Sri SAI RAM ENGINEERING COLLEGE
INSTITUTE OF TECHNOLOGY
West Tambaram, Chennai - 44

Sairam INSTITUTIONS

SAIRAM DIGITAL RESOURCES

YEAR II | SEM IV

GE8291

ENVIRONMENTAL SCIENCE AND ENGINEERING

UNIT NO 1

ENVIRONMENT, ECOSYSTEMS AND BIODIVERSITY

- **Energy Flow in an ecosystem, ecological succession, Food chain, Food web, Ecological Pyramids.**
- **Introduction, Types, Characteristic features, structure and function of Forest, Grassland, desert, Aquatic (Ponds, Streams, Lakes, Rivers, Oceans, Estuaries). Ecosystem.**

SCIENCE & HUMANITIES

4 QUALITY EDUCATION

NBA NATIONAL BOARD OF ACCREDITATION | NAAC A+ | nirf NATIONAL INSTITUTIONAL RANKING FRAMEWORK | BUREAU VERITAS Certification

Energy Flow in an Ecosystem

- Energy is the most essential requirement for all the living organisms.
- Solar energy is the only source to our planet earth. Solar energy is transferred to chemical energy in photosynthesis by the plants. Because, it is the first step in the production of energy for living things, it is called “Primary production”.
- Though a lot of sunlight falls on the green plants, only 1% of it is utilized for photosynthesis. This is the most essential step to provide energy for all other living organisms in the ecosystem.

The flow of energy from producer level to top consumer level is called energy flow

Energy Flow through atmosphere to an ecosystem

Sun is the ultimate source of energy, its radiations travel through space in the form of waves and reach the earth's atmosphere.

The atmosphere absorbs 50% of the radiation and allows the remaining to reach the earth surface, some of which is absorbed by organisms to produce organic matter through photosynthesis.

Carbon Dioxide water Carbohydrate Oxygen Water

$$CO_2 + 2H_2O \longrightarrow CH_2O + O_2 + H_2O$$

- The plants are used by herbivores and herbivores are used by carnivores as their food, In this way energy is transferred from one organism to another and so on.

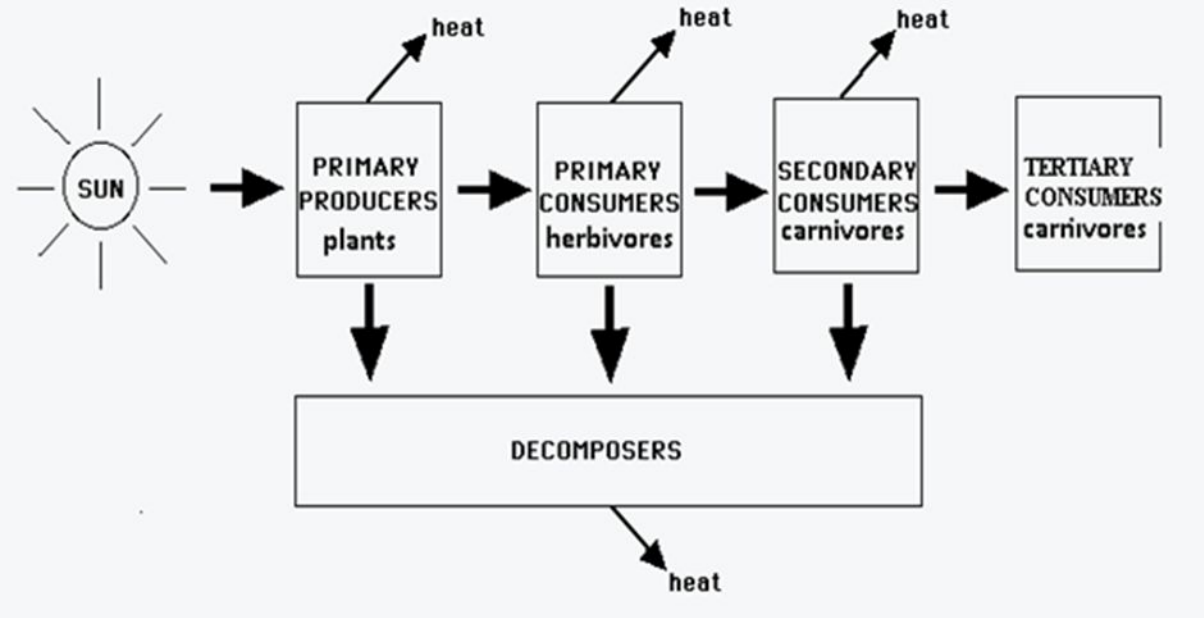
- The conversion of solar energy is governed by law of thermodynamics.
- I law of thermodynamics states that 'energy can neither be created nor be destroyed but it can be transferred from one form to another'.
- The solar energy captured by the green plants (producers) gets converted into biochemical energy of plants and later into that of consumers.

