Ecosystem Ecology

Living organisms and their non living (abiotic) environment are interrelated and interact with each other. The term 'ecosystem' was proposed by **A. G. Tansley** and it was defined as the system resulting from the integration of all living and non living factors of the environment.

Some parallel terms such as biocoenosis, microcosm, geobiocoenosis, holecoen, biosystem, bioenert body and ecosom were used for each ecological systems. However, the term 'ecosystem' is most preferred, where 'eco' stands for the environment, and 'system' stands for an interacting, interdependent complex.

Any unit that includes all the organisms, i.e. communities, in a given area, interacts with the physical environment so that a flow of energy leads to a clearly defined trophic structure, biotic diversity and material cycle within the system, is known as an ecological system or ecosystem.

It is usually an open system with regular but variable influx and loss of materials and energy. It is a basic functional unit with unlimited boundaries.

Types of ecosystems

The ecosystems can be broadly divided into the following two types;

1. Natural ecosystems
2. Artificial (man cultured ecosystems

Natural ecosystems

The ecosystems which are self-operating under natural conditions with any interference by man, are known as natural ecosystems. These ecosystems may be classified as follows:

1. Terrestrial ecosystems, e.g. Forests, grasslands and deserts
2. Aquatic ecosystems, which may be further classified as

i) ***Freshwater***: ecosystem, which in turn is divided into lentic (running water like streams, springs, rivers, etc.) and lentic (standing water like lakes, bonds, pools, swamps, ditches, etc.)

ii) Marine ecosystem, e.g. oceans, seas, estuaries, etc.

Artificial (man cultured) ecosystems

Some ecosystems which are managed or maintained by man may be termed as artificial ecosystems.

Structural Aspects of Ecosystem

An ecosystem has two major components

A. Abiotic (nonliving) components

B. Biotic (living) components

A. Abiotic components

A.1. **Inorganic substances**: There are about forty elements that are required in various processes of living organisms. Some of these are macronutrients and others are micronutrients.

A.2. **Organic substances**: These include carbohydrates, proteins, lipids and their derivatives. Organic fragments of different sizes and composition formed as a result of decomposition of organic residues are collectively called **organic detritus.** Decomposing organic matter releases nutrients along with the formation of **humus** which is important for the fertility of soil. New humus is added as old humus gets converted into mineral elements.

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A.3. **Climatic Factors:** This includes temperature, rainfall, humidity and light, and their daily and seasonal fluctuations.

It is obvious that the abiotic components comprise the inorganic substances (carbon, nitrogen, hydrogen, Sulphur, phosphorus, etc.), inorganic chemicals such as chlorophyll, organic materials (proteins, carbohydrates, lipids etc.), present either in the biomass or in the environment, i.e. biochemical structures that link the biotic and abiotic components of the ecosystem, with the climate of the given region.

B. **Biotic Components**

Biotic components are the trophic structure of any ecosystem where living organisms are distinguished on the basis of their nutritional relationships.

1. Autotrophic or self-nourishing components/Producers
2. Heterotrophic or other nourishing components/ Heterotrophs

B.1 **Producers:** Producers, also called **autotrophs**, are green plants that can make food from simple inorganic materials through the process of photosynthesis by conserving radiant energy of the sun. The energy is conserved by reducing CO_2 into carbohydrates.

Besides the green plants there are certain **chemosynthetic bacteria** that are also autotrophic.

B.2 **The heterotrophic components:** Heterotrophs or consumers of the ecosystem utilize, rearrange and decompose the complex materials synthesized by the autotrophs. T

These are also called as **phagotrophs** or **heterotrophs**. The organisms cannot manufacture their own food but obtain their energy and nutrients by feeding on other organisms. They lack the ability to reduce inorganic carbon into organic compounds. They utilize, rearrange and decompose the complex materials synthesized by the autotrophs.

