In an ecosystem nutrients are consumed and recycled back in various forms for the utilisation by various organisms.

Stability in Ecosystems

All ecosystems are stable systems. This means that they maintain a natural balance. An ecosystem involves the flows of nutrients and energy (in the form of food). If the organisms in an ecosystem use up nutrients, like nitrogen, from their environment, without replenishing them, soon the system will collapse.

However, a balance is maintained between the availability and use of nutrients by recycling them through natural processes. You already know how things like nitrogen and carbon are recycled in nature. A balance is also required to provide different amounts of energy (from food) needed by different organisms.

As we shall see, the numbers of different organisms in an ecosystem are balanced in such a way that each organism gets the required amount of food. For example, in a forest ecosystem, the numbers of the prey (like rabbits) are always more than the numbers of the predator (like foxes), to ensure adequate food for the predator.

Types of Ecosystem

An ecosystem can be as small as an oasis in a desert, or as big as an ocean, spanning thousands of miles. There are two types of ecosystem:

1. **Terrestrial Ecosystem**
2. **Aquatic Ecosystem**

Terrestrial Ecosystem

Terrestrial ecosystems are exclusively land-based ecosystems. There are different types of terrestrial ecosystems distributed around various geological zones.

They are as follows:

1. **Forest Ecosystem**
2. **Grassland Ecosystem**
3. **Tundra Ecosystem**
4. **Desert Ecosystem**

Forest Ecosystem

A forest ecosystem consists of several plants, particularly trees, animals and microorganisms that live in coordination with the abiotic factors of the environment. Forests help in maintaining the temperature of the earth and are the major carbon sink.

Grassland Ecosystem

In a grassland ecosystem, the vegetation is dominated by grasses and herbs. Temperate grasslands and tropical or savanna grasslands are examples of grassland ecosystems.

Tundra Ecosystem

Tundra ecosystems are devoid of trees and are found in cold climates or where rainfall is scarce. These are covered with snow for most of the year. Tundra type of ecosystem is found in the Arctic or mountain tops.

Desert Ecosystem

Deserts are found throughout the world. These are regions with little rainfall and sparse vegetation. The days are hot, and the nights are cold.

Aquatic Ecosystem

Aquatic ecosystems are ecosystems present in a body of water.

These can be further divided into two types, namely:

1. **Freshwater Ecosystem**
2. **Marine Ecosystem**

Freshwater Ecosystem

The freshwater ecosystem is an aquatic ecosystem that includes lakes, ponds, rivers, streams and wetlands. These have no salt content in contrast with the marine ecosystem.

Marine Ecosystem

The marine ecosystem includes seas and oceans. These have a more substantial salt content and greater biodiversity in comparison to the freshwater ecosystem.

Community

Communities in most instances are named after the dominant plant form.

For example, a grassland community is dominated by grasses,
though it may contain herbs, trees, etc.

1.Major Communities

These are large sized and relatively independent. They depend only on the sun's energy from outside. E.g. Tropical evergreen forests.

2.Minor Communities
These are dependent on neighbouring communities and are often called societies.They are secondary aggregations within a major community.
E.g. A mat of lichen on a cow dung pad.

Characteristics of a Community

EcologySome of the major characteristics of a community ecology are as follows:

(a) Species Diversity
(b) Growth From and structure
(c) Dominance
(d) Self reliance
(e) Relative abundance
(f) Trophic structure.

Community ecology deals with the group of various kinds of population in the areas. A group of several species (plants/ animals) living together with mutual tolerance in a natural area is called a community.

(a) Species Diversity:

Each community consists of different organisms like plants, animals, microbes etc. They differ taxonomically from each other. This species diversity may be regional or local.

(b) Growth From and structure:

Communities can be analysed in terms of major growth forms like trees, shrubs, herbs etc. In each growth from trees, there may be different kinds of plants such as-

broad leaved trees, evergreen trees etc. These different growth forms determine the structural pattern of a community.

(c) Dominance:

All species are not equally important in each community. The nature of the community is determined by a few species in a community. These limited species have control and dominating influence in the community.

(d) Self reliance:

Each community has a group of autotrophic plants as well as heterotrophic animals. The autotrophic plants are self dependent.

(e) Relative abundance:

Different populations in a community exist in relative proportions and this idea is called relative abundance.

(f) Trophic structure:

Each community has a trophic structure that determines the flow of energy and material from plants to herbivores to carnivores.

Ecotone

An ecotone is an area that acts as a boundary or a transition between two ecosystems. A common example could be an area of marshland between a river and its riverbank. Ecotones are of great environmental importance. Because the area is a transition between two ecosystems or biomes, it is natural that it contains a large variety of species of fauna and flora as the area is influenced by both the bordering ecosystems.

Examples of ecotones include marshlands (between dry and wet ecosystems), mangrove forests (between terrestrial and marine ecosystems), grasslands (between desert and forest), and estuaries (between saltwater and freshwater). Mountain ranges can also create ecotones due to the changes in the climatic conditions on the slopes.

Characteristics of Ecotones

- It may be wide or narrow.
- It is a zone of tension (as it has conditions intermediate to the bordering ecosystems).

- It could contain species that are entirely different from those found in the bordering systems.
- Ecotones can be natural or man-made. For example, the ecotone between an agricultural field and a forest is a man-made one.

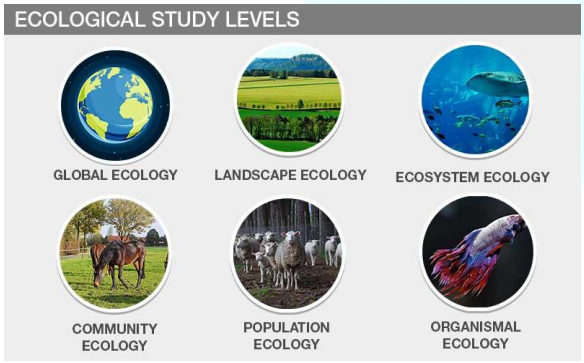
Edge Effect

Edge effects refer to the changes in population or community structures that occur at the boundary of two habitats. Generally, there is a greater number of species found in these regions (ecotones) and this is called the edge effect. The species found here are called edge species.

Importance of Ecotone

1. They have a greater variety of organisms.
2. They also offer a good nesting place for animals coming in search of a nesting place or food.
3. They serve as a bridge of gene flow from one population to another because of the larger genetic diversity present.
4. They can act as buffer zones offering protection to the bordering ecosystems from possible damage. For example, a wetland can absorb pollutants and prevent them from seeping into the river.
5. Ecotones are also a sensitive indicator of global climate change. A shifting of boundaries between ecosystems is thought to be due to climate change. So, scientists and environmentalists are studying ecotones with greater interes

Types of Ecology



1.Global Ecology

It deals with interactions among earth's ecosystems, land, atmosphere and oceans. It helps to understand the large-scale interactions and their influence on the planet.

2.Landscape Ecology

It deals with the exchange of energy, materials, organisms and other products of ecosystems. Landscape ecology throws light on the role of human impacts on the landscape structures and functions.

3.Ecosystem Ecology

It deals with the entire ecosystem, including the study of living and non-living components and their relationship with the environment. This science researches how ecosystems work, their interactions, etc.

4.Community Ecology

It deals with how community structure is modified by interactions among living organisms. Ecology community is made up of two or more populations of different species living in a particular geographic area.

5.Population Ecology

It deals with factors that alter and impact the genetic composition and the size of the population of organisms. Ecologists are interested in fluctuations in the size of a population, the growth of a population and any other interactions with the population.

In biology, a population can be defined as a set of individuals of the same species living in a given place at a given time. Births and immigration are the main factors that increase the population and death and emigration are the main factors that decrease the population.

Population ecology examines the population distribution and density. Population density is the number of individuals in a given volume or area. This helps in determining whether a particular species is in endanger or its number is to be controlled and resources to be replenished.

Characteristics of Population Ecology

Ecologists use various terms when understanding and discussing populations of organisms. A population is all of one kind of species residing in a particular location. Population size represents the total number of individuals in a habitat. Population density refers to how many individuals reside in a particular area.

Population Size is represented by the letter N, and it equals the total number of individuals in a population. The larger a population is, the greater its generic variation

and therefore its potential for long-term survival. Increased population size can, however, lead to other issues, such as overuse of resources leading to a population crash.

Population Density refers to the number of individuals in a particular area. A low-density area would have more organisms spread out. High-density areas would have more individuals living closer together, leading to greater resource competition.

Population Dispersion: Yields helpful information about how species interact with each other. Researchers can learn more about populations by studying they way they are distributed or dispersed.

Population distribution describes how individuals of a species are spread out, whether they live in close proximity to each other or far apart, or clustered into groups.

