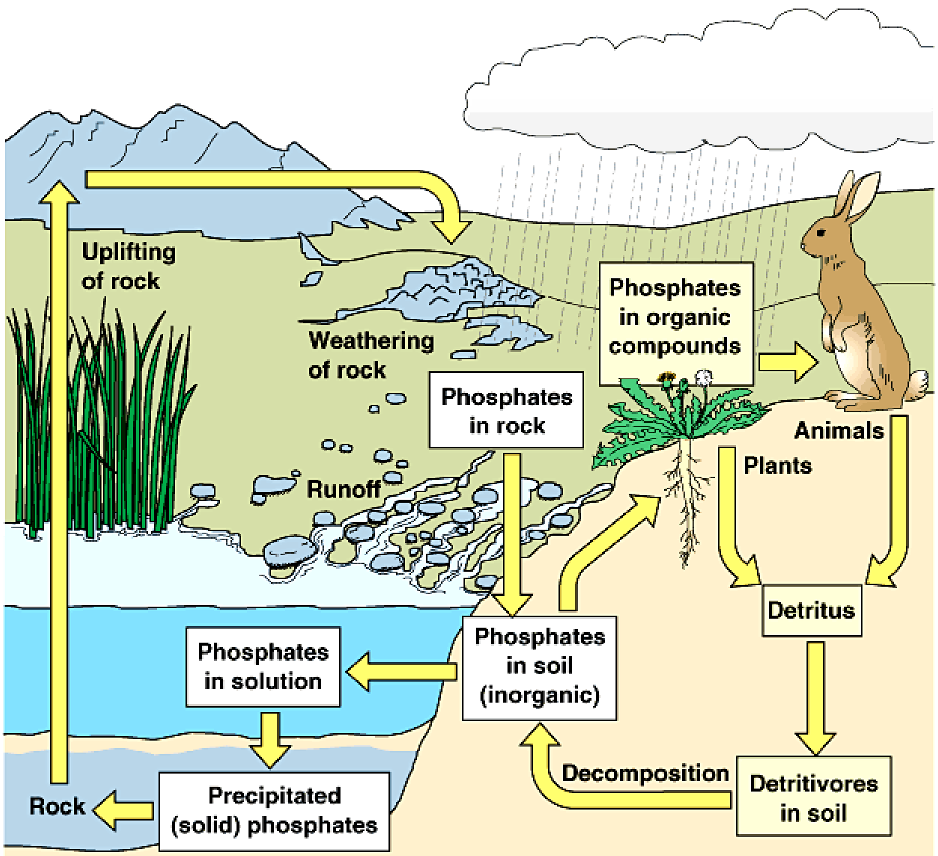
BIOLOGY

for NEET & BOARD



ECOLOGY

Key Features

1. **All-In One Study Material (For Boards/Medical/Olympiads).**
2. **Concise, Conceptual & Trick – Based Theory.**
3. **NTA Based Solved Multiple Choice Questions With Answers.**

Ecology

Chapter – **14**

India's First Trick Based Study Material

1 INTRODUCTION

- The term ecology was coined and described by . E.Haeckel
- Father of ecology . Reiter
- Father of Indian Ecology . Prof. Ram Deo Misra
- First of all term ecology was employed for study of plant by. Warming

Some Important Definitions :–

1. **Ecosystem:** Sum total of interactions between living and non-living components which is capable of independent existence.
2. **Stratification:** Vertical distribution of different species occupying different levels in the community.
3. **Gross primary productivity:** Rate of organic matter synthesized by producers per unit area per unit time.
4. **Net primary productivity:** Rate of organic matter built up or stored by producers in their bodies per unit time and area.
5. **Secondary productivity:** Rate of increase in energy containing organic matter or biomass by heterotrophs or consumers per unit time and area.
6. **Community productivity:** Rate of net synthesis of built up of organic matter by a community per unit time and area.
7. **Ecological efficiency:** Percentage of energy converted into biomass by a higher trophic level over the energy of food resources available at the lower trophic level.
8. **Decomposition:** Breakdown of complex organic matter into inorganic substances with the help of decomposers.
9. **Humification:** Process of formation of humus from detritus.
10. **Mineralisation:** Release of inorganic substances from organic matter during the process of decomposition.
11. **Food chain:** Sequence of living organisms due to interdependence in which one

organism con- sumes another.

12. **Standing state:** Amount of all the inorganic substances present in an ecosystem per unit area at a given time.

13. **Standing crop:** Amount of living material present in different trophic levels at a given time.

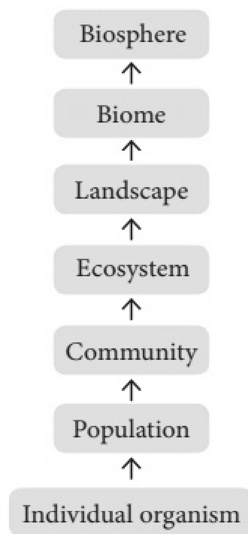
14. **Ecological pyramid:** Graphic representation of trophic levels of a food chain.

15. **Nutrient cycling:** Movement of nutrient elements through the various components of an ecosystem.

16. **Ecological succession:** Gradual and fairly predictable changes in the species composition of a given area.

Ecological hierarchy

The interaction of organisms with their environment results in the establishment of grouping of organisms which is called **ecological hierarchy** or ecological levels of organization. The basic unit of ecological hierarchy is an individual organism. The different hierarchy of ecological systems is illustrated below:



HABITAT

Habitat is a specific physical place or locality occupied by an organism or any species which has a particular combination of abiotic or environmental factors. But the environment of any community is called **Biotope**.

NICHE

An ecological niche refers to an organism's place in the biotic environment and its functional role in an ecosystem. The term was coined by the naturalist **Roswell Hill Johnson** but **Grinell** (1917) was probably first to use this term. The habitat and niche of any organism is called **Ecotope**

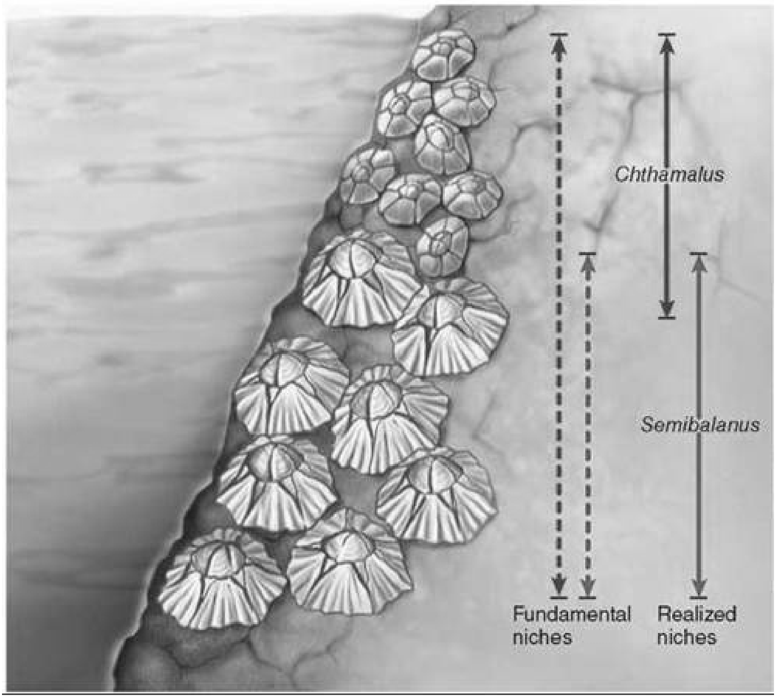


Fig. Competition among two species of barnacles limits niche use.

Chthamalus can live in both deep and shallow zones (its fundamental niche), but Semibalanus forces Chthamalus out of the part of its fundamental niche that overlaps the realized niche of Semibalanus.

The differences between habitat and niche are as follows.

	Habitat	Niche
1.	A specific physical space occupied by an organism (species)	A functional space occupied by an organism in the same eco-system
2.	Same habitat may be shared by many organisms (species)	A single niche is occupied by a single species
3.	Habitat specificity is exhibited by organism.	Organisms may change their niche with time and season.

2 ORGANISM

- An organism is the smallest unit of ecological hierarchy and basic unit of ecological study.
- It may be small/large, unicellular/multicellular.
- Fixed life span and organized life cycle (birth to death)
- *Ecology at the organismic level is essentially physiological ecology.*

3 POPULATION

- ✓ A group of Individuals (members) of same species living at one place (specific geographical area) constitute a population.
- ✓ Local Population or demes (Sub groups of population) . Population of organism inhabiting a particular area. eg. Homosapiens inhabiting hills, plains
- ✓ ***Sister population :*** Different population of same species of organisms which are found in different places are known as sister population
- ✓ ***Meta population :*** *A set of local population which are interconnected by dispersing individuals*

4 SPECIES

Definition - Species is a basic unit of classification, defined as the group of living organisms similar in structure,function and behaviour and produced by similar parents, have common gene pool, can inter breed under natural conditions and reproductively isolated from other group of organism.

SOME TERMS RELATED TO SPECIES :

a) ***Endemic Species or Endemism :***A species which is found only in a particular area is known as endemic species.e.g. Meta sequoia is found only in valley of China, Kangaroo in Australia

b) ***Key-stone Species :***The species which have great influence on the community's characteristics relative to their lowabundance or biomass are called key-stone species. The activities of key-stone species determine the structure of the community. e.g. Lion in forest, Kangaroo rat in desert, fig tree in tropical forest.

5 COMMUNITY

- ***Critical Link Species :***
  The species which establishes an essential link with other species to help the latter in some vital activity is called link species. e.g. Mycorrhizal fungi, many insect species which works as pollinators of flowers.
- Groups of organisms of different species that live in common area, which are interrelated and interdependent.
- It is a natural aggregation of plants and animals in the same environment.
  Biotic Community = Animal community + Plant community + Microbial community
- ***Characteristics of a community .***

  1. Species Diversity .
  - There are different types of population (species) found in community, this is called species diversity. It
  - depends on size of the area, type of area, type of soil , altitude, climate.