Some eat primary producers to get their food supply and are called **herbivores**. In terrestrial ecosystem typical herbivores are insects, birds and mammals. Primary consumers also include parasites (fungi, plants or animals). Besides, there are animals which depend on herbivores for food and are called **secondary consumers.** Since secondary consumers feed on herbivores, they are carnivores**.** There are also animals that feed on secondary consumers. They too are carnivores, and are known as **tertiary consumers.** They may be (a) predators (b) carrion feeders (c) parasites.

There are some animals that eat both plants and animals. They are known as **omnivores.**

B.3 **Decomposers**: They are microscopic heterotrophic organisms. They are microconsumers. They are also known as **saprotrophs (osmotrophs)** and consists chiefly of bacteria, actinomycetes and fungi. They breakdown complex compounds of dead or living protoplasm, absorb some of the decomposed or breakdown products and release inorganic nutrients into the environment thus making them available again to the autotrophs.

The trophic structure: The trophic structure of an ecosystem is one kind of producer-consumer arrangement where each step or level is known as *trophic level*. The amount of living material in different trophic levels or in a component population is known as the *standing crop*. The standing crop is usually expressed in terms of (i) number of organisms per unit area, or (ii) biomass.

ECOLOGICAL PYRAMIDS

The different trophic levels of an ecosystem are related to one another and can be summarized in the form of ecological pyramids. Ecological pyramid is a diagram of differences among trophic levels of an ecosystem.

The base of each pyramid represents the producers of the first trophic level while the apex represents tertiary or high level consumers; other consumer trophic levels are in between.

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Pyramid of numbers

The relationship between producers, herbivores and carnivores at the successive trophic levels, when expressed in terms of their number, is called pyramid of numbers of numbers pyramid. The pyramids of number in three different types of ecosystems are as follows

In a grassland ecosystem, producers are mainly grasses and they form the base of the pyramid. The number of producers is maximum at the base. The number then decreases towards the apex, as the primary consumers (herbivores) like rabbits, mice, etc. are still lesser in number than the grasses. The secondary consumers like snakes and lizards are lesser in number than rabbits and mice. Finally, at the top are the tertiary consumers like, hawks or other birds which are the least in number. The number pyramid of a grassland ecosystem is upright in shape.

In a forest ecosystem, the number pyramid is partially upright in shape. Producers are the large trees which are lesser in number and form the base of the pyramid. The primary consumers i.e. herbivores like fruit eating birds, elephant, deer, etc. are more in number than producers. Thereafter, the numbers gradually decrease thus making the pyramid partially upright.

In a parasitic food chain, the pyramids are always inverted. This is because, a plant may support the growth of many herbivores and carnivores which in turn may provide nutrition to several parasites, which support many hyper parasites. As a result, from producers towards consumers there is a reversal of position which forms an inverted pyramid.

The pyramids of number do not represent a true picture of the food chain as they are not very functional. They do not indicate the relative effects of the geometric, food chain and size factors of the organism. They usually vary with different communities which have different types of food chains in the same environment.

Pyramid of biomass

The pyramidal of biomass gives a rough picture of the overall effect of the food chain relationships on the ecological group. They are comparatively more fundamental as, instead of geometric factors, they show the quantitative relationships of the standing crop. Like number pyramids, biomass pyramids are also of three kinds (upright, partially upright and inverted). The biomass pyramids of different ecosystems.

Biomass represents the total dry weight of living beings of different species at each trophic level at a particular time. And it is usually determined by collecting all the organisms occupying each trophic level separately and measuring their dry weight.

Generally the biomass of producers is much greater than biomass of herbivores and the biomass of herbivores is greater than the biomass of carnivores and so on and so forth.

Diagrammatic representation of biomass of individuals belonging to the different trophic levels assumes the shape of an upright pyramid. Some aquatic ecosystems like lakes and oceans, the pyramid of biomass, sometimes assumes an inverted form. Since microscopic phytoplanktonic algae are primary producers in the aquatic system.