- Uniform dispersion refers to organisms that live in a specific territory. One example would be penguins. Penguins live in territories, and within those territories the birds space themselves out relatively uniformly.
- Random dispersion refers to the spread of individuals such as wind-dispersed seeds, which fall randomly after travelling.
- Clustered or clumped dispersion refers to a straight drop of seeds to the ground, rather than being carried, or to groups of animals living together, such as herds or schools. Schools of fish exhibit this manner of dispersion.

6.Organismal Ecology

Organismal ecology is the study of an individual organism's behaviour, morphology, physiology, etc. in response to environmental challenges. It looks at how individual organisms interact with biotic and abiotic components. Ecologists research how organisms are adapted to these non-living and living components of their surroundings.

Individual species are related to various adaptations like physiological adaptation, morphological adaptation, and behavioural adaptation.

7.Molecular Ecology

The study of ecology focuses on the production of proteins and how these proteins affect the organisms and their environment. This happens at the molecular level.

DNA forms the proteins that interact with each other and the environment. These interactions give rise to some complex organisms.

Energy Flow

The chemical energy of food is the main source of energy required by all living organisms. This energy is transmitted to different trophic levels along the food chain. This energy flow is based on two different laws of thermodynamics:

First law of thermodynamics states that energy can neither be created nor destroyed, it can only change from one form to another.

Second law of thermodynamics states that as energy is transferred more and more of it is wasted.

Energy Flow in Ecosystem

The energy flow in the ecosystem is one of the major factors that support the survival of such a great number of organisms. For almost all organisms on earth, the primary source of energy is solar energy. It is amusing to find that we receive less than 50 per cent of the sun's effective radiation on earth. When we say effective radiation, we mean the radiation, which can be used by plants to carry out photosynthesis.
Most of the sun's radiation that falls on the earth is usually reflected back into space by the earth's atmosphere. This effective radiation is termed as the Photosynthetically Active Radiation (PAR).

Overall, we receive about 40 to 50 percent of the energy having Photosynthetically Active Radiation and only around 2-10 percent of it is used by plants for the process of photosynthesis. Thus, this percent of PAR supports the entire world as plants are the producers in the ecosystem and all the other organisms are either directly or indirectly dependent on them for their survival.

The energy flow takes place via the food chain and food web. During the process of energy flow in the ecosystem, plants being the producers absorb sunlight with the help of the chloroplasts and a part of it is transformed into chemical energy in the process of photosynthesis.

This energy is stored in various organic products in the plants and passed on to the primary consumers in the food chain when the herbivores consume (primary consumers) the plants as food. Then conversion of chemical energy stored in plant products into kinetic energy occurs, degradation of energy will occur through its conversion into heat.

Then followed by the secondary consumers. When these herbivores are ingested by carnivores of the first order (secondary consumers) further degradation will occur.

Finally, when tertiary consumers consume the carnivores, energy will again be degraded. Thus, the energy flow is unidirectional in nature.

Moreover, in a food chain, the energy flow follows the 10 percent law. According to this law, only 10 percent of energy is transferred from one trophic level to the other; rest is lost into the atmosphere. This is clearly explained in the following figure and is represented as an energy pyramid.

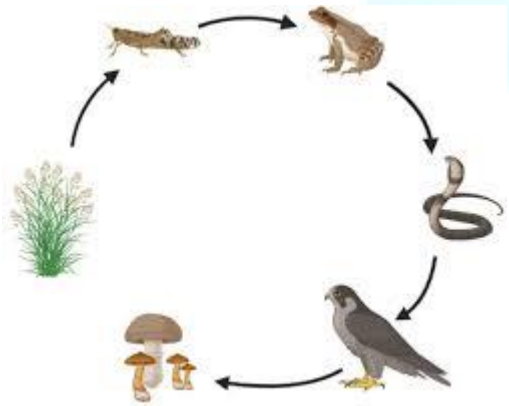
Ecological Concepts

1. Food Chain

The sun is the ultimate source of energy on earth. It provides the energy required for all plant life. The plants utilise this energy for the process of photosynthesis, which is used to synthesise their food.

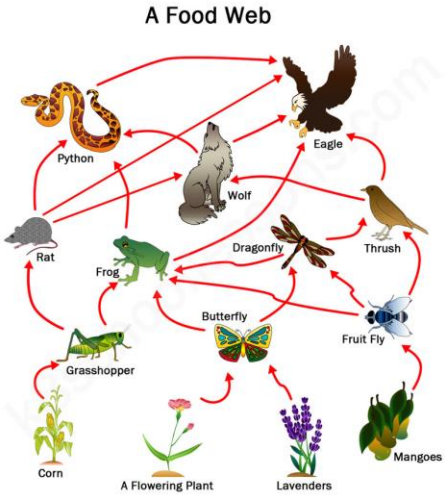
During this biological process, light energy is converted into chemical energy and is passed on through successive trophic levels. The flow of energy from a producer, to a consumer and eventually, to an apex predator or a detritivore is called the food chain.

Dead and decaying matter, along with organic debris, is broken down into its constituents by scavengers. The reducers then absorb these constituents. After gaining the energy, the reducers liberate molecules to the environment, which can be utilised again by the producers



2.Food Web

Food web is a network of interconnected food chains. It comprises all the food chains within a single ecosystem. It helps in understanding that plants lay the foundation of all the food chains. In a marine environment, phytoplankton forms the primary producer.



Difference Between Food Chain And Food Web

Food Chain	Food Web
A linear pathway showing the flow of energy	A multitude of networks showing the flow of energy
An organism of higher level trophic feeds on a specific organism of lower trophic level	An organism of higher trophic level has access to more members of a lower trophic level.
Has no effect on the adaptability and competitiveness of organisms.	Has a role in improving the adaptability and competitiveness of an organism.

3.Ecological Pyramids

An ecological pyramid is the graphical representation of the number, energy, and biomass of the successive trophic levels of an ecosystem. Charles Elton was the first ecologist to describe the ecological pyramid and its principals in 1927.

The biomass, number, and energy of organisms ranging from the producer level to the consumer level are represented in the form of a pyramid; hence, it is known as the ecological pyramid.

The base of the ecological pyramid comprises the producers, followed by primary and secondary consumers. The tertiary consumers hold the apex. In some food chains, the quaternary consumers are at the very apex of the food chain.

The producers generally outnumber the primary consumers and similarly, the primary consumers outnumber the secondary consumers. And lastly, apex predators also follow the same trend as the other consumers; wherein, their numbers are considerably lower than the secondary consumers.

For example, Grasshoppers feed on crops such as cotton and wheat, which are plentiful. These grasshoppers are then preyed upon by common mice, which are comparatively less in number. The mice are preyed upon by snakes such as cobras. Snakes are ultimately preyed on by apex predators such as the brown snake eagle.

Productivity

In ecology, productivity refers to the rate of formation of biomass in the ecosystem. It can also be referred to as the energy accumulated in the plants by photosynthesis. There are two types of productivity, namely:

1. Primary Productivity
2. Secondary Productivity

Primary Productivity

Primary Productivity refers to the generation of biomass from autotrophic organisms such as plants. Photosynthesis is the primary tool for the creation of organic material from inorganic compounds such as carbon dioxide and water. Primary productivity can be divided into two aspects:

- Gross primary productivity
- Net primary productivity
- Gross primary productivity

The solar energy trapped by the photosynthetic organism is called gross primary productivity. All the organic matters produced falls under gross primary productivity. This depends upon the photosynthetic activity and environmental factors.

Net primary productivity

This is estimated by the gross productivity minus energy lost in respiration.

NPP = GPP – Energy lost by respiration

It is the net energy stored in the plants. This energy serves as food for the animals that feed on plants. It is measured as the amount of organic matter produced in a community in a given time. Annually, over 170 billion tons of net primary productivity occurs over the entire biosphere.

Secondary Productivity

Heterotrophs such as animals influence Secondary Productivity. It is the accumulation of energy at the consumer's level. It keeps moving from one organism to another, unlike primary productivity. This process occurs as a result of organic materials being transferred between various trophic levels. It is also referred to as the rate of increase in the biomass of heterotrophs. Organisms such as animals, fungi, bacteria and numerous protists influence Secondary Production.

Typically, productivity is expressed in units of mass per unit volume (or surface) per unit time.

Biomagnification Definition

Biomagnification or biological magnification is the process of accumulation of certain chemicals in living organisms to a concentration higher than that occurring in the inorganic, non-living environment.
Biomagnification can be defined as the rise or increase in the contaminated substances caused by the intoxicating environment. The contaminants might be heavy metals such as mercury, arsenic, and pesticides such as polychlorinated biphenyls and DDT.

