CHAPTER-12

ECOSYSTEM

Topic-1

Patterns, Components, Productivity and Decomposition

Concepts Covered • *Ecosystem, Types of ecosystem, component of ecosystem, productivity and decomposition.*

Revision Notes

- **Introduction**
  - An ecosystem is a functional unit of nature, where living organisms interact among themselves and also with the surrounding physical environment.
  - The entire biosphere can be regarded as a global ecosystem.
- **Types of Ecosystems**
  - **(a) Terrestrial ecosystem :** Forest, grassland, desert, etc.
  - **(b) Aquatic ecosystem :** Pond, lake, wetland, river, estuary and ocean.
  - **(c) Man-made ecosystem :** Crop fields and aquarium.
- **Ecosystem : Structure and Function**
  - An ecosystem, consists of biotic and abiotic components. These components function as a unit. Unidirectional flow of energy takes place within these components of an ecosystem.
  - Vertical distribution of different species occupying different levels is called stratification. e.g., trees occupy top vertical strata (layer) of a forest, shrubs the second and herbs and grasses occupy the bottom layers.
- **Components of Ecosystem**

  There are four main functions of ecosystem :

  (i) Productivity **(ii)** Decomposition

  (iii) Energy flow **(iv)** Nutrient cycling

  - **Example : Pond - Aquatic Ecosystem**
    - **(a)** A pond is a shallow, simple, self-sustainable water body that exhibits all basic components of an ecosystem.

(b) Abiotic components in pond : Water and the soil which is deposited at the bottom.
(c) Climatic conditions : The solar input, the cycle of temperature, day-length, etc.
(d) Autotrophic components : Phytoplankton, some algae and the floating, submerged and marginal plants.

Key Words

Phytoplankton : They are microscopic marine algae.

Zooplanktons: Zooplankton is made up of small water invertebrates feeding on phytoplankton.

(e) Consumers (heterotrophs) : Zooplankton, free swimming and bottom-dwelling forms.
(f) Decomposers : Fungi, bacteria and flagellates.
(g) Pond performs all the functions of an ecosystem such as :
- **(i)** Conversion of inorganic into organic material with the help of the radiant energy of the sun by the autotrophs.
- **(ii)** Consumption of the autotrophs by heterotrophs.
- **(iii)** Decomposition and mineralization of the dead matter to release them back for reuse by the autotrophs.

(h) There is a unidirectional movement of energy towards the higher trophic levels and its dissipation and loss as heat to the environment.

- **Productivity**
  (a) A constant input of solar energy is the basic requirement for any ecosystem to function and sustain.
  (b) The rate of biomass production is called productivity.
  (c) The productivity is expressed in terms of $g^{-2}yr^{-1}$ or (kcal m^{-2}) yr^{-1}.
  (d) It can be divided into gross primary productivity (GPP) and net primary productivity (NPP).
- **Primary Productivity**
  (a) The amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis is called primary production.
  (b) The primary production is expressed in terms of weight (g^{-2}) or energy (kcal m^{-2}).
- **Gross Primary Productivity**
  (a) It is the rate of production of organic matter during photosynthesis.
  (b) A considerable amount of GPP is utilized by plants in respiration.
  (c) Gross primary productivity minus respiration losses (R) is the net primary productivity (NPP), i.e., NPP is the available biomass for the consumption of heterotrophs (herbivores and decomposers).

$$NPP = GPP - R$$

  (d) Primary productivity depends on
  - **(i)** The plant species inhabiting a particular area.

Key Facts

- Phytoplankton are responsible for producing upto 50% of the oxygen we breathe.
- Zooplanktons eat algae, so they can be used to control algal blooms. This method is called "biomagnification".

  - **(ii)** Environmental factors.
  - **(iii)** Availability of nutrients.
  - **(iv)** Photosynthetic capacity of plants.

  Therefore, it varies in different types of ecosystems.