Solar energy → Chemical energy

- II law of Thermodynamics states that "whenever energy is transferred, there is a loss of energy through the release of heat".

This occurs when energy is transferred between tropic levels. There will be a loss of energy in the form of heat as it moves from one tropic level to another tropic level.

Energy Flow Model.



Ecological Succession

The progressive replacement of one community by another community till the development of stable community in a particular area is called ecological succession.

Stages of Ecological Succession

1. **Pioneer community**

The first group of organisms, which establish their community in the area is called Pioneer community.

2. **Seral Stage**

The various developmental stages of a community is called seral stage.

Community

It is the group of plants or animals living in an area.

Types of Ecological Succession

1. **Primary Succession**

It involves the gradual establishment of biotic communities on a lifeless ground.

(a**). Hydrarch**: Establishment starts in a watery area like pond and lake.

(b). Xerarch: Establishment starts in a dry area like, desert and rock.

2. **Secondary Succession**

It involves the establishment of biotic communities in an area, where some type of biotic community is already present.

Process of Ecological Succession

The process of ecological succession can be explained in the following steps.

1. **Nudation**: It is the development of a bare area without any life form.

2. **Invasion**: It is the establishment of one or more species on a bare area through migration followed by establishment.

(a) Migration: Migration of seeds is brought about by wind, water or birds.

(b) Establishment: The seeds the germinate and grow on the land and establishes their pioneer communities.

3. **Competition:** As the number of individual species grows, there is a competition with the same species and between different species for pace, water and nutrients

4. **Reaction:** The living organisms, take water, nutrients and grow and modify the environment is known as reaction. This modification becomes unsuitable for the existing species and favors some new species, which replace the existing species. This leads to Seral Communities.

5. **Stabilizations:** It leads to stable community, which is in equilibrium with the environment.

Food Chain and Food Web

Food Chain:

The sequence of eating and being eaten in an ecosystem is known as food chain.

Eg. Grass → Grasshopper → Frog → Snake → Hawk

- When the organisms die, they are all decomposed by microorganisms into nutrients that can again be used by the plants.
- At each and every transfer, nearly 80-90% of the potential energy gets lost as heat.

A food chain always starts with plant life and ends with animal.

1. Food chain in a grass land Ecosystem:

Plants → Rats → Snakes → Eagles.

2. Food Chain in Pond

Phytoplankton → Zooplankton → Small fish → Large fish → Man

3. Food Chain in a Forest

Plants → Deer → Tigers.

Types of Food Chain

Food Chains are classified into two main types.

1. Grazing food chain
2. Detritius food chain

Grazing food chain

Found in grassland ecosystem and pond ecosystem. It starts with the green plants and goes to decomposer food chain or detritus food chain through herbivores and carnivores

Detritius food chain

Found in Grassland ecosystem and forest ecosystem. It starts with dead organic matter and goes to decomposer food chain through herbivores and carnivores.

Food Web.

- Food web is the interlocking pattern of various food chains in an ecosystem
- In a food web many food chains are interconnected, where different types of organisms are connected at different trophic levels, so that there is a number of opportunities of eating and being eaten at each trophic level.
- The food web is formed by interconnecting seven linear grazing food chains which in sequence are

.