These substances are taken up by the organisms through the food they consume. When the organisms in the higher food chain feed on the organisms in the lower food chain containing these toxins, these toxins get accumulated in the higher organisms.

Causes of Biomagnification

Following are the major causes of biomagnification:

Agriculture

The agricultural pesticides, insecticides, fertilisers and fungicides are very toxic and are released into the soil, rivers, lakes, and seas. These substances contain small amounts of heavy metals such as mercury, arsenic, copper, lead and cadmium. These cause health issues in aquatic organisms and humans.

Organic Contaminants

Manures and biosolids are processed industrially and contain contaminants like pharmaceuticals and personal care products. These substances have an adverse impact on the health of humans, animals, and wildlife.

Industrial Activities

The industries and factories release toxic substances that are released into the soil, lakes, oceans, and rivers. The gaseous emissions pollute the environment which enters into the food chain leading to biomagnification.

Mining Activities in the Ocean

Mining activities are carried out in the deep sea to extract metal like zinc, aluminium, cobalt, silver and gold. The mining process generates a large amount of selenium and sulphide, which deposits in water and destroys the oceans and coastal regions.

The level of toxicity has increased. These toxic substances are absorbed by the aquatic organisms higher in the food chain.

Effects of Biomagnification

Following are the effects of biomagnification on living organisms and the environment:

Impact on Human Health

Biomagnification makes humans more prone to cancer, kidney problems, liver failure, birth defects, respiratory disorders, and heart diseases.

Effects on Reproduction and Development of Marine Creatures

The toxic chemicals accumulate in the important organs of aquatic organisms that affect their reproduction and development processes.

For eg., the shells of the eggs of the sea-birds are very thin that might get crushed by the birds themselves during incubation. The toxic chemicals, mercury and selenium destroy the reproductive organs of aquatic creatures.

Destruction of Coral Reefs

Cyanide that is used in leaching gold and fishing is the main cause of the destruction of coral reefs. Coral reefs are the dwelling and feeding grounds for many sea creatures. Their destruction affects the lives of many aquatic animals.

Disruption of Food Chain

The chemicals and toxins which are released into the water bodies disrupt the food chain. The small organisms absorb the toxins which are eaten up by larger animals. These toxins, thus, get accumulated in the higher level of organisms.

Importance of Ecology

The following reasons explain the importance of ecology:

Conservation of Environment

Ecology helps us to understand how our actions affect the environment. It shows the individuals the extent of damage we cause to the environment.

Lack of understanding of ecology has led to the degradation of land and the environment. It has also led to the extinction and endangerment of certain species. For eg., dinosaurs, white shark, mammoths, etc. Thus, the study of the environment and organisms helps us to protect them from any damage and danger.

Resource Allocation

With the knowledge of ecology, we are able to know which resources are necessary for the survival of different organisms. Lack of ecological knowledge has led to scarcity and deprivation of these resources, leading to competition.

Energy Conservation

All organisms require energy for their growth and development. Lack of ecological understanding leads to the over-exploitation of energy resources such as light, nutrition and radiation, leading to its depletion.

Proper knowledge of ecological requirements prevents the unnecessary wastage of energy resources, thereby, conserving energy for future purposes.

Eco-Friendliness

Ecology encourages harmonious living within the species and the adoption of a lifestyle that protects the ecology of life.

Examples of Ecology

Following are a few examples of ecology:

Human Ecology

It focuses on the relationship between humans and the environment. It emphasises the impact human beings have on the environment and gives knowledge on how we can improve ourselves for the betterment of humans and the environment.

Niche Construction

It deals with the study of how organisms alter the environment for the benefit of themselves and other living beings. For example, termites create a 6 feet tall mound and at the same time feed and protect their entire population.

Ecological Succession

A universal process of directional change in vegetation, on an ecological time scale —> leads to stable climax community

Ecological succession is the steady and gradual change in a species of a given area with respect to the changing environment. It is a predictable change and is an inevitable process of nature as all the biotic components have to keep up with the changes in our environment.

The ultimate aim of this process is to reach equilibrium in the ecosystem. The community that achieves this aim is called a climax community. In an attempt to reach this equilibrium, some species increase in number while some others decrease.

In an area, the sequence of communities that undergo changes is called sere. Thus, each community that changes is called a seral stage or seral community.

All the communities that we observe today around us have undergone succession over a period of time since their existence. Thus, we can say that evolution is a process that has taken place simultaneously with that of ecological succession. Also, the initiation of life on earth can be considered to be a result of this succession process.

If we consider an area where life starts from scratch through the process of succession, it is known as primary succession. However, if life starts at a place after the area has lost all the life forms existing there, the process is called secondary succession.

It is obvious that primary succession is a rather slow process as life has to start from nothing whereas secondary succession is faster because it starts at a place which had already supported life before. Moreover, the first species that comes into existence during primary succession is known as the pioneer species.

Types of Ecological Succession

These are the following types of ecological succession:

Primary Succession

Primary succession is the succession that starts in lifeless areas such as the regions devoid of soil or the areas where the soil is unable to sustain life.

When the planet was first formed there was no soil on earth. The earth was only made up of rocks. These rocks were broken down by microorganisms and eroded to form soil. The soil then becomes the foundation of plant life. These plants help in the survival of different animals and progress from primary succession to the climax community.

If this primary ecosystem is destroyed, secondary succession takes place.

Secondary Succession

Secondary succession occurs when the primary ecosystem gets destroyed. For eg., a climax community gets destroyed by fire. It gets recolonized after the destruction. This is known as secondary ecological succession. Small plants emerge first, followed by larger plants. The tall trees block the sunlight and change the structure of the organisms below the canopy. Finally, the climax community arrives.

Cyclic Succession

This is only the change in the structure of an ecosystem on a cyclic basis. Some plants remain dormant for the rest of the year and emerge all at once. This drastically changes the structure of an ecosystem.

Seral Community

A seral community is an intermediate stage of ecological succession advancing towards the climax community.

A seral community is replaced by the subsequent community. It consists of simple food webs and food chains. It exhibits a very low degree of diversity. The individuals are less in number and the nutrients are also less.

There are seven different types of seres:

Types of Seres	Explanation
Hydrosere	Succession in aquatic habitat.
Xerosere	Succession in dry habitat.
Lithosere	Succession on a bare rock surface.
Psammosere	Succession initiating on sandy areas.
Halosere	Succession starting in saline soil or water.
Senile .	Succession of microorganism on dead matter
Eosere	Development of vegetation in an era

Examples of Ecological Succession

Following are the important examples of ecological succession:

Acadia National Park

This national park suffered a huge wildfire. Restoration of the forest was left to nature. In the initial years, only small plants grew on the burnt soil. After several years, the forest showed diversity in tree species. However, the trees before the fire were mostly evergreen, while the trees that grew after the fire were deciduous in nature.

Ecological Succession of Coral Reefs

Small coral polyps colonise the rocks. These polyps grow and divide to form coral colonies. The shape of the coral reefs attracts small fish and crustaceans that are food for the larger fish. Thus, a fully functional coral reef exists.

Biogeochemical Cycle

Biogeochemical cycles mainly refer to the movement of nutrients and other elements between biotic and abiotic factors.

The term biogeochemical is derived from “bio” meaning biosphere, “geo” meaning the geological components and “chemical” meaning the elements that move through a cycle.

The matter on Earth is conserved and present in the form of atoms. Since matter can neither be created nor destroyed, it is recycled in the earth’s system in various forms.

The earth obtains energy from the sun which is radiated back as heat, rest all other elements are present in a closed system. The major elements include:

- Carbon
- Hydrogen
- Nitrogen
- Oxygen
- Phosphorus
- Sulphur

These elements are recycled through the biotic and abiotic components of the ecosystem. The atmosphere, hydrosphere and lithosphere are the abiotic components of the ecosystem.

Types of Biogeochemical Cycles

Biogeochemical cycles are basically divided into two types:

1. Gaseous cycles – Includes Carbon, Oxygen, Nitrogen, and the Water cycle.
2. Sedimentary cycles – Includes Sulphur, Phosphorus, Rock cycle, etc.

Let us have a look at each of these biogeochemical cycles in brief:

Water Cycle

The water from the different water bodies evaporates, cools, condenses and falls back to the earth as rain.

This biogeochemical cycle is responsible for maintaining weather conditions. The water in its various forms interacts with the surroundings and changes the temperature and pressure of the atmosphere.

There's another process called Evapotranspiration (i.e. vapour produced from leaves) which aids this process. It is the evaporation of water from the leaves, soil and water bodies to the atmosphere which again condenses and falls as rain.

Stages of Water Cycle

There are many processes involved in the movement of water apart from the major steps given in the above water cycle diagram. Listed below are different stages of the water cycle.