  (e) The annual net primary productivity of the whole biosphere is approximately 170 billion tons (dry weight) of organic matter.
  (f) Of this, despite occupying about 70% of the surface, the productivity of the oceans is only 55 billion tons. The rest of course is on land.
- **Secondary Productivity**

  It is the rate of formation of new organic matter by consumers.
- **Decomposition**
  (a) It is the breakdown of complex organic matter by decomposers into inorganic substances like carbon dioxide, water and nutrients.
  (b) It is largely an oxygen-requiring process.
  (c) **Detritus** (dead plant remains such as leaves, bark, flowers and dead remains of animals, including faecal matter) is the raw material for decomposition.
- **Steps in decomposition**

  The important steps in the process of decomposition are fragmentation, leaching, catabolism, humification and mineralisation.

  (a) Fragmentation

It is the breakdown of detritus into smaller particles by **detritivores** (e.g., Earthworm).

(b) Leaching

In this process, water-soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts.

(c) Catabolism

(i) Here, the degradation of detritus into simpler inorganic substances takes place by bacterial and fungal enzymes.

(ii) Fragmentation, leaching and catabolism operate simultaneously on the detritus.

Key Word

Detrivores : Animals that feed on decaying organic matter (detritus). Examples: earthworms, termites, snails, etc.

(d) Humification

(i) It is the accumulation of humus (dark amorphous substance) in soil.

(ii) Humus is resistant to microbial action and so decomposes very slowly.

(iii) Being colloidal, it serves as a reservoir of nutrients.

(e) Mineralization

It is the release of inorganic nutrients due to the degradation of humus by some microbes.

Factors Influencing Decomposition

The rate of decomposition is controlled by the chemical composition of detritus and climatic factors.

(a) Chemical composition of detritus :

Decomposition rate is slower if detritus is rich in lignin and chitin and quicker, if detritus is rich in nitrogen and water-soluble substances like sugars.

(b) Climatic factors like temperature and soil moisture :

- Temperature and soil moisture are the most important climatic factors that regulate decomposition through their effects on the activities of soil microbes.
- Warm and moist environment favours decomposition whereas low temperature and anaerobic conditions inhibits decomposition resulting in the build up of organic materials.

Mnemonics

Concept : Steps in decomposition

Mnemonics : Fly **L**ike **C**rane with **H**igh **M**oral

Interpretations : Fragmentation**,** Leaching**, C**atabolism**,** Humification**,** Mineralization

Example 1

Q. How are productivity, gross productivity, net primary productivity and secondary productivity interrelated ?

Sol. *NPP = GPP – R*

NPP- Net Primary Productivity

GPP- Gross Primary Productivity

R - Respiration

Productivity is the rate of production of biomass at any trophic level at any given interval of time.

Gross productivity : It is the rate of production of organic matter by green plants per unit time per unit area. On the other hand we can say that it is the total amount of productivity.

Net Primary Productivity : It is the difference between gross primary productivity and the loss due to respiration.

Secondary Productivity : It is rate of production or formation of new organic matter by consumers especially the consumers of the first order or herbivores.

Topic-2

Energy Flow and Ecological Pyramids

Concepts Covered • *Energy flow in an ecosytem, Ecological pyramids- Pyramid of number, Pyramid of biomass and Pyramid of energy.*

Revision Notes

Energy Flow

- Sun is the only source of energy for all ecosystems on the earth.
- Of the incident solar radiation less than 50% of it is photosynthetically active radiation (PAR).
- Plants, photosynthetic and chemosynthetic bacteria (autotrophs) fix solar radiant energy to make food.

- Plants capture only 2-10% of the PAR and this small amount of energy sustains the entire living world. So, it is very important to know how the solar energy captured by plants flows through different organisms of an ecosystem.
- Ecosystem obeys first and second law of Thermodynamics.
- The energy of the ecosystem is constant.
- They need a constant supply of energy to synthesize the molecules they require, to counteract the universal tendency toward increasing disorderliness.

Producers

- The green plants in the ecosystem which capture the solar energy and convert it into chemically bound energy are called producers.
- All organisms are dependent for their food on producers (green plants), either directly or indirectly.
- In a terrestrial ecosystem, major producers are herbaceous and woody plants.
- Primary producers in an aquatic ecosystem are phytoplankton, algae and higher plants.
- The energy trapped by the producer is either passed on to a consumer or the organism dies.
- Death of an organism is the beginning of the detritus food chain / web.

