The Concept of Ecosystem

INTRODUCTION

'Ecology' is the study of the interrelationship between living organisms and their environment. Ecology shows the interdependence of life and the environment and deals with balance in nature.

Ecology studies ecosystems which are composed of dynamically interacting parts including organisms, the communities they make up, and the non-living components of their environment.

E.P. Odum (Eugene Pleasants) (1953) is regarded as the father of Ecosystem Ecology. He brought forward the importance of ecology as a discipline. He adopted and developed further the term "ecosystem".

R. Margalef (1968) suggested that ecology is 'the study of ecosystems'.

Prof. Ramdeo Mishra who is called as the 'Father of Indian Ecology', defined it as 'the study of interactions of form, function and factors'.

Ecology involves various biological organizations. The levels of biological organizations of interest in ecology are:
Organism----Population----Community----Ecosystem-----Biosphere.

Ecosystem

A biotic community lives in an abiotic environment called 'biotope'. The biotope provides material and energy to the bio-community inhabiting it. This shows that there is an interaction between a biotic community and its environment. Therefore, a bio-community cannot live isolated from the biotope. A bio-comunnity and its biotope together form an 'ecological system' or 'ecosystem'. In Greek 'eco' means 'environment' and 'system' means an 'interacting and interdependent complex'. The term ecosystem was coined by A.G.Tansley (1935). Some other terms were also coined for ecosystem e.g. 'Biocoenosis' by Carl Mobius (1877), 'Microcosm' by S.A. Forbes (1887), 'Geobiocoenosis' or 'biogeocoenosis' by Sukhchev (1944).
Organisms such as plants, animals and microorganisms, interact with the physical environment of their habitat, and form an ecological complex working system which

is termed as the 'ecosystem'. The ecosystem has two interacting components. These are:

- Organisms (biotic)
- Physical environment (abiotic)

Definition of Ecosystem

An ecosystem may be defined as 'a structural and functional unit of the biosphere, comprising living organisms and their nonliving environment that interact by means of food chains and chemical cycles, resulting in energy flow, biotic diversity and mineral cycling, to form a stable self-supporting system'. An ecosystem involves a whole network of relationships, exchanges and interactions, between the living and nonliving components. The relationship between a biotic community and the nonliving environment is always a mutual one, that is, not only does the environment affect the community but the community also modifies the environment.

An ecosystem does not remain constant. Changes occur in it continuously in one form of the other. It is significant that even a small change in one part of an ecosystem is felt throughout the ecosystem. This establishes the importance of inter-linkages in an ecosystem.

TYPES & STRUCTURE OF ECOSYSTEMS

Ecosystems may be classified on the basis of their nature, duration and size.

1. On the basis of nature: On this basis an ecosystem may be natural or artificial. Common examples of natural ecosystems are a pond, a lake, a meadow, a desert, grassland, a forest, a village, a flied, a hill- side etc. Even a single log and edge of a pond are also instances of ecosystem.
   Instances of artificial ecosystems are a manned spaceship, a flowerbed or kitchen garden in the backyard, an aquarium and a pot of houseplants.

2. On the basis of duration : On this basis an ecosystem may be temporary, such as a rainfed pond and laboratory culture of protozoa, or permanent, such as a forest or a lake.
3. On the basis of size : On this basis an ecosystem may be very small, called microecosystem, such as a flowerpot or a site under a stone or it may be very large, termed macroecosystem, such as, an ocean, a forest etc.

Scope of the Study of an **Ecosystem**

The study of an ecosystem focuses on various aspects. Besides the organisms and their environment, it also includes:

- Nutritive relationships between the organisms
- Interactions between the organisms and the environment
- Cycling of matter, and
- Flow of energy through it.

Structure of Ecosystem

To sustain itself and to last indefinitely, an ecosystem must have recourses for supporting its resident organisms and for disposal of their wastes.

The necessary components of an ecosystem are matter (water, minerals, carbon dioxide, and oxygen) and several species of organisms. An ecosystem must also receive a continuous supply of energy.

The components of an ecosystem may be divided into two main types:

- Biotic components comprising the various kinds of organisms and
- Abiotic components comprising of environmental factors.

ABIOTIC COMPONENTS

Abiotic components of an ecosystem include the nonliving physical-chemical factors of the environment. These components not only affect the distribution and structure of organisms but also their behavior and interrelationships.