1. Evaporation

The sun is the ultimate source of energy, and it powers most of the evaporation that occurs on earth. Evaporation generally happens when water molecules at the surface of water bodies become excited and rise into the air. These molecules with the highest kinetic energy accumulate into water vapour clouds. Evaporation usually takes place below the boiling point of water. Another process called evapotranspiration occurs when evaporation occurs through the leaves of plants. This process contributes to a large percentage of water in the atmosphere.

2. Sublimation

Sublimation occurs when snow or ice changes directly into water vapour without becoming water. It usually occurs as a result of dry winds and low humidity. Sublimation can be observed on mountain peaks, where the air pressure is quite low. The low air pressure helps to sublimate the snow into water vapour as less energy is utilised in the process. Another example of sublimation is the phase where

fog bellows from dry ice. On earth, the primary source of sublimation is from the ice sheets covering the poles of the earth.

3. Condensation

The water vapour that accumulated in the atmosphere eventually cools down due to the low temperatures found at high altitudes. These vapours become tiny droplets of water and ice, eventually coming together to form clouds.

4. Precipitation

Above 0 degrees centigrade, the vapours will condense into water droplets. However, it cannot condense without dust or other impurities. Hence, water vapours attach itself on to the particle's surface. When enough droplets merge, it falls out of the clouds and on to the ground below. This process is called precipitation (or rainfall). In particularly cold weather or extremely low air pressure, the water droplets freeze and fall as snow or hail.

5. Infiltration

Rainwater gets absorbed into the ground through the process of infiltration. The level of absorption varies based on the material the water has seeped into. For instance, rocks will retain comparatively less water than soil. Groundwater can either follows streams or rivers. But sometimes, it might just sink deeper, forming aquifers.

6. Runoff

If the water from rainfall does not form aquifers, it follows gravity, often flowing down the sides of mountains and hills; eventually forming rivers. This process is called runoff. In colder regions, icecaps form when the amount of snowfall is faster than the rate of evaporation or sublimation. The biggest ice caps on earth are found at the poles.

All the steps mentioned above occur cyclically with neither a fixed beginning nor an end.

Carbon Cycle

It is one of the biogeochemical cycles in which carbon is exchanged among the biosphere, geosphere, hydrosphere, atmosphere and pedosphere.

All green plants use carbon dioxide and sunlight for photosynthesis. Carbon is thus stored in the plant. The green plants, when dead, are buried into the soil that gets converted into fossil fuels made from carbon. These fossil fuels when burned, release carbon dioxide into the atmosphere.

Also, the animals that consume plants, obtain the carbon stored in the plants. This carbon is returned to the atmosphere when these animals decompose after death. The carbon also returns to the environment through cellular respiration by animals.

Huge carbon content in the form of carbon dioxide is produced that is stored in the form of fossil fuel (coal & oil) and can be extracted for various commercial and non-commercial purposes. When factories use these fuels, the carbon is again released back in the atmosphere during combustion.

Carbon Cycle Steps

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

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

Carbon Cycle on Land

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

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

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

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

Oceanic Carbon Cycle

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

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

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

Importance of Carbon Cycle

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

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

Key Points on Carbon Cycle

- Carbon cycle explains the movement of carbon between the earth’s biosphere, geosphere, hydrosphere and atmosphere.
- Carbon is an important element of life.
- Carbon dioxide in the atmosphere is taken up by green plants and other photosynthetic organisms and is converted into organic molecules that travel through the food chain. Carbon atoms are then released as carbon dioxide when organisms respire.
- The formation of fossil fuels and sedimentary rocks contributes to the carbon cycle for very long periods.
- The carbon cycle is associated with the availability of other compounds as well.

Nitrogen Cycle

It is the biogeochemical cycle by which nitrogen is converted into several forms and it gets circulated through the atmosphere and various ecosystems such as terrestrial and marine ecosystems.

Nitrogen is an essential element of life. The nitrogen in the atmosphere is fixed by the nitrogen-fixing bacteria present in the root nodules of the leguminous plants and made available to the soil and plants.

The bacteria present in the roots of the plants convert this nitrogen gas into a usable compound called ammonia. Ammonia is also supplied to plants in the form of fertilizers. This ammonia is converted into nitrites and nitrates. The denitrifying bacteria reduce the nitrates into nitrogen and return it into the atmosphere.

Stages of Nitrogen Cycle

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

Nitrogen Fixation Process

It is the initial step of the nitrogen cycle. Here, Atmospheric nitrogen (N2) which is primarily available in an inert form, is converted into the usable form -ammonia (NH3).

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

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

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

Types of Nitrogen Fixation

Atmospheric fixation: A natural phenomenon where the energy of lightning breaks the nitrogen into nitrogen oxides, which are then used by plants.

Industrial nitrogen fixation: It is a man-made alternative that aids in nitrogen fixation by the use of ammonia. Ammonia is produced by the direct combination of nitrogen and hydrogen. Later, it is converted into various fertilisers such as urea.

Biological nitrogen fixation: We already know that nitrogen is not used directly from the air by plants and animals. Bacteria like Rhizobium and blue-green algae transform the unusable form of nitrogen into other compounds that are more readily usable. These nitrogen compounds get fixed in the soil by these microbes.

Nitrification

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

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

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

$$2NO_2^- + O_2 \rightarrow 2NO_3^-$$

Assimilation

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

Ammonification

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

Denitrification

Denitrification is the process in which the nitrogen compounds make their way back into the atmosphere by converting nitrate (NO_3^-) into gaseous nitrogen (N). This

process of the nitrogen cycle is the final stage and occurs in the absence of oxygen. Denitrification is carried out by the denitrifying bacterial species- Clostridium and Pseudomonas, which will process nitrate to gain oxygen and gives out free nitrogen gas as a byproduct.

Nitrogen Cycle in Marine Ecosystem

The process of the nitrogen cycle occurs in the same manner in the marine ecosystem as in the terrestrial ecosystem. The only difference is that it is carried out by marine bacteria.

The nitrogen-containing compounds fall into the ocean as sediments get compressed over long periods and form sedimentary rock. Due to the geological uplift, these sedimentary rocks move to land. Initially, it was not known that these nitrogen-containing sedimentary rocks are an essential source of nitrogen. But, recent researches have proved that the nitrogen from these rocks is released into the plants due to the weathering of rocks.

Importance of Nitrogen Cycle

The importance of the nitrogen cycle are as follows:

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

Nitrogen is also cycled by human activities such as the combustion of fuels and the use of nitrogen fertilisers. These processes increase the levels of nitrogen-containing compounds in the atmosphere. The fertilisers containing nitrogen are washed away in lakes, rivers and result in eutrophication.

Oxygen Cycle

This biogeochemical cycle moves through the atmosphere, the lithosphere and the biosphere. Oxygen is an abundant element on our Earth. It is found in the elemental form in the atmosphere to the extent of 21%.

Oxygen is released by the plants during photosynthesis. Humans and other animals inhale the oxygen and exhale carbon dioxide which is again taken up by the plants. They utilise this carbon dioxide in photosynthesis to produce oxygen, and the cycle continues.

Stages of the Oxygen Cycle

The steps involved in the oxygen cycle are:

Stage-1: All green plants during the process of photosynthesis, release oxygen back into the atmosphere as a by-product.

Stage-2: All aerobic organisms use free oxygen for respiration.

Stage-3: Animals exhale Carbon dioxide back into the atmosphere which is again used by the plants during photosynthesis. Now oxygen is balanced within the atmosphere.

The four main processes that use atmospheric oxygen are:

Breathing :It is the physical process, through which all living organisms, including plants, animals and humans inhale oxygen from the outside environment into the cells of an organism and exhale carbon dioxide back into the atmosphere.

Decomposition: It is one of the natural and most important processes in the oxygen cycle and occurs when an organism dies. The dead animal or plants decay into the ground, and the organic matter along with the carbon, oxygen, water and other components are returned into the soil and air. This process is carried out by the invertebrates, including fungi, bacteria and some insects which are collectively called as the decomposers. The entire process requires oxygen and releases carbon dioxide.

Combustion: It is also one of the most important processes which occur when any of the organic materials, including fossil fuels, plastics and wood, are burned in the presence of oxygen and releases carbon dioxide into the atmosphere.

Rusting: This process also requires oxygen. It is the formation of oxides which is also called oxidation. In this process, metals like iron or alloy rust when they are exposed to moisture and oxygen for an extended period of time and new compounds of oxides are formed by the combination of oxygen with the metal.