  2. Dominance .
  - The highest number of organism of a species present in community, is called as the dominant species.
  - Whole community is known by the name of that particular dominant species.
  - e.g. Prosopis in Aravali hills, Pinus in Himalaya

  3. Stratification .

- The different growth form (trees, shrubs, under shrubs, herbs) determines the structure of a plant community. Stratification is based on mode of arrangement of various growth forms.

(i) Stratification in lake

- In deep lake, zonation or stratification may be according to the need of light. There are three types of zones differentiated in a deep lake.
- ***Littoral Zone .*** This zone is found at bank of lake where very shallow water or marshy land is present. Rooted vegetation is found in this zone.
- ***Limnetic zone .*** This is the zone of lake water, where light reaches in sufficient amount to entire surface area. It means this is not too deep. In this region different types of floating plants (phytoplanktons), suspended and submerged plants are present.
- ***Profundal zone*** . It is very deep area of the lake where light does not reach up to the bottom. Only heterotrophs are present in this zone.

(ii) Stratification in forest .

- The clear stratification (vertical arrangement) in various growth forms of plants according to the need of light in any dense forest.
- Surface dewellers ® Herbs ® Under shrubs ® Shrubs ® Trees

Note :

- The clear stratification is found in tropical rain forest. So it is known as multistoried forest.

6 ECOLOGICAL SUCCESSION (BY HULT)

- Biotic community is seldom static.
- Its composition changes with time due to interactions between biotic and abiotic components.
- This change is orderly and sequential, parallel with the changes in the physical environment.
- These changes lead finally to a community that is in near equilibrium with the environment and is called **climax community**.
- Such gradual and fairly predictable changes in the species composition of a given area are collectively called **ecological succession**.
- During succession, some species colonise an area and their populations become more numerous, whereas populations of other species decline and even disappear.
- The first biotic community that develops in a bare area is termed as pioneer community, *e.g.*,lichens on bare rock.
- The pioneer community is followed by a specific orderly sequence of series of plant communities called **transitional communities** or **seral communities**.
- The entire series of communities is known as sere.
- The last community in biotic succession which is relatively stable and in harmony with environment of that area is termed' as climax community.
- It is also called as **climatic climax**.
- All successional processes leads to a similar mesic climax.
- Succession is hence a process that starts where no living organisms are there.

TYPES OF BIOTIC SUCCESSION

(A) Depending upon the nature of habitat of its start, it is of two types, *i.e.*, xerosere, starting on terrestrial habitat and hydrosere, starting on aquatic habitat. Xerosere is further of different types, *i.e.*, lithoserestarting on barren rock and psammosere-starting on sand, halosere-in salt marshes *(i.e.*, in a physiologically dry soil).

(B) Depending upon the type of nudity of the area, it is of two types:

(i) **Primary succession.** It starts at barren area, never having vegetation of any type. Cooled volcanic lava, sand dunes, igneous rocks, newly exposed sea or newly submerged terrestrial habitats in water, etc., are the areas where primary succession starts. It is very difficult for the pioneer community to get established in these areas and thus it takes a very long time.

(ii) **Secondary succession.** It starts at the habitats which become barren secondarily by the destruction of earlier vegetation under the influence of natural calamaties like forest fire, volcanic eruptions, earthquakes, landslides, floods, etc., or due to overgrazing and leaving the crop fields uncultivated for a long period. Such habitats are fertile, rich in organic matter and even occupied by certain organisms. Secondary succession, thus, starts quickly and climax community is established in a short span.

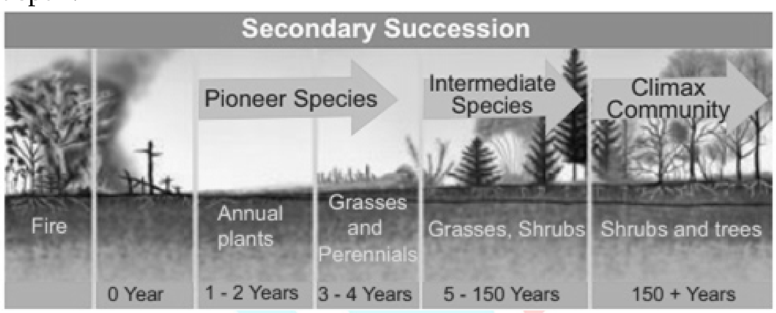


Fig: Diagrammatic representation of secondary succession

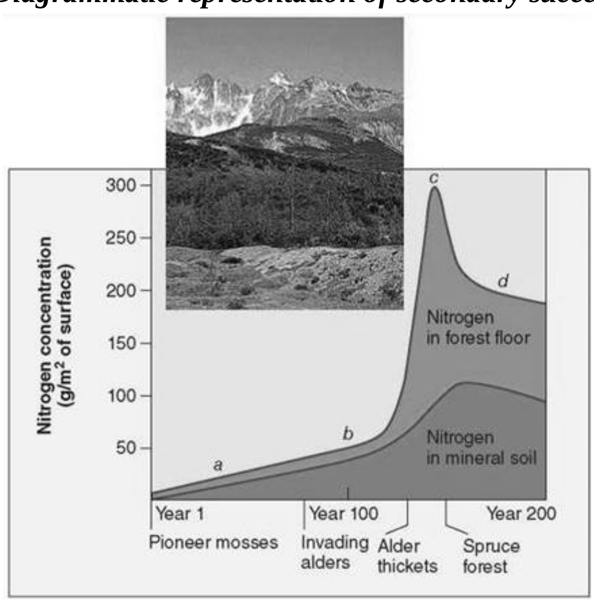


Fig. Plant succession produces progressive changes in the soil.
Initially the glacial moraine at Glacier Bay, Alaska, had little soil nitrogen, but nitrogen-fixing alders (photo above) led to a buildup of nitrogen in the soil, encouraging the subsequent growth of the conifer forest.

	Primary succession	Secondary succession
1	Developing in an barren area	Developing in disturbed area
2	Initiated due to a biological or any other external factors	Starts due to external factors only
3	No soil, while primary succession starts	It starts where soil covers is already present
4	Pioneer species come from outside environment	Pioneer species develop from existing environment
5	It takes more time to complete	It takes comparatively less time to complete

Fig: Differences between primary and secondary succession

(C) **Autogenic and Allogenic Succession :** When a community replaces the other due to the modification of the environment by the community itself (internal factors) the succession is called autogenic. On the contrary, when a community replaces the other, largely due to the forces other than the effects of communities on the environment, the succession is said to be allogenic.

(D) **Autotrophic and Heterotrophic Succession :** Autotrophic succession is characterised by early dominance of autotrophic organisms and begins in predominantly inorganic environment. On the contrary, heterotrophic succession is characterised by early dominance of heterotrophs and begins in a predominantly organic environment.

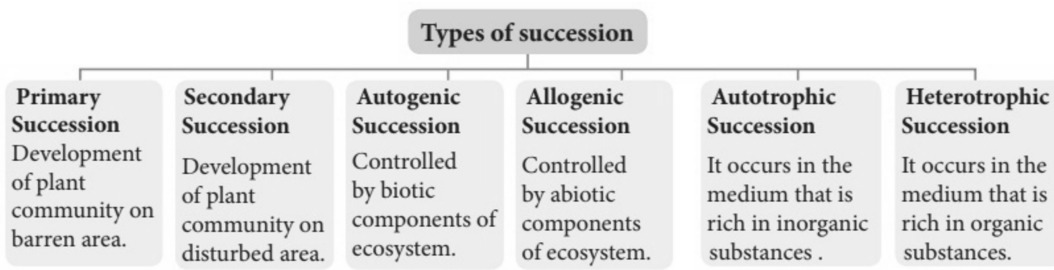


Fig: Types of succession

PROCESS OF SUCCESSION

Major steps in a primary autotrophic succession are as follows :

1. **Nudation:** Exposure of an area.
2. **Migration:** The process of dispersal of seeds, spores and other structure of propagation of the species to bare area is known as migration.
3. **Germination:** It occurs when conditions are favourable.
4. **Ecesis:** Successful germination of propagules and its establishment in a bare area is known as

   ecesis.
5. **Colonisation and Aggregation:** After ecesis, the individuals of the species increase in number as the result of reproduction.
6. **Competition and Co-action :** Due to limited resources, species show both inter and intraspecific competition. This results into elimination of unsuitable and weaker plants.
7. **Invasion:** Various other types of plants try to establish in the spaces left by the elimination of previous plants due to competition.
8. **Reaction:** The newly arrived plants interrupt with the existing ones. As the result of

reaction, environment is modified and becomes unsuitable for the existing community which sooner or later is replaced by another community.

9. **Stabilisation:** The process when the final climax community becomes more or less stabilised for a longer period of time and it can maintain itself in equilibrium with the climate of the area. As compared to transitional communities, the climax community has larger size of individuals, complex organization, complex food chains and food webs, more efficient energy use and more nutrient conservation

Succession on bare rock

- ✍ Succession starting on bare rock is termed lithosere. The various seral stage in lithosere are as follows.

1. Lichen stage.

- ✍ The pioneer lichens on such habitats are usually crustose lichens, *e.g., Graphis, Rhizocarpon.*
- ✍ The propagules of these lichens settle and get established on wet rock surface soon after rainfall.
- ✍ They can tolerate desiccation and high temperature.
- ✍ The acidic substance produced by lichens corrodes the rock surface forming small depressions and release minerals needed for the growth of lichens.
- ✍ The dead and decaying organic matter of the lichens along with sand particles, brought by wind, to get collected in depressions and forms a little bit of soil by mixing with weathered rock particles.
- ✍ The habitat becomes suitable for foliose lichens like *Parmelia*.
- ✍ Foliose lichens compete with crustose lichens and slowly replace the latter due to their larger size.
- ✍ They increase shading of rocks, more accumulation of organic matter and formation of larger depressions.
- ✍ This accelerates the process of soil formation and makes the habitat more suitable for next seral stage, the moss stage.

