Ecology and Ecosystem

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Description Of Module	
Subject Name	Anthropology
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Contents

Learning objectives:

- This module focuses on the basic concepts of Ecosystem.
- The study of this module enables the students at postgraduate level to understand the Principle Steps and Components in a Self-Sufficient Ecosystem.
- This module also discuss about the important concepts of Food Chain, Food Web and Energy Flow in an Ecosystem.

1. Introduction

Ecology is concerned with the study of interrelationships between organisms and their environments. Two distinct components of environment can be identified: Abiotic (nonliving or nonorganic, sometime called the physical environment) and Biotic (living or organic). These two components, are, however, very much interdependent and sometime it becomes difficult to separate biotic components from the abiotic ones, especially when environment is looked at as a factor for determining man's biology and culture (Odum, and Barrett, 2005).

Ecology is a purely scientific discipline which aims to understand the relationships between organisms and their wider environment. Like any science, the outcomes of ecological studies do not dictate ethical or political actions. It is important to make this distinction because the environmental movement has endowed the word 'ecology' with political connotations. It is right that ecology should inform politics, but as a student of ecology it is imperative to consider ecological research from a rigorous scientific viewpoint (Begon, et.al, 2006).

2. Ecosystem

The term ‘ecosystem’ was proposed by a British ecologist A.G. Tansley in the year 1935. The ecosystem represents the basic functional unit of ecology which comprises of the biotic communities mutually related with their nonliving or abiotic environment. Thus a biotic community and its abiotic environment together represent an ecosystem. Ecosystem, therefore, includes both the living organisms (biotic community) and the nonliving environment (abiotic environment) which are inseparably inter-related and interact upon each other (Tansley, 1935.)

Odum has defined the ecosystem as the basic fundamental unit of ecology which includes both the organisms and the nonliving environment, each influencing the properties of the other and each is necessary for the maintenance of life (Odum, 1971).

Mathavan (1974) has given another definition of ecosystem according to which ecosystem is the sum total of living organisms, the environment and the processes of interaction between the various components of the system (Odum, and Barrett, 2005).

The concept of ecosystem can be best illustrated by the fact that holozoic animals cannot synthesize their food and depend upon plants either directly or indirectly. Even plants which are capable of synthesizing their own food depend upon the abiotic environment from which they receive light, water, carbon dioxide and mineral salts, other inorganic and organic substances of absolute necessity for the synthesis of food. The organic substances and some of the inorganic compounds are accumulated in the soil by the dead and the decaying organisms and the excreta of living individuals.

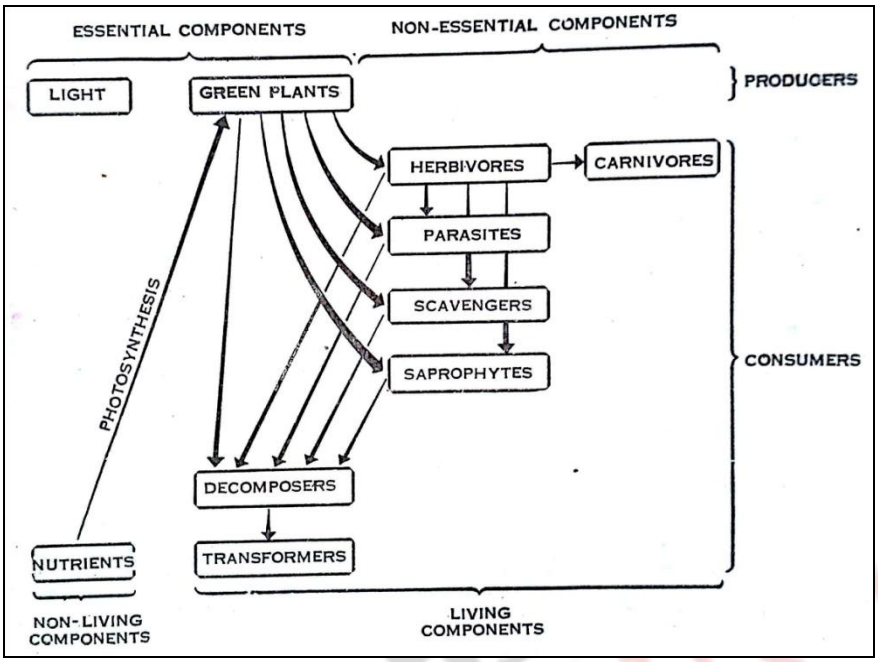


Figure 1. Principle steps and components in a self- sufficient ecosystem ((Odum, and Barrett, 2005).