Phosphorus Cycle

In this biogeochemical cycle, phosphorus moves through the hydrosphere, lithosphere and biosphere. Phosphorus is extracted by the weathering of rocks. Due to rains and erosion phosphorus is washed away in the soil and water bodies. Plants and animals obtain this phosphorus through the soil and water and grow. Microorganisms also require phosphorus for their growth. When the plants and animals die they decompose, and the stored phosphorus is returned to the soil and water bodies which is again consumed by plants and animals and the cycle continues.

Steps of Phosphorus Cycle

Following are the important steps of phosphorus cycle:

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

Weathering

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

Absorption by Plants

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

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

Absorption by Animals

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

Return of Phosphorus Back to the Ecosystem

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

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

Human Impact on Phosphorus Cycle

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

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

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

Sulphur Cycle

This biogeochemical cycle moves through the rocks, water bodies and living systems. Sulphur is released into the atmosphere by the weathering of rocks and is converted into sulphates. These sulphates are taken up by the microorganisms and plants and converted into organic forms. Organic sulphur is consumed by animals through food. When the animals die and decompose, sulphur is returned to the soil, which is again obtained by the plants and microbes, and the cycle continues.

The process of sulphur cycle is explained below:

- The sulphur is released by the weathering of rocks.
- Sulphur comes in contact with air and is converted into sulphates.
- Sulphates are taken up by plants and microbes and are converted into organic forms.
- The organic form of sulphur is then consumed by the animals through their food and thus sulphur moves in the food chain.
- When the animals die, some of the sulphur is released by decomposition while some enter the tissues of microbes.

- There are several natural sources such as volcanic eruptions, evaporation of water, and breakdown of organic matter in swamps, that release sulphur directly into the atmosphere. This sulphur falls on earth with rainfall.

Steps of Sulphur Cycle

Following are the important steps of the sulphur cycle:

Decomposition of Organic Compounds

Protein degradation releases amino acids that contain sulphur. Sulphates are reduced to H2S by the action of Desulfotomaculum bacteria.

Oxidation of Hydrogen Sulphide to Elemental Sulphur

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

Oxidation of Elemental Sulphur

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

Reduction of Sulphates

Sulphates are reduced to hydrogen sulphide by Desulfovibrio desulfuricans. This occurs in two steps:

- Firstly, the sulphates are converted to sulphites utilising ATP.
- Secondly, the reduction of sulphate to hydrogen sulphide.

Importance of Biogeochemical Cycles

These cycles demonstrate the way in which the energy is used. Through the ecosystem, these cycles move the essential elements for life to sustain. They are vital as they recycle elements and store them too, and regulate the vital elements through the physical facets. These cycles depict the association between living and nonliving things in the ecosystems and enable the continuous survival of ecosystems.

It is important to comprehend these cycles to learn their effect on living entities. Some activities of humans disturb a few of these natural cycles and thereby affect related ecosystems. A closer look at these mechanisms can help us restrict and stop their dangerous impact.

Pollution

Types of Pollution
As stated before, there are different types of pollution, which are either caused by natural events (like forest fires) or by man-made activities (like cars, factories, nuclear wastes, etc.)

Pollution is the introduction of substances (or energy) that cause adverse changes in the environment and living entities .

Pollution need not always be caused by chemical substances such as particulates (like smoke and dust). Forms of energy such as sound, heat or light can also cause pollution. These substances that cause pollution are called pollutants.

Pollution, even in minuscule amounts, impacts the ecological balance. Pollutants can make their way up the food chain and eventually find their way inside the human body. Read on to explore the types of pollution and their implications.

Types of Pollution

1. Air Pollution
2. Water Pollution
3. Soil Pollution
4. Noise Pollution

Besides these 4 types of pollution, other types exist such as light pollution, thermal pollution and radioactive pollution. The latter is much rarer than other types, but it is the deadliest.

Air Pollution

Air pollution refers to the release of harmful contaminants (chemicals, toxic gases, particulates, biological molecules, etc.) into the earth’s atmosphere. These contaminants are quite detrimental and in some cases, pose serious health issues. Some causes that contribute to air pollution are:

- Burning fossil fuels
- Mining operations
- Exhaust gases from industries and factories

The effects of air pollution vary based on the kind of pollutant. But generally, the impact of air pollution ranges from:

- Increased risk of respiratory illness and cardiovascular problems
- Increased risk of skin diseases
- May increase the risk of cancer
- Global warming
- Acid rain
- Ozone depletion
- Hazards to wildlife

Among the other types of pollution, air pollution is theorised to have a planet-wide implication. Scientists have even speculated an apocalypse-like scenario where air pollution, if left unchecked, can bring about an extreme form of global warming called the runaway greenhouse effect. Though this is purely speculative, it is a phenomenon that has already occurred on Venus.

Water Pollution

Water pollution is said to occur when toxic pollutants and particulate matter are introduced into water bodies such as lakes, rivers and seas. These contaminants are generally introduced by human activities like improper sewage treatment and oil spills. However, even natural processes such as eutrophication can cause water pollution.

Other significant causes of water pollution include:

- Dumping solid wastes in water bodies
- Disposing untreated industrial sewage into water bodies
- Human and animal wastes
- Agricultural runoff containing pesticides and fertilisers

The effects of water pollution are very pronounced in our environment. Furthermore, toxic chemicals can bioaccumulate in living beings, and these chemicals can travel their way up the food chain, ultimately reaching humans.

Among the other types of pollution, water pollution has severe consequences on humans. For instance, in 1932, a grave case of water pollution incapacitated the inhabitants of an entire city in Japan with neurological diseases and mental illness for many decades. However, the immediate cause was not apparent but was eventually attributed to acute mercury poisoning. Methylmercury was dumped into the surrounding bay and had ultimately bio accumulated inside the fish. The local

population then consumed these fish, and this resulted in the manifestation of ill effects and neurological diseases.

Other consequences of water pollution include:

- Disruption of the ecosystem
- Threats to marine life
- Increased risk of water-borne diseases
- Increases toxic chemicals (such as mercury) in water bodies
- Eutrophication

Soil Pollution

Soil pollution, also called soil contamination, refers to the degradation of land due to the presence of chemicals or other man-made substances in the soil. The xenobiotic substances alter the natural composition of soil and affect it negatively. These can drastically impact life directly or indirectly. For instance, any toxic chemicals present in the soil will get absorbed by the plants. Since plants are producers in an environment, it gets passed up through the food chain. Compared to the other types of pollution, the effects of soil pollution are a little more obscured, but their implications are very noticeable.

Some of the common causes of soil pollution are:

- Improper industrial waste disposal
- Oil Spills
- Acid rain which is caused by air pollution
- Mining activities
- Intensive farming and agrochemicals (like fertilisers and pesticides)
- Industrial accidents

The effects of soil pollution are numerous. Specific wastes, such as radioactive waste become particularly hazardous when they are not well-contained. A well-documented example is a nuclear accident in Chernobyl, which has left an area of 2,600 km2 uninhabitable for several thousand years.

Other effects of soil pollution include:

- Loss of soil nutrients, which renders the soil unfit for agriculture
- Impacts the natural flora and fauna residing in the soil
- Degrades vegetation due to the increase of salinity of the soil
- Toxic dust (such as silica dust) can cause respiratory problems or even lung cancer

Noise Pollution

Noise pollution refers to the excessive amount of noise in the surrounding that disrupts the natural balance. Usually, it is man-made, though certain natural calamities like volcanoes can contribute to noise pollution.

In general, any sound which is over 85 decibels is considered to be detrimental. Also, the duration an individual is exposed plays an impact on their health. For perspective, a normal conversation is around 60 decibels, and a jet taking off is around 15o decibels. Consequently, noise pollution is more obvious than the other types of pollution.

Noise pollution has several contributors, which include:

- Industry-oriented noises such as heavy machines, mills, factories, etc.
- Transportation noises from vehicles, aeroplanes, etc.
- Construction noises
- Noise from social events (loudspeakers, firecrackers, etc.)
- Household noises (such as mixers, TV, washing machines, etc.)

Noise pollution has now become very common due to dense urbanisation and industrialisation. Noise pollution can bring about adverse effects such as :

- Hearing loss
- Tinnitus
- Sleeping disorders
- Hypertension (high BP)
- Communication problems

Solid Waste Management

The term solid waste management mainly refers to the complete process of collecting, treating and disposing of solid wastes.

In the waste management process, the wastes are collected from different sources and are disposed of. This process includes collection, transportation, treatment, analysis and disposal of waste. It needs to be monitored so that strict regulations and guidelines are followed.

Sources of Solid Wastes

- Solid domestic garbage.
- Solid waste material from various industries.
- Solid agricultural waste.

- Plastics, glass, metals, e-waste, etc.
- Medical waste.
- Construction waste, sewage sludge

Disposal of Waste

The process of waste handling and disposal varies in different countries. In India, the processes differ according to the source of solid waste. They can be classified as:

- Municipal Solid Waste.
- Hazardous Solid Waste.