1. Grass → insects → fishes → birds → tigers

2. Grass → insects → birds → tigers

3. Grass → deer → tigers

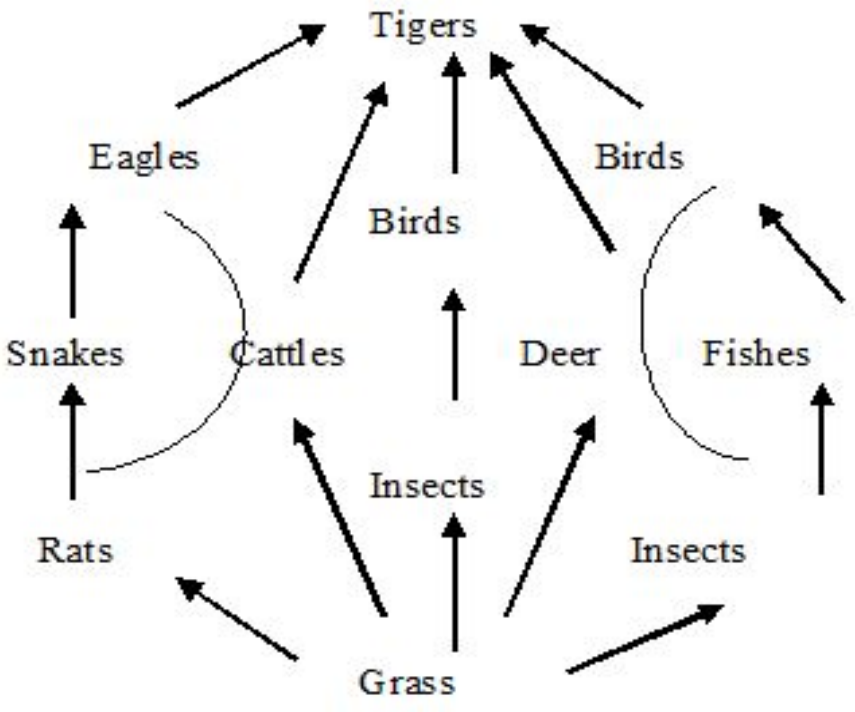
4. Grass → insects → fishes → birds → tigers

5. Grass → cattles → tigers

6. Grass → rats → snakes → eagles → tigers

7. Grass → rats → eagles → tigers

Food Web


Tigers
Eagles
Birds
Birds
Snakes
Cattles
Deer
Fishes
Insects
Rats
Insects
Grass

Difference between food chains and food web

- In a linear food chain, if one species is affected or becomes extinct, the species in the subsequent trophic levels are also affected.
- But in the food web, if one species gets affected, it does not affect other trophic levels so seriously. There are a number of options available at each trophic level.

Significance of Food Chain and Food Web

1. Food chains and food webs play a very important role in the ecosystem.Energy flow and nutrient cycling takes place through them.
2. They maintain and regulate the population size of different trophic levels, and thus help in maintaining ecological balance
3. They have the property of biomagnification. The non-biodegradable materials keep on passing from one trophic level to another. At each successive trophic level, the concentration keeps on increasing. This process is known as bio magnification.

Ecological Pyramids.

The graphical representation of structure and functions of trophic levels of an ecosystem, starting with the producer at the base and each successive trophic level forming the apex is known as ecological pyramids.

Pyramid of numbers

It represents the number of individual organisms present in each trophic levels.