2. Moss stage.

- ✍ Due to interaction of foliose lichens, the habitat becomes suitable for hardy mosses *(e.g., Tortula, Grimmia)* to grow.
- ✍ Mosses, being larger in size and having gregarious habit, shade the lichens and replace them.
- ✍ Their rhizoids can penetrate deeper.
- ✍ Growth of mosses leads to accumulation of more soil and organic matter which can retain moisture for a longer span and soon the habitat is occupied by moisture loving mosses *(e.g., Hypnum, Bryum).*

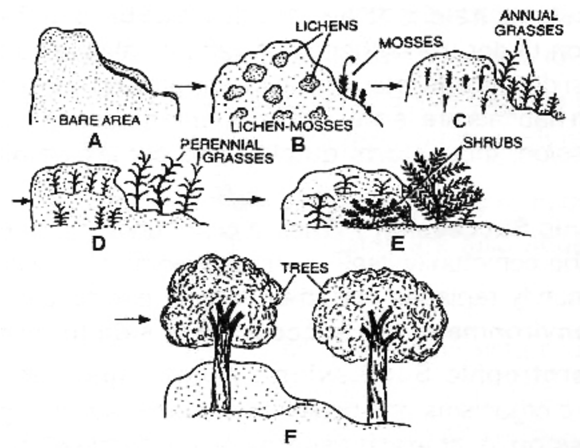


Fig. : Different stages in xerosere starting on rock (lithosere)

2. Annual grass stage.

- During rainy season, the compact mat formed by mosses on weathered rock retain sufficient moisture and the habitat thus becomes suitable for germination of seeds of annual grasses and hardy herbs, e.g., *Aristida, Poa, Eleusine,* etc.
- Their roots penetrate deeper and cause more weathering of rocks.
- They replace mosses, grow for a couple of months and their death and decay results in *increased organic matter.*
- This mixes with weathered rock particles to form soil and thus process of soil formation continues.

3. Perennial grass stage.

- Due to increasing moisture and soil in rock crevices, annual grasses are replaced by perennial grasses.
- These grasses like *Heteropogon, Cymbopogon,* etc., spread very fast due to the presence of runners and rhizomes.

4. Shrub stage.

- The habitat occupied by perennial grasses soon become suitable for invasion of xerophytic shrubs like *Zizyphus, Rubus, Rhus, Capparis,etc.*
- These shrubs soon get established in such habitats, replacing the perennial grasses.
- As shrubs are larger in size, their roots penetrate deeper, causing **more fragmentation** of rock and hence **more accumulation of soil.**

5. Climax stage.

- Shrubs are soon replaced by hardy trees.
- Soon the atmosphere becomes more moist due to large amount of water transpired by large sized plants and ultimately the community, which is relatively more stable, occupies the habitat.
- This is termed climax community.

- *The nature of climax community is determined by the climate of that area.*

Succession in aquatic habitat

- The succession starting in aquatic habitat like freshly formed pond is termed **hydrosere.**
- The various seral stages are as follows:

1. Plankton stage.

- The **pioneers of hydrosere are the phytoplanktons,** the minute microscopic autotrophic organisms like diatoms, unicellular, colonial or filamentous green algae and blue green algae (cyanobacteria).
- The spores of these organisms reach the newiy formed pond through wind or animals.
- They multiply rapidly.
- The pond water containing large number of phytoplanktons becomes suitable habitat for **zooplanktons** which feed upon phytoplanktons, thus maintaining the balance
- The organic matter formed by death and decay of planktons, particulary zooplanktons mixes with clay and silt at the bottom of pond to form **soft mud.**
- The habitat becomes suitable for the growth of next stage.

2. Submerged stage.

- With the formation of soft mud at the bottom of pond, the habitat becomes suitable for the growth of **anchored and submerged plants** like *Hydrilla, Najas, Potamogeton,* etc.
- They are anchored in mud and form dense growth. More silt gets deposited around plants.
- The accumulated silt along with decomposition of organic matter formed by decay of submerged plants makes the substrate fertile and raises the bottom level.

3. Floating stage.

- In the pond, where the water becomes shallow, anchored plants with leaves floating *(e.g., Nelumbo, Nuphar, Nymphaea),* start growing and replace the plants of submerged stage which migrate to deeper waters in a pond.
- These plants have subterranean stems like rhizomes and corms.
- With the growth of these plants, water becomes richer in minerals and organic matter and the habitat becomes suitable for free floating plants like *Lemna,Azolla, Spirodela, Wolffia, Eichhornia,* etc.
- The bottom level is further raised due to growth of free floating plants and accumulation of dead and decaying remains of these plants.
- Water becomes much shallower at the periphery of pond.
- It becomes almost a marshy habitat.

4. Reed swamp stage.

- The periphery of the pond, where the water is very shallow due to interaction of free floating stage, becomes suitable for the growth of amphibious plants like *Typha, Sagittaria, Phragmites, Scirpus* etc.

- ✍ These plants lose large quantity of water during transpiration and produce large amount of organic matter.

5. Sedge or marsh meadow stage.

- ✍ The peripheral area of pond built up by plants of reed swamp stage is invaded by *Cyperus, Carex* (Sedge), *Juncus* and grasses like *Themeda* and *Dichanthium* and herbs like *Campanula, Caltha, Polygonum,* etc.

6. Scrub/Woodland stage.

- ✍ The peripheral area of the pond occupied by marsh meadow stage is invaded by shrubs which can grow in water-logged soil and tolerate bright sunlight *e.g., Comus* (8ogwood), *Cephalanthus* (button brush).
- ✍ This further invite invasion of trees capable of bearing bright sunlight and water logging *e.g., Populus* (cottonwood), *Alnus* (Alder).

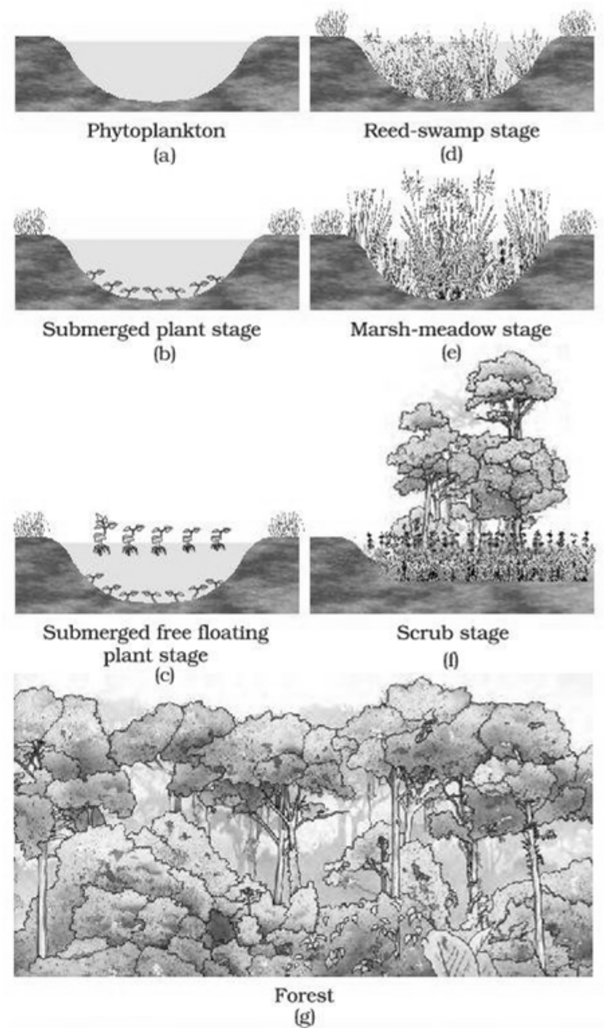


Fig. : Diagrammatic representation of primary succession on pond

- ✍ The woodland stage trees are replaced by new trees which grow to greater heights.

- ✍ The **nature of climax community is determined by climate,** *e.g.*, rain forest in moist tropical area and mixed coniferous or deciduous forest in temperate area.

- ✍ Mixed tropical forest include trees like *Quercus* (oak), *Ulmus* (elm), *Acer* (maple) and gymnosperms like *Abies* (fir), *Taxus* (yew) and *Picea* (spruce).

MAJOR TRENDS DURING ECOLOGICAL SUCCESSION

- The major structural and functional attributes of ecological succession are:

  (i) Increase in species diversity.

  (ii) Increase in structural complexity.

  (iii) Increase in organic matter.

  (iv) Decrease in net community production.

  (v) Food chain relationship becomes complex.

  (vi) Niche become specific and narrower.

  (vii) Stability increases.

  (viii) More immobilization of nutrients (mineral nutrients fixed in biota).

  (ix) Increased energy efficiency.