Pyramid of energy

For comparing the functional roles of the trophic levels in an ecosystem, energy pyramid is probably the most informative. It accurately reflects the law of thermodynamics, with loss of energy being depicted at each transfer to another trophic level hence the pyramid is always upright. In the case of aquatic ecosystem energy pyramids are also upright even where the pyramid of biomass is inverted.

In energy pyramids, a given trophic level, always has a smaller energy content than the trophic level immediately below it. This is due to the fact that some energy is always lost as heat in going from one trophic level to the next. Each bar in the pyramid indicates the amount of energy utilized at each trophic level in a given time, annually per unit area. The unit of measurement is kcal/m/yr. Each bar of a pyramid of energy represents the amount of energy per unit area or volume that flows through that trophic level in a given time period.

Advantages of pyramid of energy are as follows:

(i) It takes into account the rate of production, in contrast to the pyramids of numbers and biomass which indicates the standing states of organisms at a particular moment in time.

(ii) Weight for weight, two species do not necessarily have the same energy content. Comparisons based on biomass may therefore be misleading.

(iii) Apart from allowing different ecosystems to be compared the relative importance of populations within one ecosystem can be compared and inverted pyramids are not obtained.

(iv) Input of solar energy can be added as an extra rectangle at the base of a pyramid of energy.

Limitations of Ecological Pyramids (i) Some species have more than one mode of nutrition or belong to two or more trophic levels. This is particularly true in the case of consumers of higher trophic levels. Man is an example. He gets his food from primary producers as well as from higher trophic levels. Such organisms which feed at more than one trophic level are extremely difficult to depict in ecological pyramids.

(ii) Saprophytes play a vital role in ecosystem but they are not represented in ecological pyramids.

(iii) Detritus such as litter and humus is an important source of energy and exerts considerable influence on ecosystem function, yet it is not depicted in ecological pyramids.

(iv) Ecological pyramids do not provide any clue to seasonal and diurnal variations.

(v) The rate of transfer from one trophic level to another is not reflected in the ecological pyramids.

ENERGY FLOW

World is a solar powered system, and green plants are the entry gates of energy into ecosystem. Out of the total incoming solar energy, only a very small fraction is absorbed by plants. And on this small fraction of sunlight trapped by plants is built the entire living world.

Any organism derives its energy from the food it consumes. All organisms cannot make their own food and only the producers have the capacity to do so. Therefore, various organisms in an ecosystem must fulfil their energy needs by relying on producers directly or indirectly.

In an ecosystem energy is transferred in an orderly sequence.

The flow of energy is in one direction only, some energy is lost as heat at every successive step.

Energy flows from lower (producer) to higher (herbivore, carnivore etc.) trophic level. It never flows in the reverse direction; that is from carnivores to herbivores to green plants. Organisms at each trophic level depend on those at lower trophic levels for the energy to sustain themselves and reproduce. Consumers cannot convert energy directly from the sun into food. Green plants make such transformation. This is in accordance with the first law of thermodynamics that energy can neither be created nor destroyed but may be transformed from one form into another. The second law of thermodynamics states that when energy is transformed from one form into another, some of it is converted into unusable energy such as heat.

Heat energy cannot be used to useful work, more energy must be supplied to a biological system from outside to compensate the inevitable energy loss. In order to continue to function, organism and ecosystems must receive energy supply on a continuing basis.