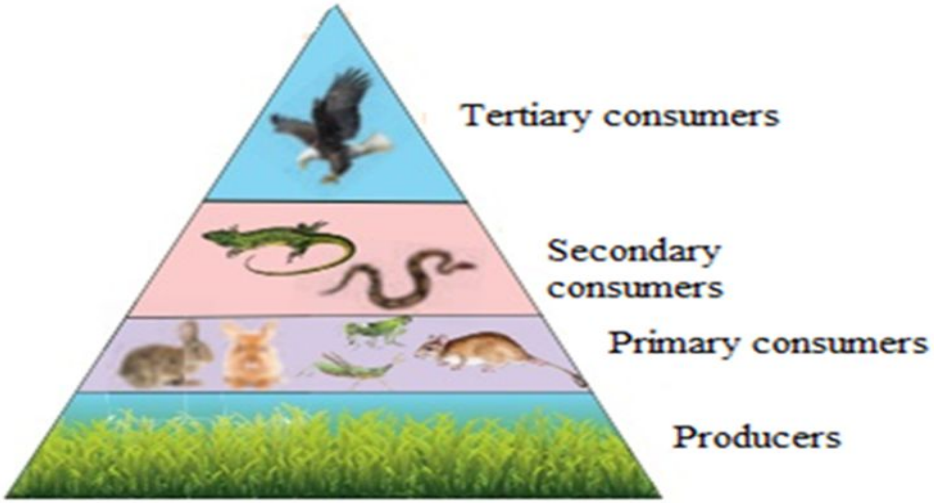
Example

A grassland ecosystem

The producers in the grasslands are grasses, which are small in size and large in numbers.

So, the producers occupy lower when compared to the grasses, the size of which is lower.

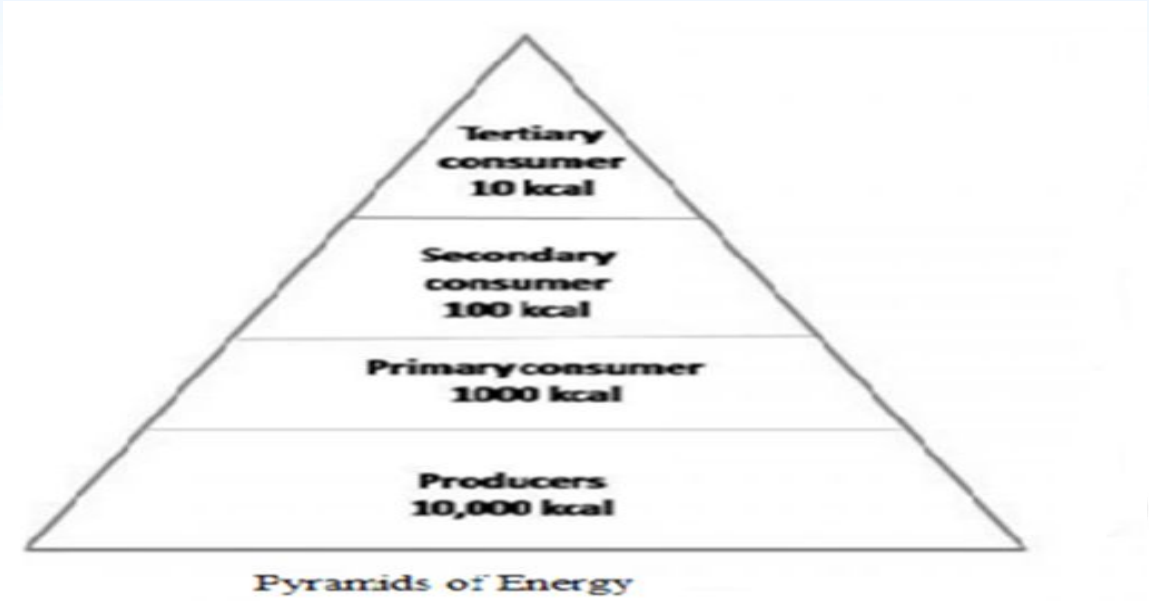
- The primary consumers are the rats, rabbits which occupy the 2nd tropic levels.
- The secondary consumers are snakes which occupy the 3rd trophic levels.
- Since the number of snakes, are lower when compared to the rats, the size of which is lower.
- The tertiary consumers are eagles, which occupy the next trophic levels. The number and size of the last trophic level



Pyramids of numbers

Pyramid of Energy

- It represents the amount of energy present in each tropic levels.
- The rate of energy flow and the productivity at each successive tropic level.
- At every successive tropic level, there is a heavy loss of energy in the form of heat Thus at each next higher tropic level only 10% of the energy is transferred.
- Hence there is a sharp decrease in energy at each and every successive tropic level as we move from producers to top carnivores.