TERM FOR COMMUNITY IN SUCCESSION :-

- ***Pioneer community .*** The first community to inhabit an area is called Pioneer community.
- ***Climax community .*** The last and stable community in an area is called climax community. This is more stable. Usually mesophytes are present in climax community.
- An important characteristic of all communities is that composition and structure constantly change in response to the changing environmental conditions. This change is orderly and sequential, parallel with the changes in the physical environment. These changes lead finally to a community that is in near equilibrium with the environment and that is called a climax community.
- **Seral communities or seral stage :** In succession, communities or stages which comes in between pioneer community and climax community is called transitional or seral communities.
- **Sere :** The entire sequence of communities that successively change in a given area is called sere.
  - The name of sere depends on where the succession occurs or takes place.
  - Succession in water: Hydrosere / Hydrarch
  - Succession in salty water : Halosere
  - Succession in acidic water : Oxalasere
  - Succession at dry Region : Xerosere / Xerarch
  - Succession on rocks : Lithosere
  - Succession on sand : Psammosere

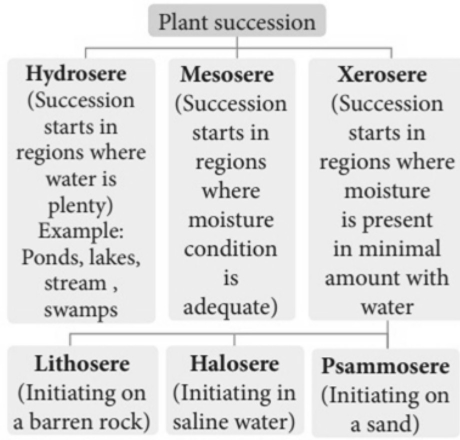


Fig: Classification Of Plant Succession

HYDROSERE :

Stages of hydrosere or hydrarch succession in the newly formed pond or lake

1. ***Phytoplankton stage .*** It is pioneer community, first coming minute autotrophic organism. These produce organic matter. e.g. Soft mud diatoms, *Cyanobacteria*

2. ***Rooted submerged stages .*** eg. Vallisneria

3. ***Floating stages .*** eg. Nymphaea, Nelumbium

4. ***Reed swamp stage (amphibious stage) .*** Most part of these rooted plants remain exposed to air eg. Typha, Azolla

5. ***Sedge (Meadow stage or marsh meadow stage) .*** Muddy plants

6. ***Scrub stage .*** woody shrubs, tolerates water logging

7. ***Forest stage .*** e.g. *Tree* (Oak, Salix)

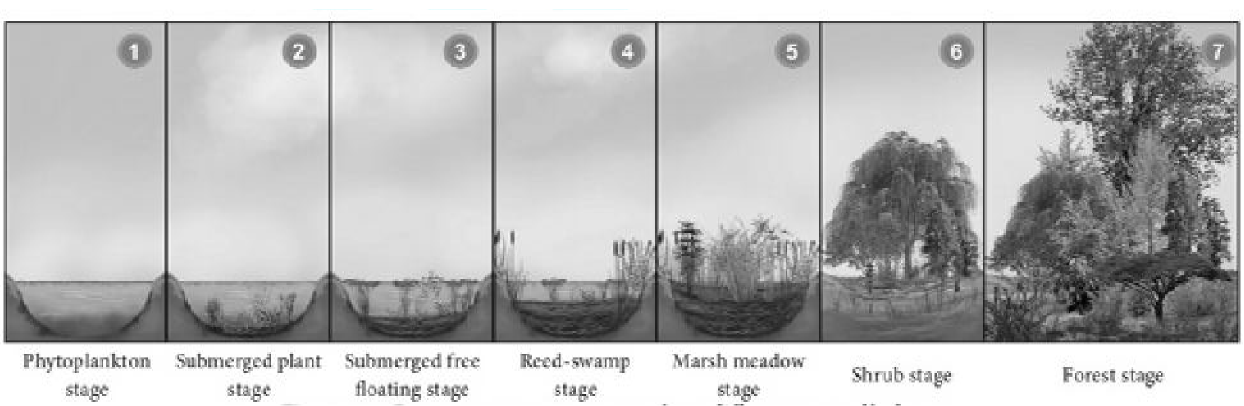


Fig: Diagrammatic representation shows different stages of Hydrosere

LITHOSERE :

Stages of Lithosere (Succession on rocks)

1. Crustose lichens stage . It is pioneer community, tolerates desiccation, produces organic acid which causes weathering of rocks, so first minerals are released for own use.
2. Foliose lichens stage . large lichens with leafy thalli
3. Moss stage
4. Herb stage . Annual hardy grasses
5. Shrub stage
6. Forest stage

Fig: Diagrammatic representation shows different stages of lithosere

INTER SPECIFIC INTER ACTIONS

Due to increase in different species in community, interaction for food, habitat and light etc. also starts between them.

(a) Positive or beneficial interaction . Member of one or both the interacting species are benefitted but neither is harmed.

(b) Negative interaction . One or both interacting species is harmed.

POSITIVE OR BENEFICIAL INTERACTIONS

It is a wide spread phenomenon, it includes ® mutualism, commensalism, protocooperation

1. Mutualism (+, +) or Obligate mutualism (co-evolution, co-existence and co-extinction)

Positive inter specific interation in which members of two different species completely depend on each other for growth and survival. It is obligatory relationship.

- ***Mutualism between animal and animal .***
  e.g. Termites and Flagellates (Trichonympha)
- ***Mutualism between plant & animals .***
  e.g. Yucca plant flowers and Pronuba insects . Pollination of yucca plant by pronuba (Female yucca moth)
- ***Mutualism between algae and fungi .***
  e.g. Lichens
- ***Fig tree and wasp species .***
  - ✓ In many species of fig trees, there is a tight one to one relationship with the pollinator species of wasp,
  - ✓ It means that a given fig species can be pollinated only by its partner wasp species and no other species.
  - ✓ The female wasp uses the fruit not only as an oviposition (egg-laying) site but uses the developing seeds with in the fruit for nourishing its larvae. The wasp pollinates the fig

inflorescence while searching for suitable egg-laying sites. In return for the favour of pollination the fig offers the wasp some of its developing seeds, as food for the developing wasp larvae.

- ***Bees and orchid flower .***
  - ✓ Orchids show diversity of floral patterns, which have evolved to attract the right pollnator insect (bees and bumblebees) and ensure guaranteed pollination by it.
  - ✓ The mediterranean orchid Ophrys employs "sexual deceit" to get pollination done by a species of bee,
  - ✓ One petal of its flower bears resemblance to the female of the bee in size, colour and markings. The male bee is attaracted to what it perceives as a female, pseudocopulates with the flower and during that process is dusted with pollen from the flower, it transfers pollen to it and thus, pollinates the flower.

2. Commensalism (+ , 0) .

- ➢ Association between members of two species in which one is benefitted while other is almost unaffected.
- ➢ ***Lianas .*** are woody plants. Their roots are present in soil but their stem use other plant or object for support to get better light. They are found in dense forest. No nutritional relationship. Lianas are the speciality of tropical rain forest. e.g. Bauhinia, Tinospora
- ➢ ***Epiphytes .*** Small plants grow on other plants in tropical rain forest. They utilise only the space of host plant for light & humidity. e.g. Orchids, Hanging mosses
- ➢ ***Epizones .*** Those animals which depends on plants or other animals.
- ➢ Sucker fish ***(Echeneis) .*** Shark
- ➢ Pilot fish . Shark
- ➢ E.coli bacteria . Intestine of man
- ➢ Clown fish . Sea anemone
- ➢ Barnacles . Whale
- ➢ Cattle egret birds . Cattle

3. Proto-cooperation (+/+) .

- ➢ Association in which both organisms are benefited but can live separately, it is a facultative or optional or occasional association also called as non-obligatory relationship.
- ➢ e.g., Hermit crab . Sea anemone
- ➢ Tick bird (Red-billed or yellow billed) . Rhinoceros
- ➢ Crocodile . Bird

NEGATIVE INTERACTION (ANTAGONISM)/DETRIMENTAL

Three type of negative interaction

(1) Exploitation (2) Amensalism (3) Competition

(1) Exploitation . One species harms the other by making its direct or indirect use for support, shelter or food.

It is of two types

(a) Parasitism (b) Predation

(a) Parasitism (+ / .) :

- ✍ This association involves individuals of two species of different size in which smaller (Parasite) is benefitted and larger (host) is harmed. The parasite gets nourishment and shelter from host but do not kill the host.

- Majority of the parasites harm the host; they may reduce the survival, growth and reproduction of the host and reduce its population density. They might render the host more vulnerable to predation by making it physically weak.
- Many parasites have evolved to be host-specific (they can parasitise only a single species of host) in such a way that both host and the parasite tend to co-evolve; that is, if the host evolves special mechanisms for rejecting or resisting the parasite, the parasite has to evolve mechanisms to counteract and neutralise them, in order to be successful with the same host species. In accordance with their life styles, parasites evolved special adaptations such as the loss of unnecessary sense organs, presence of adhesive organs or suckers to cling on to the host, loss of digestive system and high reproductive capacity.
- ***Type of Parasite :***
  - ***(i)*** ***Ectoparasite*** ® lives on the body of host.
  - ***(ii)*** ***Ectozooparasite .*** Leech on cattle, ticks on dogs, copepods on marine fish and lice on human.
  - ***(iii)*** ***Ectophytoparasite*** . Aphids, Lac insects, Red cotton bug live on plants.
  - ***(iv)*** ***Endoparasites*** ® live in the body of host
    Tapeworm, Taenia, Ascaris, Entamoeba ® live in intestine of man.
    Plasmodium ® live in R.B.C. of human

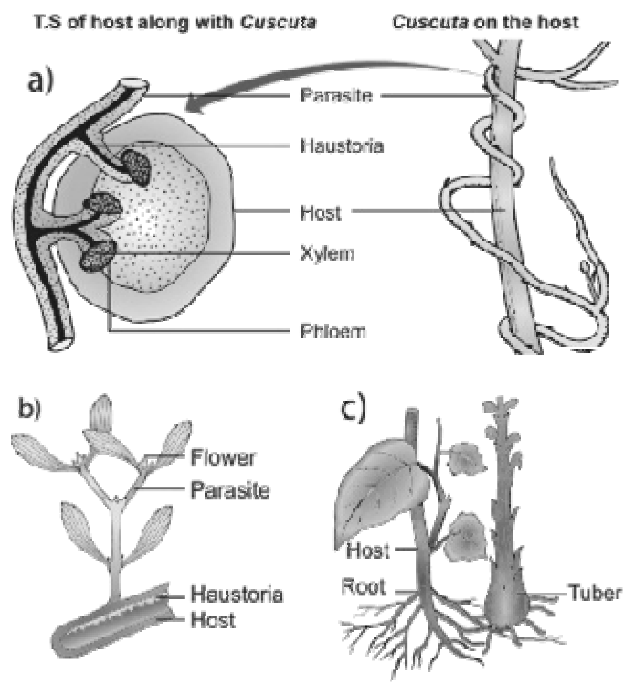


Fig: a) Holoparasite – Cuscuta; b) A partial stem parasite – Viscum; c) Root parasite on the brinjal root Orobanche spp.