The diagrammatic representation of basic component, is as follows :

In figure, the shaded box labelled "B" represents the living structure or "biomass" of the component. The total energy input or intake is indicated by "I". For strict heterotrophs it is organic food. Not all of the

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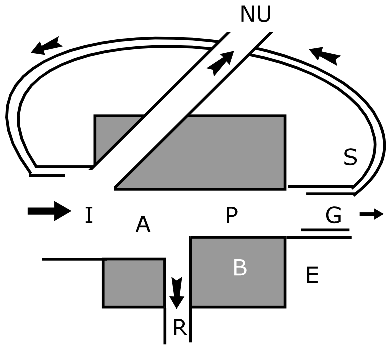
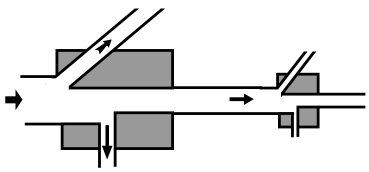
input into the biomass is transformed; some of it may simply pass through the biological structure, as occurs





when food is egested from the digestive tract without being metabolized or when light passes through vegetation without being fixed. This energy component is indicated by "NU" ("not utilized"). That portion which is utilized or assimilated is indicated by "A" in the diagram. The ratio between these two components, i.e., the efficiency of assimilation varies widely.

In autotrophs the assimilated energy ("A") is "gross production" or "gross photosynthesis".

In higher animals the term "metabolized energy" is often used for the "A" component . Assimilated energy is separated into the "P" and "R" components. That part of the fixed energy ("A") which is burned and lost as heat is designated as respiration ("R") and that portion which is transformed to new or different organic matter is designated as production ("P"). This is "net production" in plants or "secondary production" in animals. "P" component is energy available to the next trophic level, as opposed to the "NU" component that is still available at the same trophic level.

Production may take a number of forms. "G" refers to growth or addition to the biomass. "E" refers to assimilated organic matter that is excreted or secreted. This "leakage" of organic matter, often in dissolved or gaseous form, may be appreciable but is too often ignored because it is hard to measure. Finally, "S" refers to "storage".

The reverse "S" flow may also be considered a "work loop" since it depicts that portion of production that is necessary to ensure a future input of the new energy.

FOOD CHAIN: In a food chain, the food energy is transformed from a given source through a series of species, each of which eats the one before itself in the chain. This repeated series of eating and being eaten is always initiated with green plants, which convert radiant energy into chemical energy which convert radiant energy into chemical energy which is stored in food.

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A food chain is an energy sequence of links of trophic levels that starts with a species that eats no other species and ends with a species that is eaten by no other species. At each transfer between feeding levels there is unavoidable loss of a proportion of the food energy. This limits the number of links or steps in a food chain, usually to four or five.

Types:

(i) **Grazing Food Chain: It** starts from a green plant base goes to grazing herbivores and on to carnivores. Deer grazing in field represents a grazing food chain. Eating of phytoplanktonic algae by zooplankton and fishes is another example of grazing food chain. In most ecosystems, only a small proportion of the total community energy flow through grazing food chains. Also at each step, significant amount or organic matter is shunted through detritus food chain .

Ocean food chains are among the longest, up to five links in contrast to forest types which mostly consist of three or rarely four links.

Longer length of grazing food chains in aquatic ecosystems is due to the small size of the phytoplanktons and zooplanktons that chiefly comprise the first two trophic levels.

(ii) **Detritus food chain** :

— Detritus food chain begins with dead organic matter which is an important source of energy.

— Various species of fungi, bacteria and other saprophyte play a prominent role in decomposing organic matter to obtain energy needed for their survival and growth. In this process they release various nutrients, locked in dead organic matter, which are used readily by the green plants. Detritus food chains are interconnected with grazing food chains and other auxiliary food chains.

They form an essential component of natural ecosystems and are necessary for self sustenance and for maintaining ecological balance. Most of the natural ecosystems possess both grazing and detritus types of chains.

(iii) **Auxiliary food chains**: They are operated through parasites and scavengers.

FOOD WEB: In nature no food chain is isolated. A food web shows all possible transfers of energy and nutrients among the organism in an ecosystem whereas a food chain traces only one pathway in the food web.

The food web for most communities is very complex, involving innumerable kinds of living organisms. With many interlocking food chains the community remains stable even if one or more of these relations are altered.

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