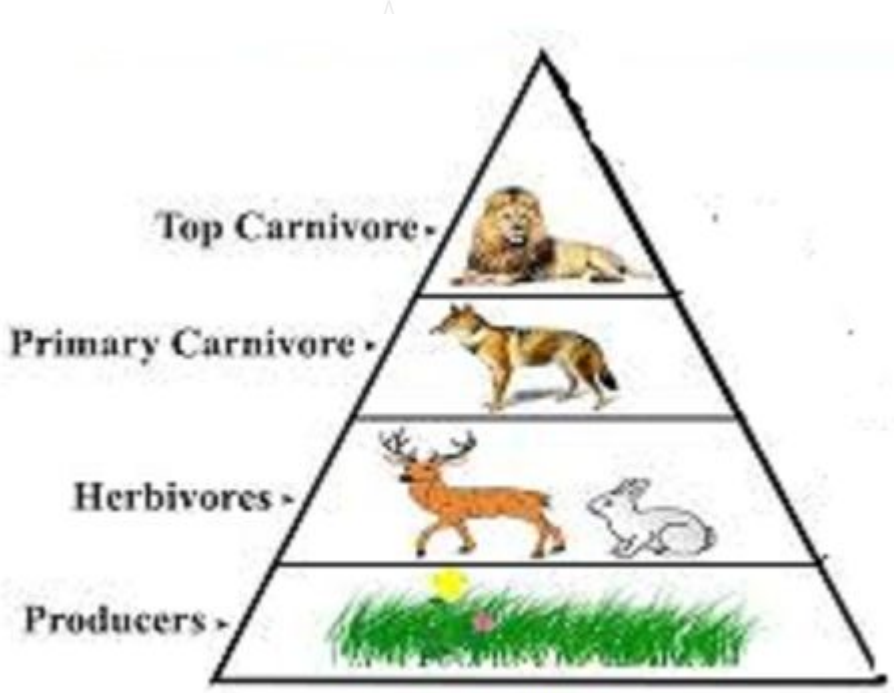


Pyramids of Energy

Pyramids of Biomass

- The below figure shows that there is a decrease in the biomass from the lower tropic level to the higher tropic level.

- This is because the trees are maximum in forest, which contribute huge biomass. The next trophic levels are herbivores and carnivores.
- The top of the trophic level contains few tertiary consumers, the biomass of which is very low.



Pyramids of Biomass

Forest Ecosystem

A forest ecosystem is the one in which a tall and dense trees grow that support many animals and birds.

Depending upon the climate conditions, forest may be classified as:

(a) **Tropical Rain Forests:** They are found near the equator. They are evergreen broadleaf forests found near the equator.

They are characterized by high temperature, high humidity and high rainfall, all of which favour the growth of trees.

(b) **Tropical deciduous forests:** They are found a little away from the equator and are characterized by a warm climate the year round. Rain occurs only during monsoon.

(c) Tropical scrub forests:

They are found in areas where the dry climate for longer time.

(d) Temperate rain forests:

They are found in temperate areas with adequate rainfall. These are dominated by trees like pines, firs, redwoods etc.

(e) Temperate deciduous forests:

They are found in areas with moderate temperatures.

(f) Evergreen coniferous forests (Boreal Forests):

They are found just south of arctic tundra. Here winters are long, cold and dry. Sunlight is available for a few hours only.

Characteristics of forest ecosystems

1. Forests are characterized by warm temperature and adequate rainfall, which make the generation of number of ponds, lakes, etc.,
2. The forest maintains climate and rainfall.
3. The forest support many wild animals and protect biodiversity
4. The soil is rich in organic matter and nutrients, which support the growth of trees.

Structure and Functions of the forest ecosystem.

1. Abiotic Components

The abiotic environment of the forest ecosystem includes the nutrients present in the soil in forest floor which is usually rich in dead and decaying organic matter.

Examples: Climatic factors and minerals.

2. Biotic Components

Producers

The plants absorb sunlight and produce food through photosynthesis.

Examples: Trees, Shrubs and ground vegetation.

Primary consumers

They directly depend on the plants for their food.

Examples: Insects like Ants, Flies, Beetles, Spiders, and big animals like Elephants, Deer, and Squirrels etc.

Secondary consumers

They directly depend on the herbivores for their food.

Examples: Snakes, Lizards, Foxes, Birds etc.,

Tertiary consumers

They depend on the primary carnivores for their food.