3. **Principle Steps and Components in a Self-Sufficient Ecosystem.**

The principal steps in the operation of an ecosystem are:

(1) Reception of energy;
(2) Manufacture of organic food by producers;
(3) Consumption of organic material by consumers;
(4) Decomposition into inorganic compounds and
(5) Transformation of these compounds into suitable compounds for the nutrition of the producers.

In the operation of an ecosystem these steps not only involve the production, growth and death of the living components but also influence the non-living environment of the habitat (Odum, and Barrett, 2005).

From a purely functional point of view Odum (1968) has divided an ecosystem into two components:

1. Autotrophic component: It consists of green plants which bring about the fixation of solar energy (sunlight) and synthesis of organic compounds (carbohydrates) from simple inorganic substances.

2. Heterotrophic component: It consists of the decomposers (micro-organisms such as bacteria and fungi) which are concerned with the utilization, rearrangement and degradation of complex food substances.

But from structural point of view, the ecosystem has been divided into four components (McIntosh, 1985; Jaiswal, 2013).:

(i) Abiotic substances
(ii) Producers
(iii) Composers
(iv) Decomposers

3.1 Abiotic substances-

The nonliving or abiotic substances of an ecosystem include basic inorganic materials such as water, carbon dioxide, oxygen, nitrogen, calcium, phosphate etc. and their compounds such as nitrates, carbonates, phosphates etc. These occur either free in nature or in the form of compounds dissolved in water in the soil. Some of them are recycled by the action of micro-organisms on the dead bodies of plants and animals.

3.2 Producers-

These are the autotrophic members of the ecosystem (the green plants) which are capable of synthesizing food from the nonliving simple inorganic compounds. In an ecosystem the producers may be represented by the small microscopic plants (the phytoplankton) and algae or the rooted or large floating plants generally growing in shallow water only. The phytoplankton are distributed throughout the pond and as deep as light could penetrate the water. These are found in all waters. But the large sized are of different types in different ecosystems. The grasses are found in the grassland, trees in the forest, floating plants in pond water and lakes.

3.3 Consumers-

These are heterotrophic organisms which are called as macro consumers or phagotrophs. These consume the producers directly or indirectly.

The herbivores are the primary consumers in the ecosystem. These solely feed upon vegetation or plants. A deer or rabbit is a primary consumer in a forest and a rat in the gardens. Protozoans, Crustaceans and mollusks are the primary consumers of the pond or lake or sea and feed upon the floating algae. Insects, rodents and ruminants are the major herbivores of terrestrial environment. The primary consumers form the food of the primary carnivores or secondary consumers.

I. The primary carnivores or the omnivorous animals constitute the category of secondary consumers. These feed upon the herbivorous animals. These are the wolves, dogs, cats, foxes, etc.
II. The secondary carnivores or the animals which feed upon the carnivorous animals are the tertiary consumers. For example, lions which feed upon the wolves, cattle, deer, etc. are the secondary carnivores. The carnivores have been called biophages by Wiegert and Owen (1971).

3.4 Decomposers-

The micro-organisms (bacteria and moulds) are decomposers of the ecosystem. These feed upon dead decaying living organisms (both plants and animals) and break them into simpler compounds. These are released free in the atmosphere and are utilized by the producers of the synthesis of their food material.

Clarke has recognized a fifth category in the ecosystem which is composed of transformers. These act upon the decomposed substances and transform them into different forms of inorganic and organic substances (Moran, 2006).

4. Nomenclature of Ecosystems

The terrestrial ecosystems are named after the type of organism and habitat conditions such as cropland ecosystem, grassland ecosystem, forest ecosystem and desert ecosystem. Similarly fresh water ecosystems are named as pond ecosystems, lake ecosystems and river ecosystems etc. The largest and most uniform ecosystem is marine ecosystem.