Abiotic components are of three types:

- Physical factors –light, heat, humidity, atmospheric pressure Organic components – carbohydrates, proteins and lipids and
- Inorganic components – oxygen, nitrogen, carbon dioxide

Light

Sunlight is an essential abiotic factor in the ecosystem. It constitutes the main supply of energy for all organisms. Plants with chlorophyll can change the light energy into chemical energy through a process known as photosynthesis. This chemical energy is stored as complex organic substances known as food. Besides the significant function of food production, the light also regulates many biological processes.

Heat

Heat is essential for maintaining the body temperatures of ectothermic animals which are not adapted to regulate their body temperature, for e.g. fishes, amphibians and reptiles.

Plants make use of a little amount of heat to perform the photosynthetic process. They are adapted to survive between great ranges of temperature. This is also applicable for all the organisms from Archea to mammalia. Some microorganisms can even tolerate extreme temperatures.

The earth receives heat from the sun. The heated earth emits infrared radiation, which is absorbed by the atmospheric water vapour. This delays the release of heat towards space. Thus, the atmosphere is kept warm. Besides water vapour other gases like carbon dioxide and methane also absorb infrared radiation. This is known as Green house effect.

Water

Water is an indispensable factor for life. Living beings originated in water and all living beings need water to survive. Water is involved in diverse organic and chemical processes. Water works as a thermo-regulator for the climate and living systems, including warm blooded animals. Water is responsible for the maintenance of stable climatic conditions on earth.

Organic Components

The main organic components of an ecosystem are carbohydrates, proteins and lipids. They are the major biomolecules and they help in the sustenance of life forms.

Inorganic Components

Various inorganic elements are essential for the metabolism of living organisms to function properly. From the 92 known natural elements, only 25 elements are found in living matter. From these 25 elements four elements- carbon, oxygen, hydrogen and nitrogen, are present in 97% of the molecules of life. The remaining comprise only 3% of living matter, the most important being phosphorus, potassium, calcium and sulphur.

BIOTIC COMPONENTS

Living organisms present in an ecosystem form the biotic components. They are interconnected through food. Matter and energy are transferred in the living world as

food. Organisms in an ecosystem can be classified on the basis of their mode of obtaining food.These are: plants, animals and microorganisms. Plants are called called producers, animals are the consumers while microorganisms are the decomposers, according to their role in keeping the ecosystem operating as a stable unit.

Producers

Producers are mainly green plants having chlorophyll. They produce carbohydrates by the process of photosynthesis. In this, the plants convert solar energy into chemical energy, using water and carbon dioxide. They are called 'autotrophs' since they produce their own food. Part of the food produced by autotrophs is utilized for their own consumption for survival and growth, while the remaining is stored in the plant parts for future consumption. This becomes the food for other biotic components in the environment.

Consumers

Consumers are the organisms that gather energy by consuming organic material from other organisms. Consumers derive their energy by aerobic respiration, which converts sugar and oxygen into carbon dioxide and water to give them energy. Since, they rely on the producers for their food requirements, consumers are also called as 'heterotrophs'. Consumers may be:

- Primary Consumers or Herbivores: 'Primary consumers' or 'herbivores' are also called 'first order consumers'. They eat the producers or plants. E.g. cattle like cows and goats, deer, rabbit etc.
- Secondary Consumers or Primary Carnivores: 'Secondary Consumers' or 'Primary Carnivores' are also called 'second order consumers'. They eat herbivores e.g. snakes, cats, foxes, etc.
- Tertiary Consumers: Tertiary Consumers are also called 'third order consumers'. They feed on secondary consumers. They are large carnivores. E.g. wolf Quaternary Consumers: Quaternary Consumers are also called 'fourth order consumers'. They are very large carnivores and feed on tertiary consumers and are not consumed by other animals. E.g. lions and tigers.
- Omnivores: Organisms that consumes both producers and other consumers are called as 'omnivores'. Omnivores may be in the second and higher trophic levels depending on their level of consumption. Example Dogs and Humans Detrivores: Detrivores are organisms that consume detritus matter - the tissues of dead organisms, either producers or consumers - and organic waste. For Example *millipedes* and *earthworms.*

Decomposers

Decomposers, also called as 'saprotrophs', are mainly microorganisms like bacteria and. The dead organic materials of producers and consumers are their food. They breakdown the organic matter into simple compounds and utilize them in their metabolic processes. These simple compounds are nutrients which are absorbed by the producers, thus completing a cyclic exchange of matter between the biotic and abiotic components of the ecosystems.