(b) Predation (+/.) :

A free living organisms which catches and kills another species for food.

1. When we think of predator and prey, most probably it is the tiger and the deer that readily come to our mind, but a sparrow eating any seed is no less a predator.
2. Predators acting as .conduits. for energy transfer across trophic levels, also play other important roles. They keep prey populations under control. In the absence of predators, prey species could achieve very high population densities and cause ecosystem instability. When certain exotic species are introduced into a geographical area, they

become invasive and start spreading fast because the invaded land does not have its natural predators.The prickly pear cactus introduced into Australia in the early 1920.s caused havoc by spreading rapidly into millions of hectares of rangeland (grassland). Finally, the invasive cactus was brought under control only after a cactus-feeding predator (a moth) from its natural habitat was introduced into the country.

3. Predators also help in maintaining species diversity in a community, by reducing the intensity of competition among competing prey species. In the rocky intertidal communities of the American Pacific Coast the starfish Pisaster is an important predator. In a field experiment, when all the starfish were removed from an enclosed intertidal area, more than 10 species of invertebrates became extinct within a year, because of interspecific competition.
4. If a predator is too efficient and overexploits its prey, then the prey might become extinct and following it, the predator will also become extinct due to lack of food. This is the reason why predators in nature are prudent. (clever).
5. Prey species have evolved various defenses to lessen the impact of predation. Some species of insects and frogs are cryptically-coloured (camouflaged) to avoid being detected easily by the predator. Some are poisonous and therefore avoided by the predators. The Monarch butterfly is highly distasteful to its predator (bird) because of a special chemical present in its body. This butterfly acquires this chemical during its caterpillar
6. For plants, herbivores are the predators. Nearly 25 per cent of all insects are known to be phytophagous (feeding on plant sap and other parts of plants). The problem is particularly severe for plants because, unlike animals, they cannot run away from their predators. Plants therefore have evolved an astonishing variety of morphological and chemical defences against herbivores. Thorns (Acacia, Cactus) are the most common morphological means of defence. Many plants produce and store chemicals that make the herbivore sick when they are eaten, inhibit feeding For digestion, disrupt its reproduction or even kill it. The weed Calotropis produces highly poisonous cardiac glycosides and that is why you never see any cattle or goats browsing on this plant.

(2) Amensalism (. / 0) .

In this interaction one species is inhibited by toxic secretion of other species. eg. Parthenium

(3) Competition (., .) :

Process in which the fitness of one species is significantly lower in the presence of another species.

1. It is generally believed that competition occurs when closely related species compete for the same resources that are limiting, but this is not entirely true. Firstly, totally unrelated species could also compete for the same resource. For eg. in some shallow South American lakes, visiting flamingoes and resident fishes compete for their common food, the zooplankton in the lake. Secondly, resources need not be limiting for competition to occur; in interference competition (indirect competition), the feeding efficiency of one species might be reduced due to the interfering and inhibitory presence of the other species, even if resources (food and space) are abundant.
2. Therefore, competition is best defined as a process in which the fitness of one species (measured in terms of its .r. the intrinsic rate of increase) is significantly lower in the presence of another species. It is relatively easy to demonstrate in laboratory experiments, as Gause and other experimental ecologists did, when resources are limited the competitively superior species will eventually eliminate the other species. The

Abingdon tortoise in Galapagos Islands became extinct within a decade after goats were introduced on the island, apparently due to the greater browsing efficiency of the goats.

3. Connell.s elegant field experiments showed that on the rocky sea coasts of Scotland, the larger and competitively superior barnacle Balanus dominates the intertidal area, and excludes the smaller barnacle Chathamalus from that zone.
4. Gause.s .Competitive Exclusion Principle. states that two closely related species competing for the same resources cannot co-exist long period and the competitively inferior one will be eliminated eventually. This may be true if resources are limiting, but not otherwise. More recent studies do not support such gross generalisations about competition. While they do not rule out the occurrence of interspecific competition in nature, they point out that species facing competition might evolve mechanisms that promote co-existence rather than exclusion. One such mechanism is .resource partitioning.. If two species compete for the same resource, they could avoid competition by choosing, different times for feeding or different foraging patterns. MacArthur showed that five closely related species of warblers living on the same tree were able to avoid competition and co-exist due to behavioural differences in their foraging activities.
5. Another evidence for the occurrence of competition in nature comes from what is called competitive release.. A species whose distribution is restricted to a small geographical area because of the presence of a competitively superior species, is found to expand its distributional range when the competing species (Superior species) is experimentally removedtage by feeding on a poisonous weed.

	Interaction type	Combination		Effects	Examples
1.Positive interaction					
1	**Mutualism**	(+)	(+)	Both species benefitted	Lichen, *Mycorrhiza* etc.
2	**Commensalism**	(+)	(0)	One species is benefitted and the other species is neither benefitted nor harmed	orchids, Lianas etc.
2.Negative interaction					
4	**Predation**	(+)	(-)	One species benefitted, the other species are harmed	*Drosera, Nepenthes* etc.
5	**Parasitism**	(+)	(-)	One species benefitted, the other species are harmed	*Cuscuta, Duranta, Viscum* etc.
6	**Competition**	(-)	(-)	Harmful for both	Grassland species
7	**Amensalism**	(-)	(0)	Harmful for one, but the other species are unaffected	*Penicillium* and *Staphylo coccus*

(+) Benefitted, (-) Harmed (0)Unaffected

Fig: Different interactions of plants

7 ECOSYSTEM

- A.G.Tansley . The term "ecosystem" first of all coined by A.G. Tansley.
- According to Tansley . Ecosystem is symbol of structure and function of nature.
- E.P. Odum . Father of ecosystem ecology.
- According to E.P. Odum . Ecosystem is the smallest structural and functional unit of nature or environment.

- ***Definition .*** Total living factor (biotic) and total non living factor (abiotic) of the environment present in a particular area is called ecosystem

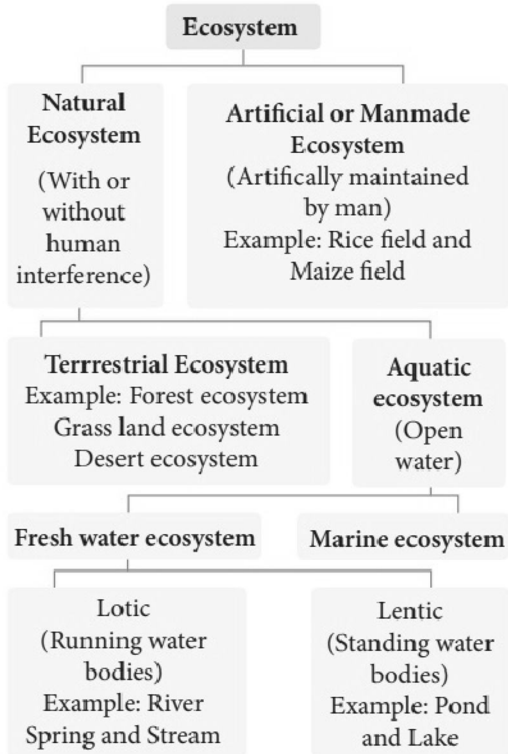


Fig: Types of ecosystem

➢ ***Note :***

- The boundaries of ecosystem are indistinct and have a overlapping character over each other.
- Ecosystem is the smallest structural and functional unit of nature or environment. It is a self regulatory and self sustaining unit.
- Ecosystem may be large or small. Single drop of water may be an ecosystem.
- Ecosystem may be temporary or permanent

➢ ***Structure of Ecosystem :*** The structure of ecosystem depends upon following components :

(i) Species diversity ***(ii) Species composition***
(iii) Life cycle ***(iv) Stratification***

➢ ***Component of Ecosystem***

1. **Abiotic components** : Consists of non living substances and factors like.

(i) Climatic factors i.e. air, water, light, temperature and precipitation.

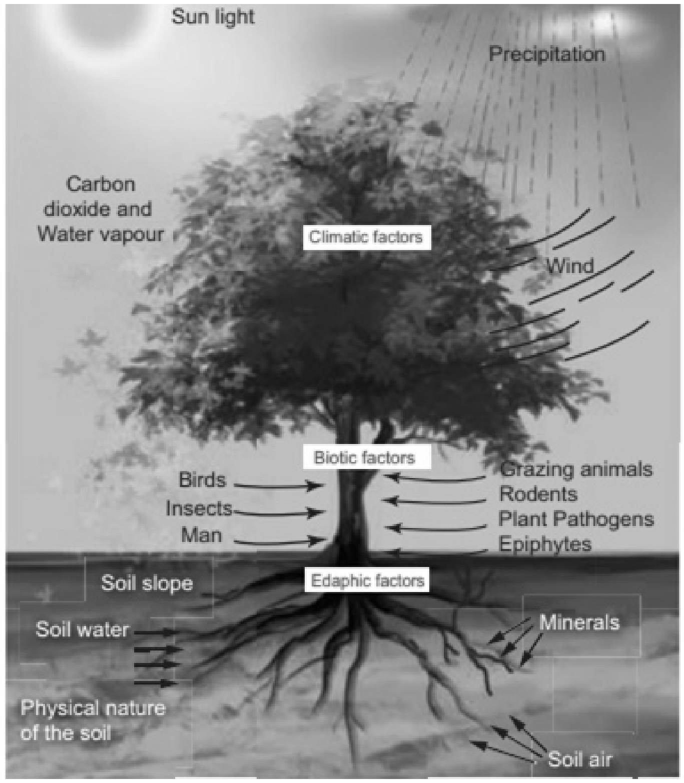


Fig: Environmental Factors affecting plant

(ii) Edaphic factors like soil composition.
(iii) Topographic factors i.e. mountains, slopes.

2. **Biotic components** : They constitute producers or transducers, consumers and decomposers or micro-consumers or saprotrophs.