The seas, estuaries, sea shores, streams, rivers, lakes, ponds, deserts, grassland an forest are the major ecosystems of the world (Friederichs, 1958).

5. Food Chain

The ecosystem is characterized by the energy flow and the circulation of material through its members. In other words the different organisms of an ecosystem i.e. plants and animals are linked together by their nutritional requirements. Individuals related in this manner constitute a food chain. A food chain can, therefore, be defined as a group of organisms in which there is a transfer of food energy through a series of repeated eating and being eaten (Egerton, 2007).

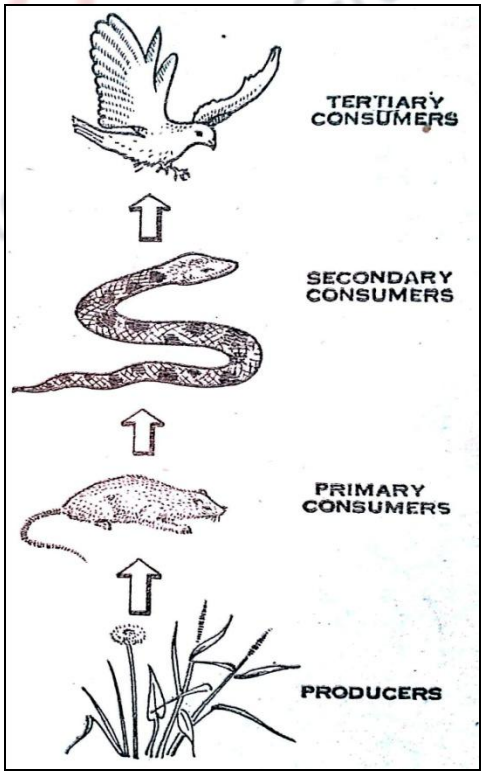


Figure 2. A Simple food chain.

The primary source of energy is sun, but the solar energy is not utilized by all groups of organisms. Green plants alone are able to trap solar energy, which they use to reduce carbon from carbon dioxide and this carbon form carbohydrates, fats and proteins- the fuels of life. The energy trapped in these compounds is stored in the plants and forms the primary source of energy supply to all other living organisms. The autotrophic plants are, therefore, known as 'producers'. In the animal community the plant eating animals or herbivores are the primary consumers. The herbivores are fed upon by secondary consumers which may include carnivores (flesh eating animals) or omnivores (feeding on mixed diet).