FUNCTIONS OF AN ECOSYSTEM

Ecosystems are complex, dynamic and perform a variety of functions. The major functions of ecosystems are energy flow and nutrient cycling through biogeochemical cycles**.**

Energy Flow in an Ecosystem

The sun is the source of all our energy. Chlorophyll bearing plants convert the energy from sun into carbohydrates and sugars using carbon dioxide and water. This process is known as 'photosynthesis'. The generalized form of the photosynthetic reaction is:

$6CO_2 + 12H_20 \text{-----} > C_6H_{12}O_6 + 6O_2 + 6H_2O$

The sun's energy, thus, enters the living beings through photosynthetic reactions and is passed from one organism to another in the form of food. The flow of energy is unidirectional and governed by the thermodynamic law that states that energy is neither created nor destroyed and can transform into different forms.

Food Chain & Food Web

The food chain is an ideal model of the flow of energy in the ecosystem. Transfer of food energy from green plants or producers, through a series of organisms, with repeated eating and being eaten, is called 'food chain'.

Each step in the food chain is called a 'trophic level'. A food chain has three main trophic levels; producers, consumers and decomposers, 84 though the overall number of trophic levels might be five or six. The energy efficiency of each trophic level is very low, which puts a limit on the number of trophic levels. The shorter the food chain the greater will be the availability of food.

There are two types of food chains: Grazing Food Chains & Detritus Food Chains.

i. Grazing food chains start from the green plants that make food for herbivores, and herbivores in turn for the carnivores.

ii. Detritus food chains start from the dead organic matter to the detrivore organisms, which in turn make food for many organisms, from protozoans to carnivores etc.

The food chains are not linear chains or isolated chains and do not operate independently. Several food chains remain linked together and form an interconnected network pattern known as 'food web'. In a food web the interconnections of food chains depend upon the availability, kind and choice of food at each trophic level.

A Food web maintains the stability of the ecosystem by providing several alternative sources of food. Greater ~~is~~ the number of interlinks, more stable is the community.

Ecological Pyramid

Ecological pyramids are the graphic representations of trophic levels in an ecosystem. They are pyramidal in shape and are of three types. – Pyramid of Biomass, Pyramid of Numbers and Pyramid of Energy.

1. Pyramid of Biomass: A pyramid of biomass is a graphical representation of biomass in an ecosystem at various trophic levels. The pyramid shows that most of the earth's biomass exists in producers, less in primary consumers and increasingly less in higher trophic levels. In some cases, the pyramid shape can vary.
   - The pyramid of biomass in a terrestrial ecosystem 88 is upright.
   - In an aquatic habitat, the pyramid of biomass is inverted or spindle shaped where the biomass of a trophic level depends upon the reproductive potential and longevity of the member.

2. Pyramid of Number: A pyramid of number represents the number of organisms at each trophic level. E.g. in a grassland the number of grasses is more than the number of herbivores that feed on them and the number of herbivores is more than the number of carnivores. In some instances, the pyramid of number may be inverted, that is herbivores are more than primary producers as we may observe that many caterpillars and insects feed on a single tree.

3. Pyramid of Energy: A pyramid of energy represents the total amount of energy at each trophic level. Energy is expressed in terms of rate such as, kcal/unit area/unit time; or cal/unit area/unit time. For E.g. in a lake autotroph energy is 20810kcal/m/year. Energy pyramids are never inverted.

BIOGEOCHEMICAL CYCLES

Several mineral cycles operate in ecosystems. The mineral elements are primarily absorbed by plants from their surroundings, that is, air, water, soil and are then passed on to animals. Later, the death and decomposition of plants and animals release these elements into their surroundings and are reused by plants. All the elements cycle continuously through the organisms and earth, and this transfer in a cyclic manner is called 'biogeochemical cycle'. Biogeochemical cycles are of two types: Gaseous cycles and Sedimentary cycles.

Gaseous Cycles:

Gaseous biogeochemical cycles are the oxygen cycle, the carbon cycle and the nitrogen cycle.

Oxygen Cycle: Molecular oxygen, through respiration, and combined oxygen in the form of water, carbon dioxide, etc., enters the living system. Oxygen returns into the atmosphere through photosynthesis and through a number of other biological processes. Oxygen in the atmosphere is an indispensable element for life. It is constantly taken in by animals and plants and is used in respiration. Oxygen deficiency causes a number of effects in plants such as stunted growth, death of roots, thin cell wall and poor root branching. This may be due to certain environmental conditions like poor aeration in soil, water logging, swampy habitat, etc., may create oxygen deficiency, even though sufficient quantity of oxygen gas is present in the atmosphere.

