Programme: Bachelor of Science (First Year)

Subject: Microbiology

Course Code: MIG 101

Course Title: Introduction and Scope of Microbiology

Unit 7 - Ecology and Ecosystems

Module Name: Energy flow: ecological pyramids (pyramid of numbers, pyramid of energy, pyramid of biomass)

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Ecological pyramids

The trophic structure of an ecosystem can be indicated by means of ecological pyramid. At each step in the food chain a considerable fraction of the potential energy is lost as heat. As a result, organisms in each trophic level pass on lesser energy to the next trophic level than they actually receive. This limits the number of steps in any food chain to 4 or 5. Longer the food chain the lesser energy is available for final members. Because of this tapering off of available energy in the food chain a pyramid is formed that is known as ecological pyramid. An ecological pyramid is a graphical representation of the relationship between the different living organisms at different trophic levels in an ecosystem. The idea of ecological pyramids was advanced by C.E. Elton (1927). Ecological pyramid also known as trophic pyramid, Eltonian pyramid, energy pyramid, or sometimes food pyramid. These pyramids are in the shape of actual pyramids with the base being the broadest, covering the lowest trophic level, i.e., producers. The next level is occupied by the next trophic level, i.e., the primary consumers and so on.

There are different types of ecological pyramids. In each ecological pyramid, producer level forms the base and successive levels make up the apex. Three types of pyramids are observed at different levels in the ecosystem. These are as follows:

1. Pyramid of numbers,

2. Pyramid of biomass (biomass is the weight of living organisms), and

3. Pyramid of energy.

1. Pyramid of numbers:

It depicts the numbers of individuals at different trophic levels in an ecosystem. A pyramid of numbers shows graphically the population, or abundance, in terms of the number of individual organisms involved at each level in a food chain without any consideration for their individual sizes or biomass. The base of pyramid is represented by producers.

Types of Pyramid of Numbers

- Upright pyramid of number
- Partly upright pyramid of number
- The inverted pyramid of number

1. Upright Pyramid of Number

This type of number pyramid is found in the grassland and pond ecosystem. This ecosystem is characterized by numerous autotrophs that support lesser herbivores. The herbivores, in turn, support a smaller number of carnivores. Therefore, this pyramid is upright. With every higher trophic level, the number of organisms decreases.

For example, the grasses sit at the lowest trophic level or the base of the number pyramid because of their abundance. The primary consumer, such as a grasshopper, occupies the next higher trophic level. Grasshoppers are fewer in number than grass. The next trophic level is a primary carnivore, such as a rat. There are fewer rats than grasshoppers because they consume grasshoppers. Secondary carnivores, such as snakes, occupy the next higher trophic level. Snakes feed on rats and snakes are eaten by hawks, which occupy the highest trophic level and are the least in number.

In a pond ecosystem, the phytoplankton are consumed by the zooplankton, which is in turn eaten by the small crustaceans. Then the predator insects feed on the small crustaceans. The predator insects are in turn consumed by the small fish, which are eaten by the large fish which are least in number in the food chain and sits at the apex of the pyramid.

Phytoplankton → Zooplankton → Small Crustaceans → Predator Insects → Small Fish → Large Fish

2. Partly Upright Pyramid of Number
This type of number pyramid is typical of the forest ecosystem. In this ecosystem, the producers are large-sized trees, which sit at the base of the number pyramid. The herbivores, such as elephants and fruit-eating birds, make the primary consumers which are more in number than the producers. The number of individual organisms reduces at each successive trophic level.

3. Inverted Pyramid of Number
An inverted number pyramid is found in parasitic food chains. In these food chains, there's normally one producer supporting numerous parasites. The parasites, in turn, support more hyper-parasites. In short, in this pyramid, number of individuals at each level is increased from lower level to higher level.

Drawbacks of pyramid of numbers

- Amongst the three ecosystem pyramids. The pyramid of number is the most incorrect, as it does not take into consideration the exact population. Hence, it cannot completely elaborate on the trophic structure in a system.
- This pyramid ignores the biomass of species and it doesn't show the energy transferred between individual groups.
- Pyramids of numbers are not very functional as they do not give a clear or true picture of the food chain.

2. Pyramid of biomass

A pyramid of biomass shows the total biomass of the organisms involved at each trophic level of an ecosystem. In ecological terms, biomass refers to the total mass of all living or organic matter that inhabit an ecosystem at any given point of time. A pyramid of biomass shows the relationship between biomass and trophic level by quantifying the biomass present at each trophic level of an ecological community at a particular time. It is a graphical representation of biomass (total amount of living or organic matter in an ecosystem) present in unit area in different trophic levels.

1. **Upright pyramid of biomass**

Grasses occupy the base with the highest biomass, then followed by herbivores such as rabbits, rats, etc. The primary consumers are followed by secondary consumers (owl, lizards, snakes, etc.) and then tertiary consumers (eagle, etc.). The biomass of the grass is much more than the primary consumers and decreases further sequentially in secondary and tertiary consumers.

2. **inverted pyramid of biomass**

Inverted pyramid is seen in a pond ecosystem where the mass of phytoplankton, the major producers, will always be lower than the mass of the heterotrophs like fish and insects. As the value of biomass become larger, the pyramid gains an inverted shape with tertiary consumers appearing at the top in biomass.

3. Pyramid of energy

A pyramid of energy or ecological pyramid or trophic pyramid shows the production or turnover (the rate at which energy or mass is transferred from one trophic level to the next) of biomass at each trophic level. This pyramid shows the flow of energy through the food chain. Since the flow of energy is always unidirectional, the pyramid of energy is always upright. Energy flows from the bottom of the pyramid, where we have producers, upwards. Energy is higher at the bottom of the pyramid, but it decreases as you move up through the trophic levels. Not all the energy is passed from one level of the food chain to the next. as energy flows through the various trophic levels, about 90 per cent of energy may be lost as heat at each level. About 10% of the total energy is transferred during energy flow through several trophic levels and hence the steady drop in the amount of energy. As a result, the number of organisms at each level decreases relative to the level below because there is less energy available to support those organisms. The top level of an energy pyramid has the fewest organisms because it has the least amount of energy. Eventually there is not enough energy left to support another trophic level; thus, most ecosystems only have four trophic levels.

Disadvantages of the pyramid of energy as a representation:

- The rate of biomass production of an organism is required, which involves measuring growth and reproduction through time.
- There is still the difficulty of assigning the organisms to a specific trophic level. As well as the organisms in the food chains there is the problem of assigning the decomposers and detrivores to a particular trophic level.

Significance of Ecological Pyramid

The importance of ecological pyramid can be explained in the following points:

1. They show the feeding of different organisms in different ecosystems.
2. It shows the efficiency of energy transfer.
3. The condition of the ecosystem can be monitored, and any further damage can be prevented.

Limitations of the Ecological Pyramid

1. More than one species may occupy multiple trophic levels as in case of the food web. Thus, this system does not take into account food webs.
2. The saprophytes are not considered in any of the pyramids even though they form an important part of the various ecosystem.
3. These pyramids are applicable only to simple food chains, which usually do not occur naturally.
4. These pyramids do not deliver any concept in relation to variations in season and climate.
5. They do not consider the possibility of the existence of the same species at different levels.