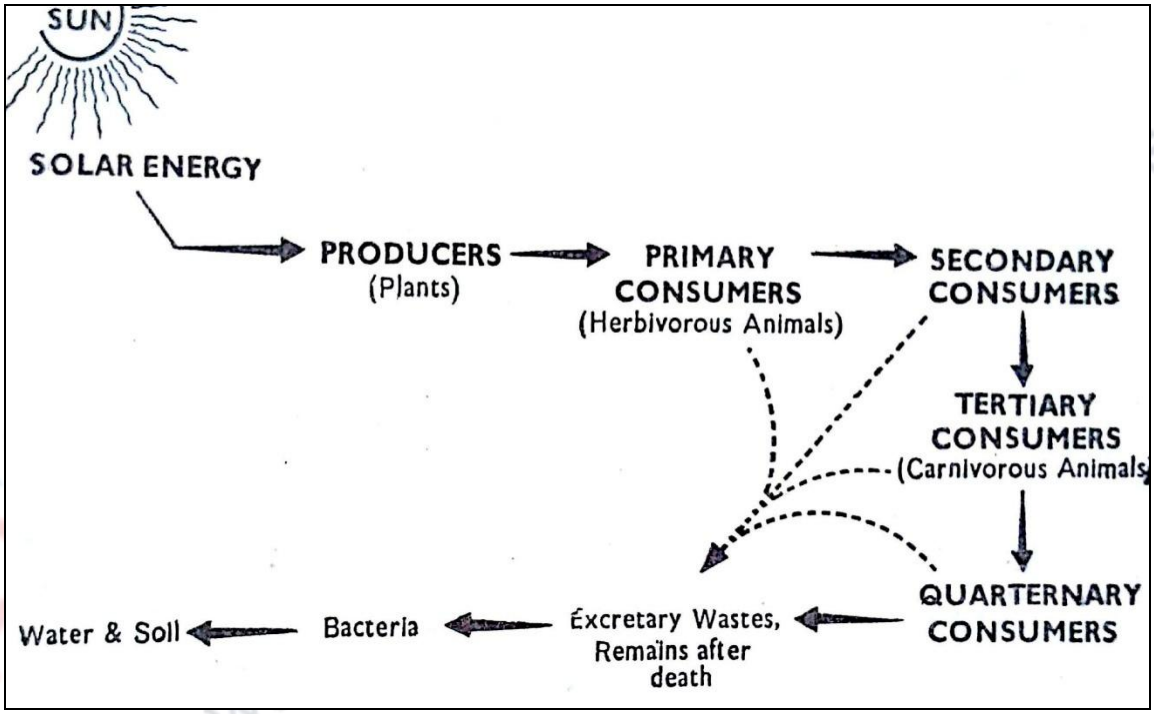


Figure 3. Graphic representation of a simple food chain in ecosystem (Egerton, 2007).

The number of steps in a food chain is limited to four or five and each step or transfer in the chain, a large proportion of the potential energy is lost as heat (Egerton, 2007).This means that the shorter the food chain the greater will be the biomass that can be supported with a given basic source of potential food energy. Hence the food chain with fewer numbers of links or transfers will prove to be most efficient.

5.1 Various types of food chain

There are three types of food chains:-

1. The predator food chain:

The predator food chain starts with herbivores (the plant base) and goes from smaller to larger predators, i.e it includes herbivores as the primary consumers (second trophic level) and predators as the secondary and tertiary consumers, but the size of the predator increases at each level in the food chain. Predators of first level are smaller than those of second level.

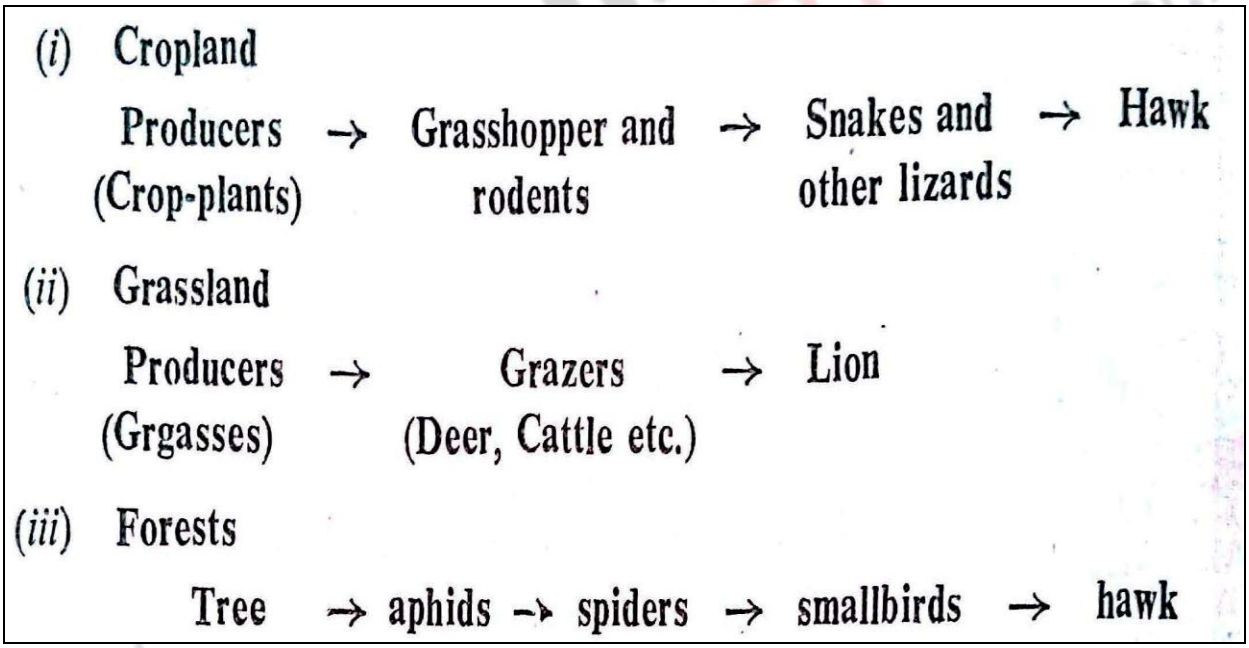
2. Parasitic food chain:

The parasitic food chain also starts with the herbivores but food energy passes from larger to smaller organisms. Therefore, the lager animals are the host and the small animals which fulfill their nutritional requirement from the host are described as parasites.