Examples: Animals like Tiger, Lion etc.

Decomposers

Examples: Bacteria and Fungi

They decompose the dead plant and animal matter. Rate of decomposition in tropical and subtropical forests is more rapid than in the temperate forests.

Grassland Ecosystem

The grassland ecosystem occupies about 20% of the earth's surface. Grass species, some trees and shrubs are present.

Types of Grassland Ecosystem

1. **Tropical grasslands**

They occur near the borders of tropical rainforests in regions of high average temperature and low to moderate rainfall. It is also known as Savana-type. They have tall grasses with scattered shrubs and stunted trees and animals like zebra, giraffes, etc.,

2. **Temperate grasslands**

They are usually found on flat, gentle sloped hills, winters are very cold but summers are hot and dry.

3. **Polar grasslands**

They are found in arctic polar region where severe cold and strong, frigid winds along with ice and snow create too harsh a climate for trees to grow.

Characteristics of Grassland Ecosystem

(i). Grassland ecosystem is a plain land occupied by grasses.

(ii). Soil is rich in nutrients and organic matter

(iii). Low or uneven rainfall.

Structure and Function of the grassland Ecosystem

1. **Abiotic Components**

The abiotic environment includes nutrient like nitrates, sulphates or phosphates and trace elements present in the soil, gases, like CO_2 present in the atmosphere and water etc

Examples: Nutrients, C, H, O, N, P, S etc.,

2. Biotic Components

Producers

Producers are mainly grass and some herbs, shrubs, and few scattered trees.

Primary consumers

Primary consumers are grazing animals such as cow, sheep, deer, kangaroo, etc. Some insects and spiders have also been included as primary consumers.

Secondary consumers

Secondary consumers are animals like fox, jackals, snakes, lizards, frogs and birds etc.

Tertiary consumers

Tertiary consumers are Hawks, eagles etc.,

Decomposers

Decomposers are bacteria, moulds and fungi, like penicillium, Aspergillus etc.

The minerals and other nutrients are thus brought back to the soil and are made available to the producers.

Desert Ecosystem

Desert occupies about 35% of our world's land area. It is characterised by less than 25 cm rainfall.

The atmosphere is dry and hence it is a poor insulator. That is why in deserts the soil gets cooled up quickly, making the nights cool.

Types of desert ecosystems

1. Tropical deserts

They are characterized by only few species. Wind blown sand dunes are very common.

Tropical deserts are found in *Africa:* Sahara desert and Rajasthan: Thar desert.

2. Temperature deserts

They are characterized by very hot summer and very cool winter time

They are found in South California: Majave

3. Cold deserts

They are characterized by cold winters and warm summers. They are found in

China: Gobi desert.

Characteristic features of Desert ecosystems

(i). The desert air is dry and the climate is hot.

(ii). Annual rainfall is less than 25 cm.

(iii). The soil is very poor in nutrients and organic matter.

(iv). Vegetation is poor

Structure and Function of the Desert Ecosystem

1. **Abiotic Components**

The temperature is very high and the rainfall is very low. The nutrient cycling is also very low. Examples: Temperature, rainfall, sunlight, water, etc.

2. Biotic Components

Producers

In deserts mostly Succulent (e.g., cacti) plants are found available. They have water inside them to stay alive. They have waxy layer on the outside to protect them from the sun.

Examples: Shrubs, bushes, some grasses and few trees.

Consumers

These animals dig holes in the ground to live in. They come out at night to find food. Most of the animals can extract water from the seeds they eat.

Examples: squirrels, mice, foxes, rabbits, deer and reptiles.

Decomposers

Desert has poor vegetation with a very low amount of dead organic matter. They are decomposed by few fungi and bacteria.

Examples: Fungi and Bacteria

Aquatic Ecosystems

Aquatic ecosystems dealing with water bodies and the biotic communities present in them are either freshwater or marine. Let us consider some important aquatic ecosystems.

Types of aquatic life zone

Aquatic life zones are divided into two types.

1. **Fresh water life zones**

   Examples: Ponds, streams, lakes, rivers.

