Unit9: Functional Aspect of Ecosystem

The components of the ecosystem are functional as a unit when following aspects are considered.

(A) Production and Productivity

(B) Energy flow model

(C) Nutrient cycling (Biogeochemical cycles)

(D) Homeostasis

(A) Productivity

Production in ecosystems involves the fixation and transfer of energy. Green plants fix solar energy by the process of photosynthesis and fixation and transfer of energy in an ecosystem is governed by the laws of thermodynamics. It is measured in terms of units of energy produced in a unit area per unit time, *i.e.* $(gm^{-2})\ yr^{-1}$ or $(k\ cal\ m^{-2})\ yr^{-1}$.

The productivity is variable in different ecosystems. *e.g.* Tropical rain forests, estuaries and coral reefs are most productive as compared to deserts and tundra.

The productivity refers to the rate of biomass production in an ecosystem *i.e.* **the amount of organic matter accumulated in any unit time.** It is of two types:

Types of Productivity:

(1) Primary productivity

(2) Secondary productivity (or Assimilative productivity)

(1) Primary Productivity of an ecosystem is defined as '**the rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producers**'. It is of two types:

- **Gross primary productivity (GPP):** It is the total rate of photosynthesis including the organic matter used up in respiration during the measured period.

  GPP = NPP + R

- **Net primary productivity:** This is estimated by the gross productivity minus energy lost in respiration.

  NPP = GPP – R (Energy lost by respiration)

It 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.

The net primary productivity accumulates over a given period of time as plant biomass at a given place and is referred to as ***standing crop***.

(2) Secondary productivity (or Assimilative 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 rate of increase in the biomass of heterotrophs. Secondary productivity is not divided into gross or net amounts, thus the term assimilation rather than production at the consumer level.

Net productivity: It refers to the rate of storage of organic matter not used by the heterotrophs. It is thus the rate of increase of biomass of the primary producers which has been left over by the consumers during the unit period, as a season or year etc.

Ecological Efficiency

Ecological efficiency describes the **efficiency** with which energy is transferred from one trophic level to the next. Ecological efficiency is defined as the percentage ratio of the energy flow at different points along the food chain.

$$\text{Ecological efficiency} = \frac{\text{Energy converted into biomass at a trophic level}}{\text{Energy present in biomass at lower trophic level}} \times 100$$

(B) Energy Flow through an Ecosystem

The energy enters into the ecosystem in the form of solar radiation and is converted into food (plant biomass) by the producers. From the producers the energy passes through various trophic levels. This **process of transfer of energy through various trophic levels of the food chain is known as flow of energy.**

Raymond Lindeman in 1942 defined these ecological efficiencies for the first time and proposed 10% law, where only 10% of the energy is transferred to the next higher trophic level. However, there are slight variations to this law in different ecosystem and ecological efficiencies may range from 5 to 35%.

Models of Energy Flow: The flow of energy through various trophic levels in an ecosystem can be explained with the help of various energy flow models.

- **(i) Single channel energy flow model**
- **(ii) Double channel or Y-shaped chain model**
- **(iii) Universal model of energy flow**

(i)Single-Channel Energy Model:

Boxes represent trophic levels,

The pipes depicts energy flow in & out of each level.

I= total energy input,

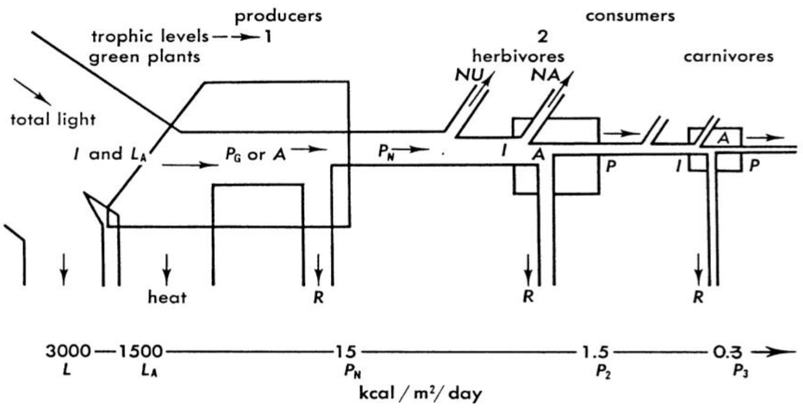
L_A =light absorbedby plants,

PG= GPP,

A= total assimilation,

PN= NPP,

R= respiration,



A simplified energy flow diagram showing unidirectional flow through primary producers, herbivores and carnivores in a grazing food chain.