3. Saprophytic food chain:

The saprophytic food chain exhibits transfer of energy from dead organic matter of decaying animal and plant bodies to microorganisms.

The sequence of various food chains in the terrestrial ecosystem may be represented as follows:-



6. Food Web

As a matter of fact the food chains are not isolated sequences but are interconnected with one another. For example, man and many other organisms are at the same time herbivore and carnivore and hence occupy different trophic levels in the food chain. There may be several carnivores also with overlapping prey types.

This trophic relationship between organisms of an ecosystem is not always in a simple chain-like fashion but forms a complicated network. Furthermore, different types of food chains interact upon each other. This interlocking pattern of several food chains is known as food web.

Thus food web may be defined as the relationship in which a predator eats several types of food and every kind of food is eaten by many different organisms and is the outcome of the interaction between different types of food chains (Egerton, 2007; Orlove,1980).).

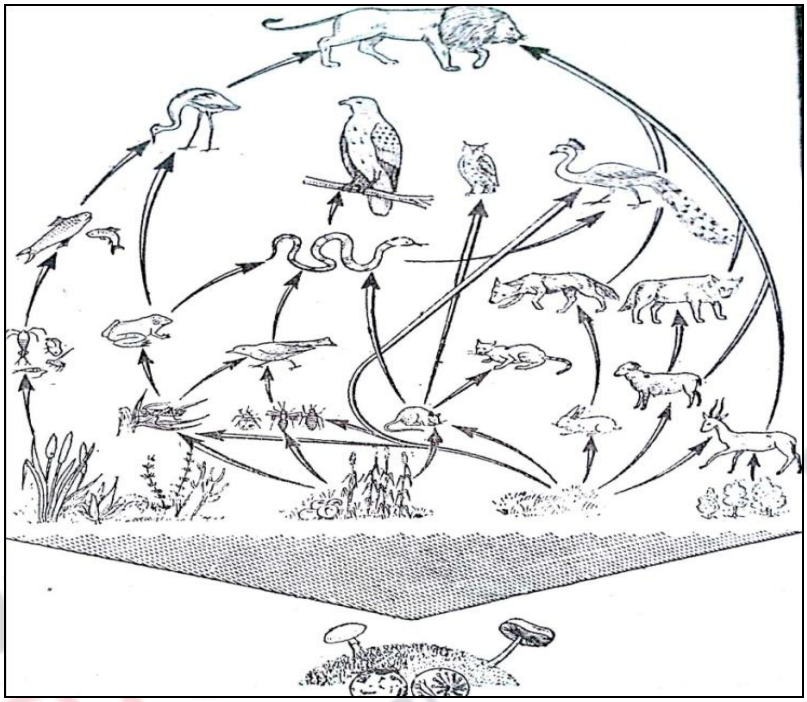


Figure 4. Diagram of food web (Egerton, 2007).

7. Trophic levels and Ecological Pyramids

7.1 Trophic Levels

Each successive level of nourishment as represented by the links of the food chain is known as a trophic level. The plant producers within an ecosystem constitute the first trophic level, the herbivores form the second trophic level, and the carnivores represent the third level. Additional links in the main food chain, and inside chains such as those formed by parasites constitute further trophic levels.

7.2 Ecological Pyramids

Ecological pyramids represent the trophic structure and also the trophic function of an ecosystem. In an ecological pyramid, the first trophic level forms the base and successive trophic levels the tiers which make up the apex. Ecological pyramids may be of three general type's (Park, 1936) i.e. :-

(1) **Pyramid of numbers**-

It represents the numerical relationship between different trophic levels of a food chain. In such a pyramid, the more abundant species form the base of pyramid and the less abundant species remain near the top. The pyramid of numbers can be best understood by taking lake or grassland as an example.