- ***Incomplete ecosystem:*** *An ecosystem lacking one or more structural components e.g., deep sea, freshly formed rain water pond ecosystem.*

- ***Functions of Ecosystem :*** *The functional components of ecosystem are studied with following aspects like*

(i) Productivity | (ii) Mineral cycling
(iii) Energy flow | (iv) Food chain and web
(v) Efficiency | (vi) Biotic interrelationships
(vii) Homeostasis | (viii) Ecoregulation

- ***Homeostasis in ecosystem :*** *Ecosystem maintains functional balance or relatively stable state of equilibrium amongst its various components. It is due to*
(i) Carrying capacity (ii) Nutrient cycling (iii) Self regulation (iv) Feed back

- ***Stratification***
  - Stratification is the structure or recognizable pattern in spatial arrangement of the members of the communities.
  - More specifically stratification **represent vertical zonation in the community.**
  - For example in grassland communities, there is subterranean floor containing basal portions of the vegetation.
  - However stratification in a **forest community** is most complicated where, as many as **five vertical subdivisions may be** recognised.
  - ***These vertical subdivisions are:***

(i) Subterranean | (ii) Forest floor

(iii) Herbaceous vegetation (iv) Shrubs
(v) Trees

- ***Artificial ecosystem:*** *These are man-made ecosystems e.g., -Modern agriculture, dams, zoological parks, plantations, aquacultures etc.*

Characteristics :

(i) Do not possess self regulatory mechanism
(ii) Have little diversity
(iii) Simple food chain
(iv) High productivity
(v) Little cycling of nutrients

- ***Boundaries of Ecosystems***
  - An ecosystem is generally regarded as a self-sufficient unit and a separate entity.
  - However, it never operates in isolation.
  - Boundaries between one ecosystem and another are indistinct and overlapping and all ecosystem on the earth are joined together to form a single global ecosystem known as biosphere.
  - Some exchange of materials and energy always occurs between different ecosystems through geological, climatic or biological processes.

✍ ***STRUCTURAL ASPECT OF ECOSYSTEM***

- The structural aspects deal with the study of number, kinds and distribution of various types of biotic (living organisms) and abiotic *(e.g.,* light, temperature, water, oxygen, carbon, nitrogen, minerals, etc.) components.

(I) Biotic components :

Living organisms, *i.e.,* plants, animals and micro-organisms constitute biotic component of the ecosystem.

1. Producers:

- They are green photosynthetic plants that entrap solar energy through chlorophyll to synthesise organic food from inorganic raw materials.
- The green plants are thus termed **autotrophs** as they are capable of synthesizing their own food materials.
- They are also termed **transducers** as they change radiant energy into chemical energy.
- The complex organic substances are utilized for building up their bodies and for releasing energy required for various metabolic and physiological activites.

2. Consumers:

- They are the animals that are not capable of synthesizing the food materials, but feed upon other organisms or their parts.
- They are thus called **heterotrophs**.
- They are also called **phagotrophs** as they ingest the solid food materials.
- The consumers are mainly of two types *i.e.,* **herbivores** and **carnivores**.
- Herbivores are termed **primary consumers** as they obtain food directly from plants.
- Cattle, deer, goat, rabbit, mouse, grasshopper, etc., are common herbivores in terrestrial ecosystem and crustaceans, molluscs and protozoans are common herbivores in aquatic ecosystems.
- Some carnivores *(e.g.,* frog, cat, jackal, fox, some fishes, etc.) feed upon herbivores and thus termed as secondary consumers.

- Other carnivores feed upon secondary consumers, not eating the herbivores.
- They are termed as tertiary consumers *(e.g.,* wolf, peacock, etc).
- Some carnivores are thus eaten by other larger and stronger carnivores.
- However, some larger and stronger carnivores *(e.g.,* tiger and lion) never become prey to any animal and act as predators only. They are called **top carnivores**.

3. Decomposers:

- They are saprophytic micro-organisms (bacteria, actinomycetes and fungi) deriving their food material from organic matter present in dead remains of plants and animals.
- They secrete digestive enzymes which convert complex organic substances into simpler ones.
- A part of the digested organic matter is assimilated by the micro-organisms and the rest is broken down into simpler inorganic compounds for recycling.
- They bring about cyclic exchange of materials between biotic community and the environment. They are thus very essential components of an ecosystem.
- They are also called **reducers** as they are capable of degrading the dead organisms
- Some workers differentiated few other categories of living beings amongst the biotic components of an ecosystem.
- They are **scavengers**, **detrivores** and **parasites**.
- Parasites belong to diverse groups, *e.g.,* bacteria, fungi, protozoans, worms, etc.
- Every type of living being can be attacked by parasites.
- Detrivores are animals which feed on detritus *e.g.*, termites, earthworm etc.
- They are helpful in quick disposal of the dead bodies.
- Scavengers are animals that feed on dead or injured animals and they clean the earth of organic garbages e.g., carrion, Marabou storks, Crow, Vultures (Full time scar vengers)

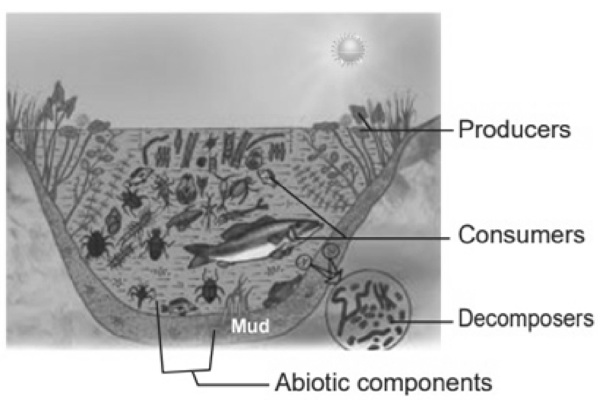


Fig: Diagram shows structure of pond ecosystem with abiotic and biotic omponents

(II) Abiotic Components:

- Non-living factors such as temperature, water, light, etc., constitute abiotic components of the ecosystem.
- They are mainly of three types, *i.e.*, **climatic**, **topographic** and **edaphic**.
- Different abiotic factors in an ecosystem are described below.

1. **Temperature:** Every organism has specific range to which it is adapted to live. There are some exceptions like prokaryotes and encysted protozoan which can withstand extremes of temperature.

   Effect of Temperature on animal .

   Temperature affect the absolute size of an animal and its body parts.

1. Bergman rule .

Birds and mammals attain greater body size in cold region and lesser in warm region.

2. Allens rule .

Mammals from colder climates generally have shorter ears and limbs to minimise heat loss. (This is called the Allen.s Rule.)

THERMAL STRATIFICATION IN LAKES

Thermal stratification occurs in deep water body because of difference in temperature of water at different depth. Mainly three layer or zone occurs in lake below (like in summer)

a. Epilimnion . The top layer gains warmth.

b. Metalimnion/thermocline . Middle region steady decline in temperature or a gradual change in temperature.

c. Hypolimnion . Bottom which is not affected by Temperature.

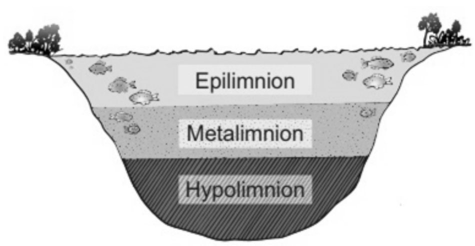


Fig: Thermal stratification of pond

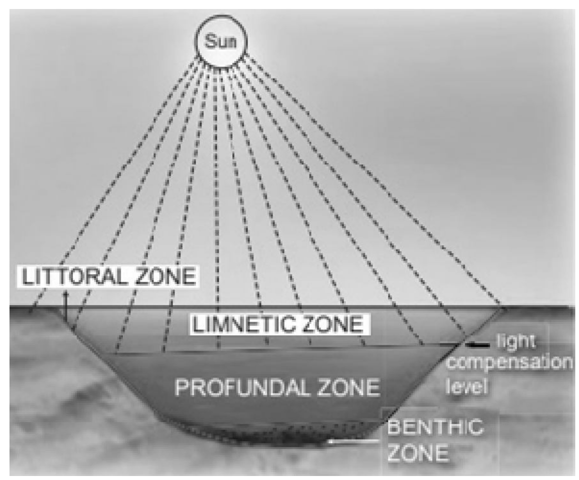


Fig: Diagrammatic sketch shows stratification of pond ecosystem

Temperature based zonation

Variations in **latitude** and **altitude** do affect the temperature and the vegetation on the earth surface. The latitudinal and altitudinal zonation of vegetation is illustrated below:

Latitude: Latitude is an angle which ranges from 00 at the equator to 900 at the poles.

Altitude: How high a place is located above the sea level is called the altitude of the place.