Municipal solid waste can further be divided into biodegradable, recyclable and hazardous domestic wastes. The biodegradable waste includes rotten food, vegetable peel and mostly wet kitchen waste. Recyclable waste includes plastic and hazardous wastes include, bulb, batteries, etc.

The industry generates waste from chemical factories, medical waste from hospitals are considered as Hazardous Solid Waste and they need special settings to dispose of them.

In any region, solid waste management is very important for the safe disposal of wastes and to reduce environmental pollution and avoid any health hazards that it may cause.

Landfills are the most common method of disposing of solid wastes. Modern-day landfills are designed by taking care of various environmental factors and types of wastes, so as to minimise pollution and health risks.

Effects of Poor Solid Waste Management

Due to improper disposal of solid waste particularly by waste management organisations, the collected wastes get heap up and become a problem for both the environment and also for the public.

The dumping of huge garbage, drives biodegradable materials to decay and decompose under abnormal, uncontrolled and unhygienic conditions. After a few days of decomposition, it becomes a breeding ground for different types of disease-causing insects as well as infectious organisms. A foul smell is produced and it also spoils the aesthetic value of the area.

The solid wastes collected from different industries include toxic metals, chemicals, and other hazardous wastes. When these wastes are released into the environment,

they can produce biological and physicochemical problems to the environment, the chemicals may drain into the soil and pollute the groundwater and also alter the productivity of the soils in that particular area.

In rare cases, the hazardous wastes may get mixed up with the ordinary garbage and other combustible wastes causing the disposal process even harder and risky.

By burning the paper and other scraps along with the hazardous wastes, dioxins and poisonous gases are produced and released into the air which results in causing various diseases including chronic disease, skin infections, cancer, etc.

Environmental Issues

Greenhouse Effect

The greenhouse effect is the process thanks to which Earth has a higher temperature than it would have without it. The gases that radiate heat also known as greenhouse gases absorb the energy radiated out by the Earth and reflect a part of it back to Earth. Of all the energy that the Earth receives from the Sun, a part of it around 26% is reflected back to space by the atmosphere and clouds. Some part of it is absorbed by the atmosphere, around 19%.

The rest hits the ground and heats the surface of the Earth. This absorbed energy is radiated out of the earth in the form of Infrared Waves. These IR waves warm the atmosphere above the Earth. The atmosphere again radiates this energy it received from the Earth both upwards and downwards. The energy sent downwards results in a higher equilibrium temperature that if greenhouse gases were absent. This greenhouse effect is essential to supporting life on Earth.

Greenhouse Gases

- Water Vapour
- Carbon Dioxide
- Methane
- Ozone

The excessive burning of fossil fuels such as petrol, coal, etc. has resulted in an increase in the number of greenhouse gases in the atmosphere resulting in a phenomenon known as Global Warming. This is an increase in the ambient temperature of Earth which will negatively affect life on Earth

Causes of Greenhouse Effect

- Deforestation: This is considered to be one of the most responsible factors for the cause of the greenhouse effect. This is due to the reduction in the release in the oxygen and absorption of carbon dioxide by the plants.
- Fossil fuel burning: Fossil fuels such as coal, oil, and natural gases are used as a means of energy which releases a huge amount of harmful gases into the environment.
- Population: As the population increases, the need for space increases which again results in deforestation.

Prevention of Greenhouse Effect

- Afforestation: Afforestation on a large scale area helps in decreasing the release of carbon dioxide in the atmosphere.
- Conservation of energy: Switching to renewable sources of energy such as solar energy, wind energy, etc will reduce the use of fossil fuels. This eventually reduces the release of carbon dioxide into the atmosphere.
- Policy intervention: When the government comes up with strict policies to maintain the overall air quality of the city.

Global Warming

Global warming is the phenomenon of a gradual increase in the temperature near the earth's surface. This phenomenon has been observed over the past one or two centuries. This change has disturbed the climatic pattern of the earth. However, the concept of global warming is quite controversial but the scientists have provided relevant data in support of the fact that the temperature of the earth is rising constantly.

There are several causes of global warming, which have a negative effect on humans, plants and animals. These causes may be natural or might be the outcome of human activities. In order to curb the issues, it is very important to understand the negative impacts of global warming.

Causes of Global Warming

1.Man-made Causes of Global Warming

Deforestation

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

Use of Vehicles

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

Chlorofluorocarbon

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

Industrial Development

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

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

Agriculture

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

Overpopulation

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

2.Natural Causes of Global Warming

Volcanoes

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

Water Vapour

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

Melting Permafrost

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

Forest Blazes

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

Effects of Global Warming

:

Rise in Temperature

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

Threats to the Ecosystem

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

Climate Change

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

Spread of Diseases

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

High Mortality Rates

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

Loss of Natural Habitat

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

Effects of Global Warming on Climate

The effects of global warming are much more apparent now than ever before. Though climate change is a natural process, it is exacerbated by human activities. And one of the biggest contributing factors to climate change is greenhouse gas emissions, with more than 90% of the emissions being carbon dioxide and methane. Today, global warming has far-reaching effects and implications that can affect life on earth. In this article, we shall explore some of the effects of global warming.

Extreme Weather Events

Scientists have linked extreme weather events to global warming. These range from blistering heat waves and severe drought to tropical storms and flash floods.

Heat Waves and Droughts

Global warming has increased global ambient temperatures, and with higher temperatures boosting evaporation, it dries out the soil during the summer months. This means longer-lasting and more severe draughts. It is also important to note that the number of heat waves have significantly increased since the 1950s. Moreover, urban areas experience higher temperatures than the surrounding rural areas. This is called an “Urban Heat Island” effect and is caused by a variety of factors such as:

- Dark surfaces (roads and concrete)
- Additional heat given out by machinery (AC and chimneys etc)
- Impermeable surfaces that limit water evaporation

Storms and Floods

Increased heat leads to increased evaporation, and in turn, more moisture accumulates in the atmosphere. This causes rainfall to intensify. As temperatures continue to rise, scientists speculate that Category 4 and 5 storms will become more frequent. In addition to hurricanes, rising sea levels directly lead to flooding and storm surges. Since the 1900s, global average sea level has risen by about 21 cm (8 inches), most of which was triggered by anthropogenic activities. The rest of the rise is contributed by melting polar ice caps and glaciers

Temperature Drops and Frigid Weather

Though it seems implausible, More moisture in the atmosphere can lead to more intense cold spells. This is because warmer air can hold more moisture, and when temperatures get cold enough, this moisture can become snow, typically at higher altitudes. For instance, in the winter of 2019, the Alps experienced an enormous amount of snowfall, which was triggered by extremely moist and warm air masses. Meteorologists had discovered that the oceans were quite warm in winter as the preceding summer was hotter than usual. As a result, a lot of water from the ocean evaporated and the air currents took it to the Alps, leading to excessive snowfall. Global warming can also cause other weather phenomena to destabilise – such as the polar vortex. This also leads to cold spells and extreme frigid temperatures.

Acid Rain

Acid rain is precipitation that has unusually high levels of hydrogen ions (low pH). The water droplets are acidic because of atmospheric pollution. It is known to have harmful effects on aquatic animals, plants and infrastructure. The term “acid rain” was coined in 1872 by Robert Angus Smith.

Causes of Acid Rain

- Excessive amounts of sulphur and nitrogen released by cars and industrial processes get mixed with rain and result in precipitation that is highly acidic.
- These pollutants react with water vapours present in the atmosphere to form sulfuric acid and nitric acid respectively.
- Sulphur and Nitrogen particles may be released in the atmosphere due to anthropogenic causes or by natural causes

Anthropogenic causes include industrial emissions, burning of fossil fuels such as diesel and coal, incineration of garbage, production of paper.
Natural causes could be release of sulphur during volcanic eruptions or nitrogen ions released in the atmosphere during a lightning strike. The chemical reaction occurs in the presence of lightning to form the nitric oxide. This further reacts with oxygen to form nitrogen dioxide.

- Furthermore, ozone, some other organic acids like formic and acetic acids also contribute to 5-20% acidity in total acid rain.