2. **Salt water life zones**

   Examples: Oceans, estuaries

I. **FRESH WATER ECOSYSTEMS**

Pond Ecosystem

Introduction

A pond is a fresh water aquatic ecosystem, where water is stagnant.

It receives enough water during rainy season.

It contains several types of algae, aquatic plants, insects, fishes and birds.

Characteristic features of pond ecosystem

1. Pond is temporary, only seasonal.
2. It is a stagnant fresh water body.
3. Ponds get polluted easily due to limited amount of water.

Structure and functions of pond ecosystem

1. **Abiotic Components**

Example: Temperature, light, water and organic and inorganic compound.

2. **Biotic Components**

Producers

These include green photosynthetic organisms. They are of two types.

Phytoplankton

These are microscopic aquatic plants, which freely float on the surface of water.

Examples: Algae, small floating plants like volvox, pandorina, anabaena, cosmarium.

(b). Microphytes

Examples: Large floating plants and submerged plants like hydrilla, Jussiaea, wolfia, demna.

Consumers

Primary consumers (Zooplanktons)

These are microscopic animals which freely float on the surface of water.

Examples: Protozoa, very small fish, ciliates, flagellates and protozoans.

Zooplanktons are found along with phytoplankton.

They feed on plants (phytoplankton).

Secondary consumers (Carnivores).

Insects like water beetles and small fish. They feed on zooplankton.

Tertiary consumers

Examples: Large fish like game fish

They feed on smaller fish.

Decomposers

Examples: Fungi, bacteria and flagellates.

They decompose the dead plant and animal matter and their nutrients are released and reused by the green plants.

LAKE ECOSYSTEM

Introduction

Lakes are large natural shallow water bodies. Lakes are used for various purposes. Lakes are supplied with water from rainfall, melting snow and streams.

(**a) Oligotrophic lakes** which have low nutrient concentrations.

(b) Eutrophic lakes which are over nourished by nutrients like nitrogen and phosphorus, usually as a result of agricultural run-off or municipal sewage discharge.

They are covered with "algal blooms" e.g. Dal lake.

(c) Dystrophic lakes that have low pH, high humic acid content and brown waters e.g. bog lakes.

(d) Endemic lakes that are very ancient, deep and have endemic fauna which are restricted only to that lake e.g. the Lake Baikal in Russia.

(e) Artificial lakes or impoundments that are created due to construction of dams e.g. Govindsagar Lake at Bhakra-Nangal.

Zones of Lake

Depending upon their depth and distance from the shore, lakes consists of four distinct zones.

1. **Littoral zones**: It is the top layer of the lake.It has a shallow water.

2. **Limnetic zone:** Next to the littoral zone is limnetic zone, where effective penetration of solar light takes place.

3. **Profundal zone:** The deep open water, where it is too dark.

4. **Benthic zone**: This zone is found at the bottom of the lake.

Characteristic features of lake ecosystem

1. Lake is a shallow freshwater body.

2. It is a permanent water body with large water resources.

3. It helps in irrigation and drinking.

Structure and function of Lake Ecosystem

I. Abiotic Components

Temperature, light, proteins and lipids, turbidity, O_2 and CO_2.

II. Biotic Components

Producers They are green plants, may be submerged, free floating and amphibious plants.

Examples: Phytoplanktons, algae and flagellates.

Consumers

Primary Consumers (Zooplanktons)

Examples: Cilictes, protozoans, etc.,

They feed on phytoplankton.

Secondary consumers (carnivores)

Examples: Insects and small fishes.

They feed on zooplankton.

Tertiary consumers

Examples: Large fishes like game fish.

They feed on smaller fish.

3. Decomposers

Examples: Bacteria, fungi and actinomycetes.

They decompose the dead plants and animals.

RIVER (OR) STREAM ECOSYSTEM

Introduction

The running water of a stream or a river is usually well oxygenated, because it absorbs oxygen from the air.

The number of animals are low in river or stream.

Characteristic features of River or Stream

1. It is a fresh water, and free flowing water systems.
2. Due to mixing of water, dissolved oxygen content is more.
3. River deposits large amount of nutrients.