Carbon Cycle: The 'carbon cycle' is the cycling of carbon between biotic and abiotic systems. Biomass is part of the carbon cycle. Carbon from the atmosphere is converted into biological matter by photosynthesis. On death or combustion the carbon goes back into the atmosphere as carbon dioxide. Most of the carbon in the form of carbon dioxide enters the living world through photosynthesis and is used in the synthesis of organic compounds in living systems. By way of respiration, decomposition of plants and animals by microorganisms or by burning of fuels etc., the carbon fixed in the form of organic compounds is released as carbon dioxide and thus it returns into the atmosphere for reuse.

Nitrogen Cycle:

Nitrogen and its compounds form a vital ingredient in all forms of life in the biosphere. Nitrogen is available in the atmosphere as molecular nitrogen in the gaseous form, which cannot be directly absorbed by the plants or producers. In order to be absorbed by the plants, it has to be converted into water-soluble compounds

with elements like hydrogen, carbon and oxygen. This process is known as ‘fixation of nitrogen’.

Sedimentary Cycles:
The ‘Sedimentary Cycles’ of an ecosystem are: Sulphur cycle and Phosphorus Cycle.

Sulphur Cycle:
Amino acids and proteins need sulphur compounds for their production. In the atmosphere, it is present as sulphur dioxide and hydrogen sulphide, in the soil as sulphates or sulphides.
Volcanic emissions and burning of fossil fuels –supply sulphur dioxide to the atmosphere, while bacterial emissions give hydrogen sulphide . Atmospheric sulphur dioxide, eventually reaches the earth along with rainfall.
Sulphur bacteria also play a vital role in the interchange and movement of sulphur compounds in the ecosystem. The sulphur compounds in the plant and animal parts are absorbed by the soil after their death, decay and converted into sulphides and sulphates by sulphur bacteria, which are subsequently used up by the plants.

Phosphorous Cycle
The bones and teeth of animals, including human beings, contain phosphates, which are necessary for their development and growth. In addition, phosphates are essential for cells in the production of DNA and RNA. Phosphates are available in the lithosphere in rocks and soil in inorganic form.
Plants absorb phosphates and convert them into organophosphates. Phosphates are also added to the soil through phosphate fertilizers. Soluble phosphates reaching rivers and streams from agricultural lands made rich in phosphates, cause excess algal growth. leading to eutrophication. Return of phosphates to the earth is by the decay of plant and animal matter and subsequent absorption.

Conclusion
In this program we have studied the Ecosystem, its definition and types and the scope of the study of an ecosystem. We have also talked about various functions of an ecosystem. I hope you now understand the Structure of an Ecosystem, including its biotic and abiotic components.

GLOSSARY

Abiotic Components = Components of an ecosystem, comprising of environmental factors

Biotope = An abiotic environment in which biotic community lives.

Biotic Community = A collection of different populations which reside at one place.

Biotic Components = Components of an ecosystem, comprising of the various kinds of organisms

Ecology = The study of interrelationship between living organisms and their environment.

Ecosystem= A community of living organisms, in conjunction with the nonliving components of their environment, interacting as a system.

Microecosystem = A very small ecosystem, such as a flowerpot or a site under a stone

Macroecosystem= A very large ecosystem, such as, an ocean, a forest, etc.

FAQ's

Q-1. What is 'Ecology'?

Ans. 'Ecology' is the study of the interrelationship between living organisms and their environment.

Q-2. Who are 'Producers'?

Ans. 'Producers' are mainly green plants having chlorophyll. They produce carbohydrates by the process of photosynthesis.

Q-3. Who are 'Consumers'?

Ans. 'Consumers' are the organisms that gather energy by consuming organic material from other organisms. Consumers derive their energy by aerobic respiration.

Q-4. Who are 'Decomposers'?

Ans. 'Decomposers', also called as 'saprotrophs', are mainly microorganisms like bacteria and fungi. The dead organic materials of producers and consumers are their food.

Q-5. What are the major functions of an ecosystem?

Ans. The major functions of ecosystems are energy flow and nutrient cycling through biogeochemical cycles**.**

Q-6. How many trophic levels are there in a food chain?

Ans. A food chain has three main trophic levels - producers, consumers and decomposers.

Q-7. **What are 'Ecological Pyramids'?**

Ans. Ecological pyramids are the graphic representations of trophic levels in an ecosystem. They are pyramidal in shape and are of three types – Pyramid of Biomass, Pyramid of Numbers and Pyramid of Energy.