(2) **Pyramid of Biomass-**

The biomass i.e. the living weight of the organisms of the food chain present at any time in an ecosystem forms the pyramid of biomass. The pyramid of biomass indicates the decrease or the gradual reduction in biomass at each trophic level from base to apex.

(3) **Pyramid of energy-**

It indicates the total energy at each trophic level of the food chain. It also exhibits that at each trophic level loss of energy and material takes place as the processes of assimilation and growth are not 100 per-cent efficient. Thus at the producer level, the total energy available is more than at the higher trophic levels because of the loss of energy from one trophic level to the other. This means that the organic matter produced per average unit of time, and the energy represented by it, becomes less at each trophic level. The production rate of energy at different trophic levels of an ecosystem can be represented by the pyramid of energy. The base of such a pyramid is represented by the autotrophs i.e. green plants and the higher levels are represented by different herbivore and carnivore trophic levels.

8. Energy Flow in an Ecosystem

The existence of living world depends upon the flow of energy and circulation of materials through the ecosystem. The energy is required for the performance of all the life activities. The source of this energy is sun. The solar energy enters the space in the form of light rays. Approximately 57 per-cent of solar energy is absorbed in the atmosphere and scattered in space. About 36 per-cents are expended in heating water and land and in evaporating water. Nearly 8 per cent of light energy strikes the plants, of which 80-85 per cent is absorbed, and only fifty per-cent of it is utilized in photosynthesis (Odum and Barrett, 2005).;Benson, 2000).

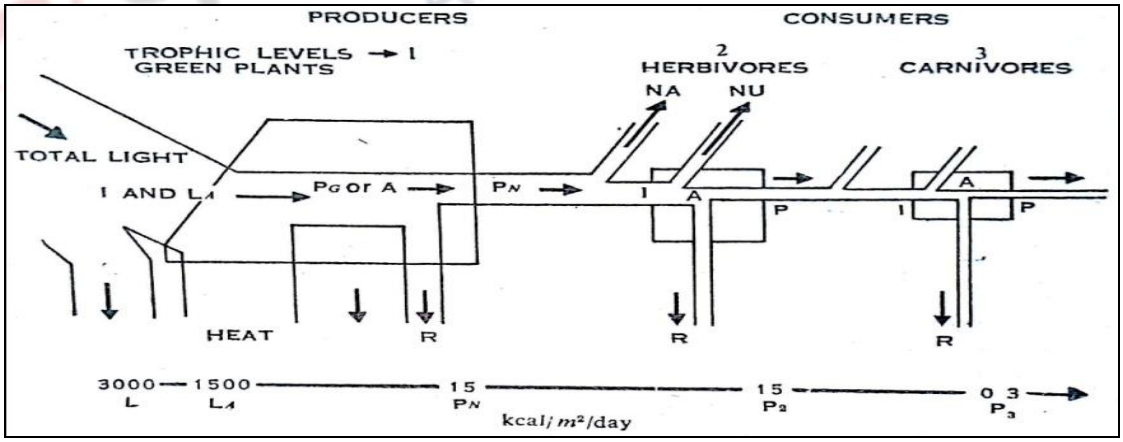


Figure 5. Diagrammatic representation of energy flow through a food chain or ecosystem.

The boxes represent biomass or population mass and the pipes show the path of flow of energy between living units. The relative size of blocks suggests the quantity of energy flowing through each pipe. I=Total energy input; L_A=light absorbed by plants; P_G= Primary gross

production; A= Total assimilation; P_N= Net primary production; P=Secondary production; NU=Energy not used; NA=Energy not assimilated by consumers; R=Respiration.

This energy is captured by plants and is stored in the form of potential energy in foodstuffs. These are known as producers and represent first trophic level in the ecosystem. The energy stored by the plants is passed along through the community or ecosystem in a chain. A food chain consists of maximum four steps, the producers, primary consumers, secondary consumers and tertiary consumers. The energy flows from the producers to consumers. At each transfer a large proportion (80 to 90 per-cent) of potential energy is dissipated as heat produced during the process of respiration and other ways (Miller, et.al, 2003).