Structure and function of River or Stream Ecosystem

1. **Abiotic Components**

Examples: Temperature, light, pH, nutrients, organic and inorganic compounds.

2. **Biotic Components**

Producers

Examples: Phytoplankton, algae, water grasses, aquatic masses and other amphibious plants.

Consumers

Primary consumers

Examples: Water insects, snails, fishes.

They feed on phytoplankton.

Secondary Consumers

Examples: Birds and mammals.

They feed on primary consumers.

Decomposers

Examples: Bacteria and fungi.

They decompose the dead animals and plants.

II. SALTWATER ECOSYSTEMS

OCEAN (MARINE) ECOSYSTEMS

Introduction

Oceans cover more than two thirds of the earth's surface.

The ocean environment is characterized by its high concentration of salts and minerals.

It supplies huge variety of sea-products and drugs.

It also provides us iron, magnesium, phosphorus, natural gas.

Zones of Oceans

The oceans have two major life zones.

1. **Coastal zone:** It is relatively warm, nutrient rich shallow water. It is the zone of high primary productivity because of high nutrients and sunlight.
2. **Open sea**: It is the deeper part of the ocean. It is vertically divided into three regions.

   (a). Euphotic zone: It receives abundant light and shows high photosynthetic activity.

   (b). Bathyal zone: It receives dim light and is usually geologically active.

   (c). Abyssal zone: It is the dark zone and is very deep (2000 to 5000 metres).

Characteristic features of Ocean Ecosystem

1. It occupies a large surface area with saline water.

2. Since ship, submarines can sail in ocean, commercial activities may be carried out.

3. It is rich in biodiveristy.

4. It moderates the temperature of the earth.

Structure and function of Ocean Ecosystems

1. Abiotic Components

Examples: Temperature, light, NaCl, K, Ca, and Mg Salts, alkalinity.

2. Biotic Components

Producers

Phytoplanktons (diatoms, unicellular algae, etc.,) and marine plants (sea weeds, chlorophyceal, phaeophyceae).

Consumers

These are heterotrophic macro consumers. They depend on producers for their nutrition.

Primary consumers (herbivores)

Examples: Crustaceans, moiluscs, fish.

They feed on producers.

Secondary consumers (carnivores)

Examples: Herring sahd, mackerel, etc.,

They feed on herbivores.

Tertiary Consumers

Examples: Cod, Haddock, etc.,

They are the top consumers. They feed on small fishes.

Decomposers

Bacteria and some fungi.

They decompose the dead organic matter

ESTUARINE ECOSYSTEM

Introduction

An estuary is a partially enclosed coastal area at the mouth of a river, where river joins the sea.

It is strongly affected by tidal action. Estuaries are generally abundant of nutrients. Estuaries are useful to human beings due to their high food potential.

It is essential to protect the estuaries from pollution.

Characteristics of Estuarine ecosystem

1. Estuaries are transition zones, which are strongly affected by tides of the sea.
2. Water characteristics are periodically changed.
3. The living organism in estuarine ecosystems have wide tolerance.
4. Salinity remains highest during the summer and lowest during the winter.

Structure and function of Estuarine Ecosystem.

1. **Abiotic Components**

Examples: Temperature, pH, sodium and potassium salts and various nutrients.

2. **Biotic Components**

Producers

Examples: Marsh grasses, seaweeds, seagrasses and phytoplankton.

Consumers

Examples: Oysters, crabs, seabirds, small fishes.

Decomposers

Examples: Bacterias, fungi and actinomycetes.

VideoLink

1. Energy flow in an ecosystem

   https://youtu.be/5jBV9vJmXZI

2. Ecological Succession

   https://youtu.be/8ceDE01iWLE

3. Food Chain and Food Web

   https://youtu.be/Cd1M9xD482s

4. Ecological Pyramids

   https://youtu.be/wGfOoRrICto

5. Forest Ecosystem

   https://youtu.be/6arGb8uAb4s

VideoLink

6. Grassland Ecosystem

https://youtu.be/4xzrgjrB2SI

7. Desert Ecosystem

https://youtu.be/-rrrdD3oang

8. Aquatic Ecosystem

https://youtu.be/4tU08jCvwGg

THANK YOU