Effects of Acid Rain

- Acid rains damage standing crops and forests.
- It has an adverse impact on freshwater life, other aquatic life forms, insects etc.
- Acid rain can cause the ocean's pH to fall. This phenomenon is known as 'ocean acidification'. Though acid rain does not have huge impacts on oceans, they significantly affect shallow coastal waters.
- Excess nitrogen inputs from the atmosphere in the oceans promote increased growth of marine plants and phytoplankton which may result in more frequent harmful algal blooms and eutrophication.
- Limestone skeleton in Corals is sensitive to decrease in pH levels, as calcium carbonate – the core component of the limestone skeleton – dissolves in low pH/acidic solutions.
- Some microbes in the soil cannot tolerate changes to low pH and get killed. The enzymes of these microbes are denatured by the acid.
- It corrodes structures as well as buildings. Example: Acid rains have turned the Taj Mahal's marble yellow.
- Acid rain also causes the corrosion of water pipes which further results in leaching of heavy metals such as iron, lead and copper into drinking water.
- Acid rain does not harm humans immediately. The sulphur dioxide creates various health problems. It can cause lung inflammation including asthma, bronchitis and emphysema.

Controlling the anthropogenic causes of acid rain by keeping a check on industrial and vehicular emissions is one of the most significant steps in reducing acid rains. Policy interventions to reduce such emissions is the need of the hour. Additionally, renewable sources of energy through fewer emissions can help reduce acid rain.

Ozone Layer

- It is a layer in the earth's stratosphere that contains high levels of ozone.
- This layer protects the earth from the Sun's harmful UV radiation. It absorbs 97 – 99% of the UV radiation from the Sun.
- In the absence of the ozone layer, millions of people would be affected by skin diseases including cancer and weakened immune systems.
- UV radiation would also affect the environment adversely leading to decreased productivity.
- Fauna on earth is also adversely affected by the ozone layer depletion.

The ozone found in the troposphere is near the earth's surface and is harmful to life (causes breathing issues in humans) and plants (damages crops and plants.) Urban smog comprises bad ozone. The good ozone is found in the stratosphere which also

hosts the ozone layer. It is called good as it absorbs the sun's harmful ultraviolet radiation.

Ozone Layer Depletion

Ozone layer depletion refers to the thinning of the protective ozone layer in the atmosphere.

- This happens when certain chemicals come into contact with ozone and destroy it.
- Chemical compounds that cause ozone layer depletion are called Ozone Depleting Substances (ODSs).
- Examples of ODSs are chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), carbon tetrachloride, methyl chloroform, hydrobromofluorocarbons, halons, etc.

1. Chlorofluorocarbons (CFC): The use of CFCs is one of the main reasons for the depletion of the layer. They are usually used as a coolant in refrigerators and air conditioners used in cars, etc. It is also used as an industrial solvent, in foam products and hospital sterilisation equipment.
2. Methyl chloroform: Finds its applications usually in industries for chemical processing, etc.
3. Carbon tetrachloride: Normally used as a solvent.

- Chlorofluorocarbons are the most abundant ODS.
- The indiscriminate use of these chemicals causes ozone layer depletion.
- These ODSs are also powerful Green-House Gases (GHGs) and have a long life as well.
- There are a few natural causes also which cause ozone depletion such as volcanic eruptions, sunspots and stratospheric winds. However, these do not cause more than 1 – 2% of the ozone depletion.

Ozone Layer Preservation Depletion

- The depletion of the Ozone Layer is a serious issue and various programmes have been launched by the governments of various countries to prevent it. But, steps should be taken at the individual level as well.
- The IMO (International Maritime Organisation) mandated that cargo ships must not use fuel that has sulphur content any higher than 0.5%.
- This will be implemented from 1st January 2020 as this is one of the many environmental-related issues that is associated with the shipping industry.
- The **Vienna Convention** for the Protection of the Ozone Layer was signed in 1985 under which UN member countries recognized the importance of curbing damage to the ozone layer.
- As per the Convention's provisions, countries agreed to adopt the Montreal Protocol to further the goals of the Vienna Convention.

- The **Montreal Protocol** was signed in 1987 and entered into force in January 1989.
- The protocol gives provisions to reduce the production and consumption of ODSs in order to protect the ozone layer.

Efforts on an Individual level can be as follows:

- Avoid Using Pesticide
- Minimise the Use of Vehicles
- Use Eco-friendly Cleaning Products
- The Use of Nitrous Oxide should be Prohibited

Energy

The word 'Energy' defines the capacity or ability to do work. Energy exists in many forms, including Kinetic Energy, Electrical Energy, Thermal Energy, Potential Energy, Chemical Energy, Nuclear Energy, etc. Motion is associated with all forms of energy. For example – any object or body in motion has Kinetic Energy associated with it. According to the principle of Conservation of Energy or the first law of Thermodynamics, energy can neither be created nor destroyed but can only be changed from one form to another. There are two prime sources of energy, namely, the Conventional Sources of Energy, and the Non-conventional Sources of Energy.

Energy is a major part of life and not only just the economic infrastructure and hence this being the basic energy needed for almost all the needs in life it is true that the energy is being exhausted as days go by. Those energies that are continuously being formed in nature are termed nonconventional energy or also called renewable energy sources. These are of various types depending on their sources. Conventional energy on the other hand is based on fossils and hence these are possibly going to be extinct quite soon. Due to the energy sources being extinct quite soon it has become an important matter on how to save these energies.

Conventional Sources of Energy

The Conventional Sources of Energy are also known as the non-renewable sources of energy, which are present in a limited quantity and are being consumed by human beings for many years now. These non-renewable sources of energy are the decaying matters, which take over hundreds of years to form, for example, coal, petroleum, etc. So, if they are depleted once, they can never be generated at a speed or pace, which could sustain their rate of consumption.

The conventional sources of energy can be further classified into two types, namely, the commercial energy sources and the non-commercial energy sources.

Commercial Energy Sources

Commercial energy sources are those energy sources for which the consumer needs to pay the price for the consumption. For instance - coal, petroleum, oil, natural gas, and electricity.

Coal:

Without any second thoughts, coal is indeed the most vital source of energy. The formation of coal takes place when dead plant matter decays into peat (accumulation of partially decayed organic matter or vegetation) which is converted into coal by pressure and heat over millions of years. Coal is mostly composed of Carbon. It has variable amounts of other elements also, like Hydrogen, Nitrogen, Sulphur, and Oxygen.

Natural Gas and Oil:

Natural gas is one of the most crucial sources of energy in the world whereas oil is considered to be liquid gold. Oil is formed from a large number of tiny animals and plants, which when die, get trapped at the bottom of the sea under multiple layers of sand and mud, and get exposed to heat and pressure. It is widely used in trains, ships, automobiles, and planes. Natural gas is formed when several layers of decomposing animal and plant matter are exposed to intense pressure and heat over millions of years under the surface of Earth. It is used for various purposes, including cooking, heating, and electricity generation.

Electricity:

Electricity is a form of energy, in which there is a flow of electrons (electric charge) in one direction. Electricity can be produced using fossil fuels (coal and petroleum), nuclear power, and renewable alternatives (solar, wind, or hydropower). As a common source of energy, electricity is commonly used for commercial and domestic purposes. The electricity is primarily utilised in electrical appliances, including refrigerators, air conditioners (AC), TV, and washing machines.

The Prime Sources of Power Generation are as follows

- **Nuclear Power**
- **Hydro-electric Power**
- **Thermal Power**

Thermal Power:

By utilising coal and oil, thermal power is generated at several power stations. The production of thermal power is the conversion of fuel into heat. It is generated using thermal generators and specifically designed furnaces. A thermal power plant burns fuels for boiling water and making steam. The steam produced then spins a turbine connected to a generator that weaves electricity.

Hydroelectric Power:

Hydroelectric power is generated or produced with the help of constructing dams above the flowing rivers, for example, Bhakra Nangal Project and Damodar Valley Project. Flowing water creates energy that can be further captured and eventually turned into electricity. Water is released from the reservoir and then flows through a turbine. The turbine spins the water and activates a generator, which produces electricity.

Nuclear Power:

Nuclear power plants use uranium and plutonium as fuel, which is less expensive than coal. The vast majority of electricity from Nuclear Power is produced via nuclear fission, nuclear fusion, and nuclear decay reactions.

Non-Conventional Sources of Energy

Also referred to as the renewable sources of energy, the non-conventional sources of energy refer to those energy sources, which are replenished by natural processes, that too continuously. The non-conventional sources of energy can’t be exhausted easily and can be generated at a constant rate for their use over and over again. Furthermore, these energy sources do not pollute the environment and natural surroundings and require less expenditure. A few examples of non-conventional sources of energy include wind energy, tidal energy, solar energy, geothermal energy, and biomass energy. The reason why they are also called renewable sources of energy lies in the fact that they can be produced or generated through natural processes, at a rate greater than or equal to the rate of their consumption.

Non-Commercial Energy Sources

In general, non-commercial energy sources are those energy sources that are freely available, and the consumers don't need to pay the price for their consumption. A few examples of non-commercial energy sources include firewood, straw, dried dung, etc.