Key Fact

The energy that enters the ecosystem, is measured in Joules or Calories. Thus, the energy flow is also called calorific flow.

Consumers (Heterotrophs)

- These are all animals that depend on plants (directly or indirectly) for their food.
- **They include :**
  - **(a) Primary Consumers**
    - These are herbivores that feed on plants.
    - *For* e.g., Insects, birds and mammals in the terrestrial ecosystem and molluscs in aquatic ecosystem.
  - **(b) Secondary Consumers**
    - These are primary carnivores that feed on herbivores e.g., Frog, fox, man etc.
  - **(c) Tertiary Consumers**
    - These are secondary carnivores that feed on primary carnivores.

Key Words

Trophic Level : A specific place of organisms in the food chain is known as their trophic level.

Ecological Pyramids: The representation of a food chain in the form of a pyramid is called ecological pyramids.

Grazing Food Chain

- A simple grazing food chain (GFC) is depicted below :

Grass - - - - - - - - - - → Goat — - - - - - - - - - - →Man

(Producer) (Primary Consumer) (Secondary Consumer)

Detritus Food Chain (DFC)

- It begins with dead organic matter.
- It is made up of decomposers (saprotrophs) which are heterotrophic organisms. e.g. fungi and bacteria.
- They meet their energy and nutrient requirements by degrading dead organic matter or detritus.
- Decomposers secrete digestive enzymes that breakdown dead and waste materials into simple, inorganic materials, which are subsequently absorbed by them.
- In an aquatic ecosystem, GFC is the major conduit for energy flow.
- In a terrestrial ecosystem, a much larger fraction of energy flows through the DFC than through the GFC.
- DFC may be connected with GFC at some levels : some of the organisms of DFC are prey to the GFC animals.
- Some animals (cockroaches, crows etc.) are omnivores.
- These interconnections of food chains make a food web.
- Organisms occupy a place in the natural surroundings or in a community according to their feeding relationship.
- A specific place of organisms in the food chain is known as their trophic level.
- Producers belong to the first trophic level, herbivores to the second and carnivores to the third.
- The amount of energy decreases at successive **trophic levels**.
- When an organism dies it becomes dead biomass (detritus) that serves as an energy source for decomposers.
- Organisms at each trophic level depend on those at the lower trophic level for their energy demands.
- Each trophic level has a certain mass of living material at a particular time called as the standing crop.
- The standing crop is measured as the mass of living organisms (biomass) or the number in a unit area. Biomass of a species is expressed in terms of fresh or dry weight.
- Measurement of biomass in terms of dry weight is more accurate.

- The number of trophic levels in the grazing food chain is restricted as the transfer of energy follows **Lindemann's 10 % law**, which states that only 10% of the energy is transferred to each trophic level from the lower trophic level.
- In nature, it is possible to have so many levels – producer, herbivore, primary carnivore, secondary carnivore in the grazing food chain.

Ecological Pyramids

- The representation of a food chain in the form of a pyramid is called an ecological pyramid. It is the relationship between the producers and consumers of various order represented graphically.
- The base of each pyramid represents the producers (first trophic level) while the apex represents tertiary or top level consumer or the last trophic level.
- **Ecological pyramids are of three types :**
  - **(a)** Pyramid of number
  - **(b)** Pyramid of biomass
  - **(c)** Pyramid of energy
- Any calculations of energy content, biomass or numbers have to include all organisms at that **trophic level.**
- The trophic level represents a functional level, not a species as such.
- A given species may occupy more than one trophic level in the same ecosystem at the same time. For e.g., A sparrow is a primary consumer when it eats seeds, fruits, peas, and a secondary consumer when it eats insects and worms.
- In most ecosystems, all the pyramids are upright i.e. producers are more in number and biomass than the herbivores and herbivores are more in number and biomass than the carnivores.
- Also, energy at a lower trophic level is always more than at a higher level.
- Example of inverted pyramids includes insects feeding on a big tree.
- Pyramid of biomass in the sea is generally inverted because the biomass of fishes far exceeds that of phytoplankton.
- Pyramid of energy is always upright, because when energy flows from a trophic level to the next trophic level, as some energy is always lost as heat at each step.