This **Single-Channel Energy** model explains the unidirectional flow of energy:

- Whatever the energy captured by the autotrophs does not revert back to solar input. As it moves progressively through the various trophic levels, it is no longer available to the previous level.
- The system would collapse if the primary source, the sun, were cut off.
- There is a progressive decrease in energy level at each trophic level. The energy received by the organism is also used for its own metabolism and maintenance. The left over is passed to next higher trophic level. So, shorter the food chain, greater would be the available food energy.

(ii) Double channel or Y-shaped chain model

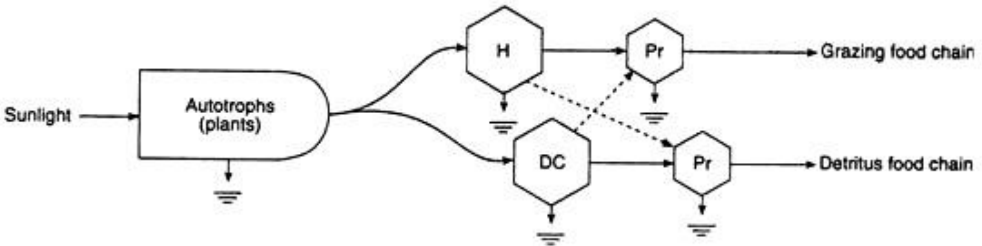
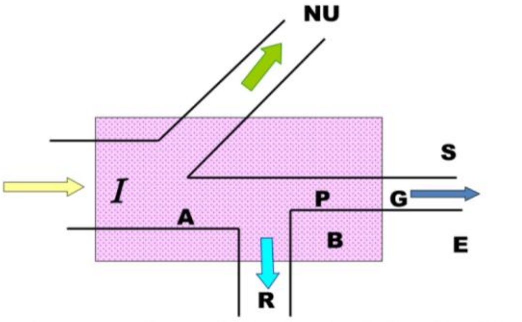


Fig. 4.5 : Y-shaped energy flow model. It shows linkage between grazing and detritus food chain (H = herbivores; DC = detritus consumers; Pr = predators)

In this energy model, one arm represents grazing food chain (GFC) and the other arm represents the decomposer (detritus) food chain (DFC). This model also indicates that under natural conditions, two food chains are not completely isolated from one another.

- it confirms to the basic stratified structure of ecosystem.
- it separates the grazing and detritus food chains in both time and space, and
- microconsumers and macroconsumers differ greatly in size and metabolic relations.

(iii) Universal model of energy flow



I = input or ingested energy; ***NU***= not used; ***A*** = assimilated energy; ***P***= production; ***R*** = respiration; ***B***= biomass; ***G***= growth; ***S***= stored energy; ***E***= excreted energy.

Boxes represent trophic levels,

The pipes depicts energy flow in & out of each level.

I= input or ingested energy,

NU=not used, **A**= Assimilated energy,

B= biomass, **G**= growth, **R**= respiration, **P**= production, **S**=stored energy, **E**-excreted energy.

(Source: E.P. Odum,1968)

It is applicable to any living component whether a plant, animal, microorganisms or individual, population or a trophic group. This model depicts the basic pattern of energy flow in ecosystem. The total energy input or intake or ingestion varies. For strict autotrophs, it is light, while, for strict heterotrophs, it is organic food.

Under natural conditions, these organisms are inter related in a way that several food chains become inter locked, this results into a complex food web.

Complexity of food web depends on the length of the food chain. Thus in nature, there operate multi-channel energy flows. But in these the channels belong to either of the two basic food chains - Grazing or Detritus.

For detailed study refer:

Sharma, P.D. (2010). *Ecology and Environment*. Meerut, India: Rastogi publications, Chapter: Ecosystem: Structure and function