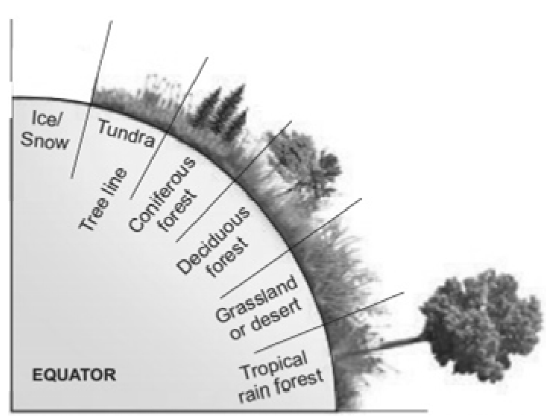


Fig: Latitudinal zonation of vegetation type

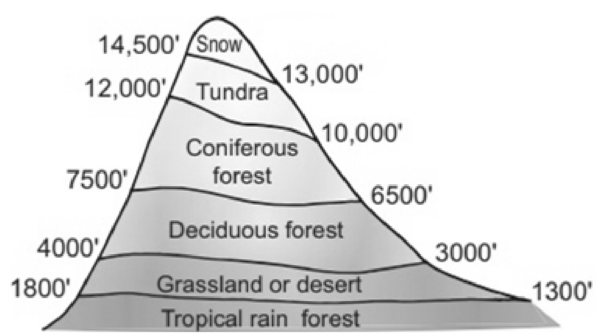


Fig: Altitudinal zonation of vegetation

Timber line / Tree line : It is an imaginary line in a mountain or higher areas of land that marks the level above which trees do not grow. The altitudinal limit of normal tree growth is about **3000 to 4000m.**

2. **Light:**
   - ✓ It is a complex physical environmental factor. Light is measured by luxmeter or photometer. It is a electromagnetic spectrum.
   - ✓ Solar Constant . Solar radiation before entering the atmosphere carries energy at a constant rate i.e., 2 cal cm.2 min.1 known as the solar constant.
   - ✓ In solar radiation wavelength (l) of light or visible spectrum is 0.4 to 0.7 mm (400.700 nm) it is also called photosynthetically active radiation (PAR).
   - ✓ The U. V. radiation distinguished in
     - U. V. . C : (0.100 to 0.280 mm)
     - U. V. . B : (0.280 to 0.320 mm)
     - U. V. . A : (0.320 to 0.400 mm)
   - ✓ ***Albido value .***
     The ability of a surface to reflect the incoming radiation is called albido value (AV) it is 80% for fresh snow, 20-30% for sand, 5-10% for the forest.
   - ✓ ***Suspension .***
   - ✓ ***Hibernation .*** Winter sleep or period of dormancy
   - ✓ ***Cold blooded animals***
     e.g. Amphibians, reptiles
   - ✓ ***Hot blooded animals***
     e.g. Polar bear, North ground squirrels
   - ✓ ***Aestivation (Summer sleep) .*** Escape from heat of sun
     e.g. Lung fishes, Snails, Ground squirrels in south-west desert
   - ✓ ***Diapause .*** Under unfavourable conditions many zooplankton species in lakes and ponds are known to enter diapause, a stage of suspended development.

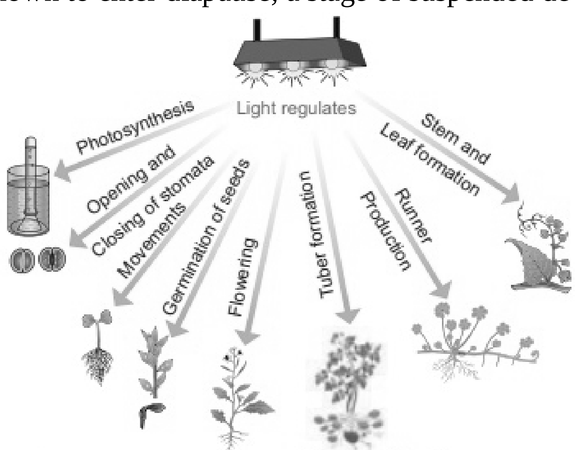


Fig: Various effects of light upon a green plants

3. **Wind:** Wind has more pronounced effect on plants than on animals.
   (i) Wind velocity increases the rate of transpiration.
   (ii) Wind brings about pollination in most of the gymnosperms and some angiosperms which is essential for seed formation and hence perpetuation of species.
   (iii) It brings about dispersal of fruits and seeds, necessary to avoid overcrowding and competition.

(iv) Wind affects the plant and animal populations by causing soil erosion in dry areas.

4. **Humidity:** It refers to water vapour or moisture content of the atmosphere and affects the water loss from the body surface of terrestrial organisms that occurs through evaporation, perspiration and transpiration.
5. **Precipitation:** It occurs in different forms like rainfall, dew, hail, snow, etc. Rainfall is the most significant of these and is the main determinant of composition of biotic community.
6. **Water:**
   - Next to temperature, water is the most important factor influencing the life of organisms.
   - You might think that organisms living in oceans, lakes and rivers should not face any water-related problems, but it is not true. For aquatic organisms the quality (chemical composition, pH) of water becomes important.
   - The salt concentration (measured as salinity in parts per thousand), is less than 5 PPT in inland waters, 30-35 PPT the sea and more then 100 PPT in some hypersaline lagoons. Some organisms are tolerant of a wide range of salinities (euryhaline) but others are restricted to a narrow range (stenohaline). Many freshwater animals cannot live for long in sea water and vice versa because of the osmotic problems, they would face.

- Based on the range of tolerance of salinity, organisms are divided into two types.
- 1. **Euryhaline:** Organisms which can live in water with wide range of salinity. Examples: Marine algae and marina angiosperms
- 2. **Stenohaline:** Organisms which can withstand only small range of salinity. Example: Plants of estuaries.

Terminology		Environmental factor
Stenothermal	Eurythermal	Temperature
Stenohaline	Euryhaline	Salinity
Stenoecious	Euryoecious	Habitat selection (niche)
Stenohydric	Euryhydric	Water
Stenophagic	Euryphagic	Food
Stenobathic	Eurybathic	Depth of water / habitat

Fig: Tolerance of Environmental factor

Examples of tolerance to toxicity

i. Soyabean and tomato manage to tolerate presence of cadmium poisoning by isolating cadmium and storing into few group of cells and prevent cadmium affecting other cells .
ii. Rice and *Eichhornia* (water hyacinth) tolerate cadmium by binding it to their proteins.

These plants otherwise can also be used to remove cadmium from contaminated soil ,this is known as **Phytoremediation.**

7. **Topography:** Topography is the surface behaviour of the earth like slope, altitude, hills, plains, mountain chain, exposure, etc. These factors affect vegetation and consequently animal life indirectly through their effect on rainfall, light intensity, wind velocity, water content in soil, etc. Vegetation on two sides of a hill, one facing the sun and other away, differ because of

the difference in environmental conditions, like humidity, light duration, light intensity, rainfall, etc., as two faces of hill receive different amount of solar radiations and wind action. Flora and fauna on the edge of pond and middle of pond and, on or underside of the rock are different for similar reason.

8. **Soil: (*SOIL ORGANIC MATTER)***
   - The dead organic matter present in soil is called humus, which is formed by decomposition of plant and animal remains. Freshly fallen plant and animal material called detritus or litter, partially decomposed litter is called duff. Fully decomposed litter is called humus.
   - Litter → Duff → Humus
   - ***Decomposition (Formation of Humas) :***
     - ✓ Decomposers break down complex organic matter into simple organic matter (humus) and inorganic substances like carbon dioxide, water and nutrients and the process is called decomposition.Dead plant remains such as leaves, bark, flowers and dead remains of animals, including fecal matter, constitute detritus, which is the raw material for decomposition. The important steps in the process of decomposition are fragmentation, leaching, catabolism, humification and mineralisation.
     - ✓ ***Detritivores*** (e.g.earthworm) break down detritus into smaller particles. This process is called ***fragmentation***.
     - ✓ By the process of leaching, water soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts. Bacterial and fungal enzymes degrade detritus into simple organic and inorganic substances, This process is called as catabolism.
     - ✓ It is important to note that all the above steps in decomposition operate simultaneously on the detritus.
     - ✓ **Humification and mineralisation** occur during decomposition in the soil. Humification leads to accumulation of a dark coloured amorphous substance called humus that is highly resistant to microbial action and undergoes decomposition at an extremely slow rate. Being colloidal in nature it serves as a reservoir of nutrients. The humus is further degraded by some microbes and release of inorganic nutrients occur by the process known as mineralisation.
     - ✓ Decomposition is largely an oxygen-requiring process. The rate of decomposition is controlled by chemical composition of detritus and climatic factors. In a particular climatic condition, 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. Temperature and soil moisture are the most important climatic factors that regulate decomposition though their effects on the activities of soil microbes. Warm and moist enviroment favour decomposition wheres low temperature and an anaerobiosis inhibit decompositon resulting in build up of organic materials

➢ ***FUNCTIONAL ASPECT OF ECOSYSTEM***

The components of the ecosystem are seen to function as a unit when following aspects are considered.

(A) Productivity

(B) Decomposition

(C) Energy flow

(D) Nutrient cycling

(B) Productivity of Ecosystem

✍ The rate of biomass production is called productivity. It is expressed in terms of $(gm^{-2})yr^{-1}$ or $(k\ cal\ m^{-2})\ yr^{1}$ to compare the productivity of different ecosystems.

(i) Coral reefs, tropical rain forests, sugarcane fields are most productive.

(ii) Deserts and deep sea ecosystems are least productive.

✍ Ecosystem productivity is maintained by the flow of energy derived from the sun.

✍ Energy trapped by plants varies from ecosystem to ecosystem.

✍ Table below shows **energy absorption** at different levels:

1.	Aquatic ecosystem	0.2%
2.	Terrestrial ecosystem	1%
3.	Grassland	1.15%
4.	Mixed forest , .	0.81%
5.	Modern crops	5%
6.	Sugarcane field	10-12% (Most efficient)

Types of productivity :

(i) **Primary Productivity :** The rate at which radiant energy is stored by photoautotrophs and chemoautotrophs.

(a) Gross primary productivity (G.P.P.) . It is the total amount of energy fixed (organic food) in an ecosystem (in producers) in unit time is called G.P.P. including the organic matter used up in respiration during the measurement period. It is also known as total (Gross) photosynthesis. A considerable amount of GPP is utilised by plants in respiration.

(b) Net primary productivity (N.P.P.) . It is the amount of stored organic matter in plant tissues after respiratory utilisation.

- NPP = GPP . R (R = Respiration / Metabolic activities)

  Or
- GPP = NPP + R
- NPP is the available biomass for the consumption to heterotrophs

- Net primary productivity = Gross primary productivity – Respiratory loss.
- Primary productivity depends on the plant species inhabiting a particular area, availability of nutrients and photosynthetic capacity of plants. This is available to herbivore level.
- The annual NPP of whole biosphere is approximately 170 billion tons (dry wt.) of organic matter, despite occupying about 70% of the surface, the productivity of the oceans is only 55 billion tons.ln deep marine habitats, both light and nutrients become limiting. The most limiting nutrient of marine ecosystem is nitrogen.