Limitations of Ecological Pyramids

(a) It does not take into account the same species belonging to two or more trophic levels.

(b) It assumes a simple food chain that seldom exists in nature. It does not accommodate a food web.

(c) Saprophytes are not included in ecological pyramids even though they play a vital role in the ecosystem.

IMPORTANT DIAGRAMS

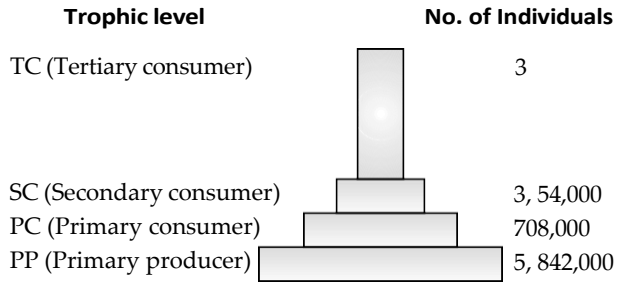

Fig. 12.1 Pyramid of numbers in a grassland ecosystem

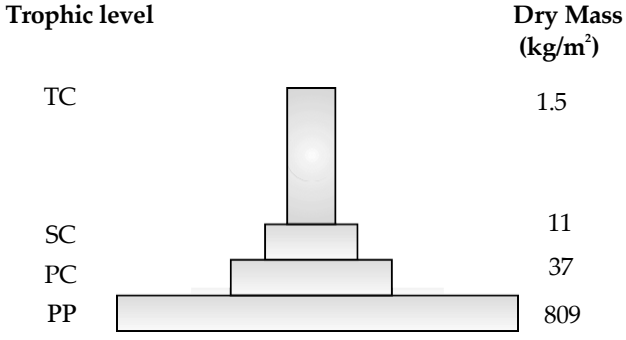

Fig. 12.2 Pyramid of Biomass in most Ecosystem

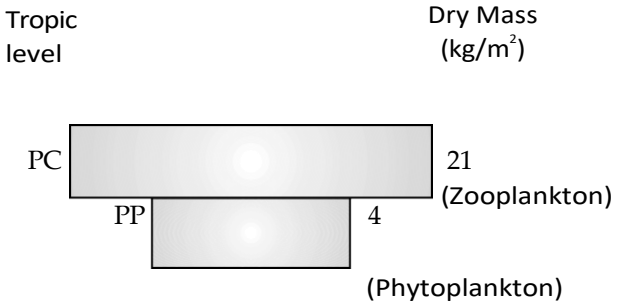

Fig. 12.3 Inverted Pyramid of Biomass in Sea

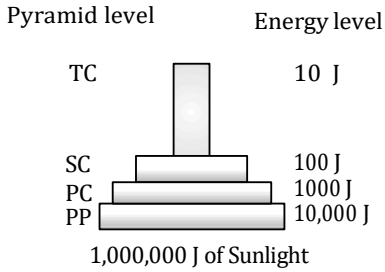

Fig. 12.4 An ideal pyramid of energy

Mnemonics

Concept: Types of Ecological pyramids
Mnemonic: Put **N**o **E**ntry **B**oard
Interpretation:

(i) Pyramid of number
(ii) Pyramid of energy
(iii) Pyramid of biomass

Example 2

Q. Write the outcomes of the following events.
(a) The consequence of eliminating all producers.
(b) The consequence of eliminating all entities at the herbivore level.
(c) The consequence of eliminating all top carnivore entities.

Sol. (a) It diminishes primary production in an ecosystem and hence unavailability of biomass to higher trophic levels.

(b) It would result in an increase in primary productivity and biomass of producers. Carnivorous animals, due to unavailability of food, will not survive.

(c) There will be an increase in the herbivore population, resulting in over-grazing and hence desertification.