The energy flow through an ecosystem can be represented diagrammatically in a simplified manner. In the fig, the boxes represent the trophic levels and the pipes depict the energy flow in and out at each level. Only about half the average light energy impinging upon the green plants is absorbed in the photosynthetic machinery, out of which 1 to 5 per cent is converted into food energy and the rest of it passes out as heat in the atmosphere. Energy accumulated by plants or the producers in an ecosystem is called primary production and is represented by PG or A and the energy left after respiration and stored as organic matter in the producers is the net primary production represented by Pn. Net primary production actually represents food potentially available to primary consumers, which feed upon plants(Miller, et.al, 2003).

The primary consumers, therefore, take in chemical potential energy in the form of plant food. Most of it dissipates in the form of heat (produced during respiration) and is lost out of the ecosystem. Only a small part of the energy is fixed in the form of chemical potential energy in the protoplasm. The same process is repeated at the secondary consumers (primary carnivorous) level and so on. Therefore, at each step in the transfer of energy from one trophic level to another a large amount of energy is degraded into heat and never returns back to the ecosystem(Miller, et.al, 2003).

In this transformation of energy through ecosystem, the energy is reduced in magnitude by about 100 from primary consumers to plant consumers and by 10 for each step thereafter.

Primary productivity of an ecosystem or community is defined as the rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producer organisms (chiefly green plants) in the form of organic substances which can be used as food materials. There are four successive steps in the production process as follows:-

1. Gross Primary Productivity- It is the total energy stored in the food materials synthesized by the green plants or total rate of photosynthesis including the organic matter used up in the respiration during "total photosynthesis or total assimilation."
2. Net Primary Productivity- It is the total gross productivity minus the energy used up in the metabolic process. In other words it is the rate of storage of organic matter in plants in excess of the organic matter utilized in respiration by the plants during the measurement period. This is also called apparent photosynthesis or net assimilation.
3. Net Community Productivity- It is the rate of storage of organic matter is not used by heterotrophs during the period under consideration, usually the growing season of the year. This is not primary production minus heterotrophic consumption.

4. Secondary Productivities- The rates of energy storage at consumer levels are referred to as secondary productivities.

There are three fundamental aspects of productivity: (1) standing crop (2) material removed and (3) production rate.

9. Balance within the Ecosystem

Changes which occur in ecosystems over a geological time span are met by evolutionary changes resulting from natural selection. Those changes that occur naturally as a result of normal succession are met by changes in species makeup of the communities involved. The ecosystem always makes efficient use of the available energy within the limitations of the physical environment. Whether artificially or naturally caused, changes are met by the adjustment of the species present or creation and filling of new ecological niches by species which are new to the ecosystems. At populations and community levels of organization, controls results from the many intraspecific and interspecific relationships (Odum and Barrett, 2005; Benson, 2000).

10. Summary

- Ecology is concerned with the study of interrelationships between organisms and their environments.
- Ecology is a purely scientific discipline which aims to understand the relationships between organisms and their wider environment.
- The term 'ecosystem' was proposed by a British ecologist A.G. Tansley in the year 1935.
- Odum has defined the ecosystem as the basic fundamental unit of ecology which includes both the organisms and the nonliving environment.
- The nonliving or abiotic substances of an ecosystem include basic inorganic materials such as water, carbon dioxide, oxygen, nitrogen, calcium, phosphate etc.
- Producers are the autotrophic members of the ecosystem.
- Consumers are heterotrophic organisms which are called as macro consumers or phagotrophs.
- The micro-organisms (bacteria and moulds) are decomposers of the ecosystem.
- The ecosystem is characterized by the energy flow and the circulation of material through its members.
- The predator and Parasite food chain starts with herbivores
- The saprophytic food chain exhibits transfer of energy from dead organic matter of decaying animal and plant bodies to microorganisms
- As a matter of fact the food chains are not isolated sequences but are interconnected with one another.
- Each successive level of nourishment as represented by the links of the food chain is known as a trophic level.
- Ecological pyramids represent the trophic structure and also the trophic function of an ecosystem
- Changes which occur in ecosystems over a geological time span are met by evolutionary changes resulting from natural selection.