Solar Energy:

Solar energy is the energy produced or generated by sunlight. Based on the form of energy that needs to be produced or generated, the photovoltaic cells are exposed to sunlight. Solar energy is widely utilised for the distillation of water and cooking purposes.

Wind Energy:

Wind energy is the energy generated or produced by harnessing the power of the wind. It is widely used in the operation of water pumps for irrigation purposes. India is the second-largest producer of wind power in the world.

Tidal Energy:

Tidal energy is the energy produced or generated by exploiting the tidal waves of the sea. As a non-conventional source of energy, tidal energy is still left to be tapped due to the lack of cost-effective technology.

Advantages of Non-Conventional Energy over Conventional Energy

- Nonconventional energy also called the renewable source of energy is an indigenous source that is available and has a significant impact on local and regional economic industries.
- There is also a huge scope of research in the nonconventional energy source sectors regarding its future and its utilisation in science and other applications.
- The power plants that are based on nonconventional energy do not have much high fuel cost and are hence much more affordable for people and industries.
- Renewable energy has low energy density and is also helpful in reducing pollution and providing a sustainable environment to live in.
- It requires a short gestation period and a low amount to be invested.

Environmental Impact Assessments

It is a process of evaluating the likely environmental impacts of a proposed project or development, taking into account inter-related socio-economic, cultural, and human-health impacts, both beneficial and adverse. EIA is a tool used to assess the positive and negative environmental, economic, and social impacts of a project. This is used

to predict the environmental impacts of a project in the pre-planning stage itself so that decisions can be taken to reduce the adverse impacts.

Evolution & History of EIA

EIA is termed as one of the best policy innovations in the 1900s. The main aim of EIA is to conserve the environment and bring out the best combination of economic and environmental costs and benefits. Read the below-mentioned points to understand the
Environmental Impact Assessment evolution and history:

- The birth of EIA is dated back to the 1970s. In 1969, The USA had brought its first National Environment Policy Act (NEPA) 1969.
- The EIA was initially practised by developed nations but slowly it was also introduced in developing nations including India.
- Columbia and the Philippines are the earliest examples of developing nations who introduced EIA in their policies. Columbia bought it in 1974 while the Philippines in 1978.
- Worldwide, EIA is now practised in more than 100 countries. By the mid-1990s, some 110 countries applied EIA as a major environmental policy.
- In 1989, EIA was adopted as the major development project by the World Bank.

Objectives of Environmental Impact Assessment

- Identifying, predicting, and evaluating economic, environmental, and social impacts of development activities.
- Providing information on the environmental consequences for decision making.
- Promoting environmentally sound and suitable development by identifying appropriate alternatives and mitigation measures.

Environmental Impact Assessment (EIA) Process

Process	Details in Brief
Screening	Which projects need a full or partial assessment study is decided in this stage
Scoping	• Which impacts are necessary to

	be assessed is decided in this stage. While doing so, legal requirements, international conventions, expert knowledge, and public engagement are also considered. • Alternative solutions that avoid or at least reduce the adverse impacts of the project are also studied in this stage • Investigation of alternate designs or sites that avoid or mitigate impact takes place
Assessment & Evaluation of Impacts and Development of Alternatives	Environmental impacts of the proposed project are analysed and light is thrown upon the alternatives present to such projects
EIA Report also called Environmental Impact Statement (EIS)	An environmental management plan (EMP) and also a non-technical summary of the project's impact is prepared for the general public in this stage
Decision Making	The fate of the project is decided. Whether the project is to be given approval or not and if it is to be given, under what conditions
Monitoring, compliance, enforcement and environmental auditing	Monitoring whether the predicted impacts and the mitigation efforts happen as per the EMP

Importance of Environmental Impact Assessment

EIA is a good tool for prudent environment management.
It is government-policy that any industrial project in India has to secure EIA clearance from the Environment Ministry before approval for the project itself.

Environmental Impact Assessment In India

- EIA started in India in 1976-77 when the Planning Commission directed the Department of Science & Technology to assess the river valley projects from the point of view of the environment. This was extended for all those projects that required approval from the Public Investment Board.
- Then, in 1986, the government enacted the Environment (Protec-tion) Act which made EIA statutory. The other main laws in this regard are the Indian Wildlife (Protection) Act (1972), the Water Act (1974), the Air (Prevention and Control of Pollution) Act (1981), and the Biological Diversity Act (2002).
- In 1982, the Ministry of Environment, Forest and Climate Change set up the Environmental Information System (ENVIS) to collect, collate, store, retrieve and disseminate information related to the environment sector. This serves as a web-based distributed network of subject-specific databases. The chief purpose of the ENVIS is to integrate all countrywide efforts to collect, store, disseminate, and use environment-information for better managing environmental assessment activities.

Remote Sensing Applications

Land Use Mapping

Remote sensing data is useful in obtaining up-to-date land use pattern of large areas at any given time and also monitor changes that occur from time to time. It can be used for updating road maps, asphalt conditions, and wetland delineation. This information is used by regional planners and administrators to frame policy matters for all-round development of the region.

Weather Forecasting

Remote sensing is extensively used in India for weather forecasting. It is also used to warn people about impending cyclones.

Environmental Study

It can be used to study deforestation, degradation of fertile lands, pollution in atmosphere, desertification, eutrophication of large water bodies and oil spillage from oil tankers.

Study of Natural hazards

Remote sensing can be used to study damages caused by earthquakes, volcanoes, landslides, floods and melting of ice in polar regions. Many times remote sensing will be helpful to predict the occurrence of natural hazards.

Resource exploration

Remote sensing data is helpful for updating existing geological maps, rapid preparation of lineament and tectonic maps, identifying the sites for quarrying the minerals and helpful in locating fossil fuel deposits.

Environmental Conventions

1. Ramsar Convention

- It is called the Convention on Wetlands
- It was adopted in the city of Iran, Ramsar in 1971.
- It came into force in 1975.

2. Stockholm Convention

- It is a convention on Persistent Organic Pollutants (POPs)
- It was adopted in 2001 in Geneva, Switzerland.
- It came into force in 2004.

3. CITES

- It is a convention on International Trade in Endangered Species of Wild Fauna and Flora
- It was adopted in 1963.
- It came into force in 1975.

4. Convention on Biological Diversity (CBD)

- It is a convention for the conservation of biological diversity.
- It was adopted in 1992
- It came into force in 1993.

.

5. Bonn Convention

- It is a convention on the Conservation of Migratory Species of Wild Animals.
- It was adopted in 1979.
- It came into force in 1983.

6. Vienna Convention

- It is a convention for the Protection of Ozone Layers.
- It was adopted in 1985.
- It came into force in 1988.

7. Montreal Protocol

- It is an international environment protocol on substances that deplete the Ozone Layer.
- It was adopted in 1987.
- It came into force in 1989.

8. Kyoto Protocol

- It is an international protocol to reduce greenhouse gas emissions.
- It was adopted in 1997.
- It came into force in 2005.

9.United Nations Framework Convention on Climate Change

- It is an international environmental treaty governing actions to combat climate change through adaptation and mitigation efforts directed at control of emission of GreenHouse Gases (GHGs) that cause global warming.
- It was adopted in 1992.
- It came into force in 1994.

10. Rio Summit

- It is a United Nations Conference on Environment and Development.
- It was held in 1992 at Rio de Janeiro, Brazil.

11. UNCCD

- It is a United Nations Convention to Combat Desertification.
- It was adopted in 1994.
- It came into force in 1996.

12. Basel Convention

- It is a convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.
- It was adopted in 1989.

- It came into force in 1992.

13. Cartagena Protocol

- It is an international environmental protocol on Biosafety to the Convention on Biological Diversity.
- It was adopted in 2000.
- It came into force in 2003.

14. UN-REDD

- It is a United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation.
- It was created in 2008.

15. Nagoya Protocol

- It is an international environment protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilisation (ABS) to the Convention on Biological Diversity (CBD).
- It was adopted in 2010.
- It came into force in 2014.

16. COP24

- It is the 24th meeting of the conference of parties (COP) to the United Nations Framework Convention on Climate Change.
- It took place in 2018.

17. COP21

- It is the 21st meeting of the conference of parties (COP) to the United Nations Framework Convention on Climate Change.
- It took place in 2018.

18. Kigali Agreement

- It is an amendment to the Montreal Protocol.
- It was adopted in 2016.
- It came into force in 2019.

19. Minamata Convention

- It is an international environmental treaty intended to protect health and the environment from the adverse effects of mercury.
- It was adopted in 2013.
- It came into force in 2017.

20. Rotterdam Convention

- It is an international environmental convention on Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade.
- It was adopted in 1998.
- It came into force in 2004.

21. COP25

- It is the 25th meeting of the Conference of Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC).
- It took place in 2019.