(ii) **Secondary productivity.** Rate of increase in energy containing organic matter or biomass by heterotrophs or consumers per unit time and area is known as secondary productivity. It is available to carnivore level.

(iii) **Community productivity.** It is the rate of net synthesis of built up of organic matter by a community per unit time and area.

(iv) **Ecological efficiency/Trophic level efficiency.** The percentage of energy converted into biomass by a higher trophic level over the energy of food resources available at the lower trophic level is called ecological efficiency

(C) Decomposition

- ✍ It is the process of physical and chemical breakdown of complex organic remains by organisms called **decomposers**, so as to produce inorganic raw materials (CO_2, HP, minerals, etc.) for recycling.
- ✍ The major site for decomposition is the upper layer of soil in terrestrial habitats and bottom of water bodies
- ✍ Freshly deposited organic matter constitutes raw material and is called **litter**.
- ✍ Detritus is degrading dead organic matter and is differentiated into above ground and below ground detritus.
- ✍ Above ground detritus consists of dried plant parts (leaves, twigs, bark, flowers), excreta and dead remains of animals.
- ✍ Below ground detritus is also called **root detritus**, because it is mainly composed of dead roots.
- ✍ Underground organisms and their excreta also form a part of below ground detritus.

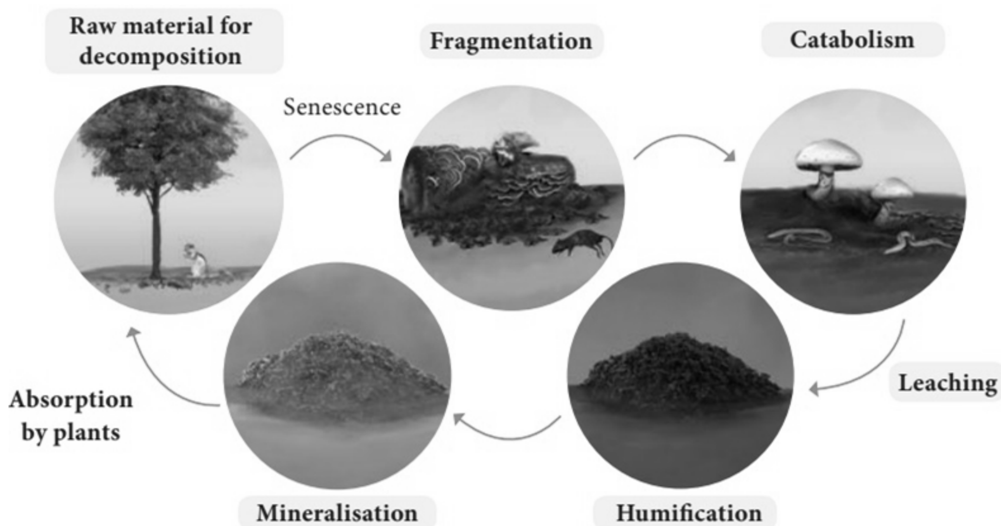


Fig: Diagrammatic representation – Process of decomposition and cycling of nutrients

- ✍ **Decomposition Processes**

  Three types of processes occur simultaneously during decomposition of detritus, viz. fragmentation, leaching and catabolism.

  1. **Fragmentation of Detritus:** Small invertebrate animals called **detrivores feed** on detritus, *e.g.,* Earthworms, termites. They bring about its fragmentation. A part of detritus eaten by detrivores comes out in highly pulverised state in their faeces. Due to fragmentation during eating and pulverisation in digestive tracts, detritus is changed into fine particles which have a large surface area.
  2. **Leaching:** Part of soluble substances present in the fragmented and decomposing detritus *(e.g.,*sugars, inorganic nutrients) get leached to upper layers of soil by percolating water.

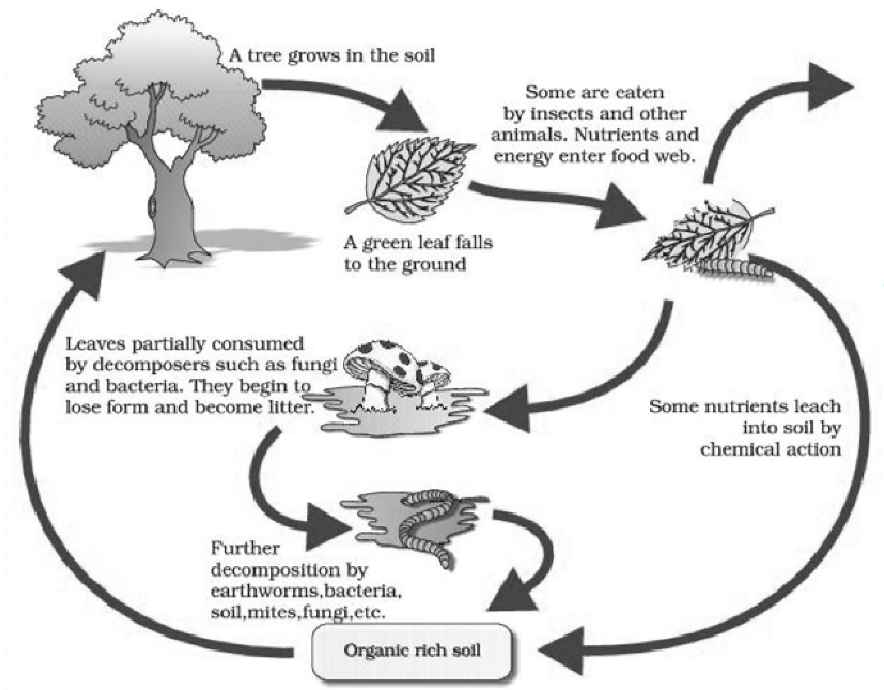


Fig. : Diagrammatic representation of decomposition cycle in a terrestrial ecosystem

3. **Catabolism:** It is carried out by saprotrophic bacteria and fungi. They secrete digestive enzymes over the fragmented detritus. The enzymes change complex organic compounds into simple compounds. Inorganic substances are also released in the process.
   - ✍ The rate of catabolic action or breakdown of different complex substances is different.
   - ✍ This differential decomposition produces two substances, humus and inorganic nutrients in processes respectively called **humification** and **mineralisation**, which occurs in soil.

   (i) **Humification.** It is the process of partial decomposition of detritus to form humus. Humus is a dark coloured, amorphous, partiaily decomposed organic matter rich in cellulose, lignin, tannins, resin, etc. and is highly resistant against microbial action. It undergoes decomposition at an extremely slow rate. Humus is slightly acidic, colloidal and functions as reservoir of nutrients.

   (ii) **Mineralisation.** It is the release of inorganic substances (*e.g.*, CO_2, H_2O, minerals) from organic matter during the process of decomposition. They are formed alongwith simple and soluble organic substances when digestive enzymes are poured over organic matter by saprotrophic microbes.

✍ ***Factors Affecting Decomposition***

✍ The rate of decomposition of detritus is controlled by a number of factors.

(i) **Chemical Nature of Detritus.** Decomposition of detritus is slow if it contains lignin, chitin, tannins (phenolics) and cellulose. It is rapid if detritus possesses more of nitrogenous compounds (like proteins, nucleic acids) and water soluble reserve carbohydrates.

(ii) **Soil pH.** Detrivores are fewer in acidic soils. Microbial activity is also low in such soils. Therefore, rate of decomposition of organic matter is slow in acidic soils. Partially decomposed organic matter piles up over such soils. Detrivores are abundant in neutral and slightly alkaline soils, while decomposer microbes are rich in neutral and slightly acidic soils.

(iii) **Temperature.** At a temperature of more than 25°C, decomposers are very active in soils having good moisture and aeration. In humid tropical regions, it does not take more than 3 – 4 months for complete decomposition of detritus. However under low temperature conditions (>10°C) of soils, the rate of decomposition is very slow even if moisture and aeration are optimum.

(iv) **Moisture.** An optimum moisture helps in quicker decomposition of detritus. Reduction in moisture reduces the rate of decomposition as in areas of prolonged dryness like tropical deserts where, otherwise, the temperature is quite high. Excessive moisture also impedes decomposition. Temperature and soil moisture are the most important climatic factors that regulate decomposition through their effects on the activities of soil microbes.

(v) **Aeration.** It is required for activity of decomposers and detrivores. A reduced aeration will slow down the process of decomposition

8 ENERGY FLOW

✍ ***Energy flow .*** The storage, expenditure, transformation of energy is based on two basic law of ***thermodynamics :***

✍ ***First law of thermodynamics :-*** Energy is neither created nor destroyed but only transformed from one state to another state.

✍ ***Second law of thermodynamics (the law of entropy) .*** The transfer of food energy from one to another organism leads to loss of energy as heat due to metabolic activity. Further, ecosystems are not exempt from the Second Law of thermodynamics. They need a constant supply of energy to synthesise the molecules they require, to counteract the universal tendency toward increasing disorderliness.

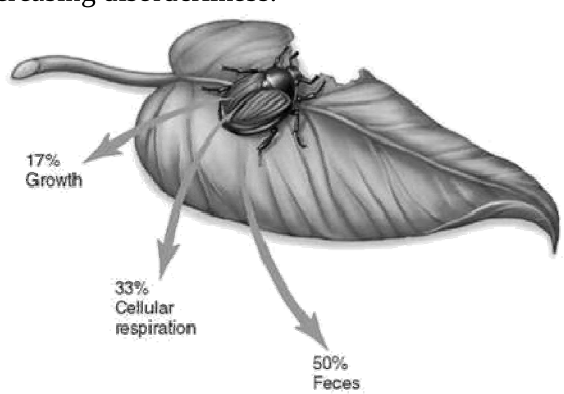


Fig. How heterotrophs use food energy.

A heterotroph assimilates only a fraction of the energy it consumes. For example, if a "bite" is composed of 500 Joules of energy (1 Joule = 0.239 calories), about 50%, 250 J, is lost in feces; about 33%, 165 J, is used to fuel cellular respiration; and about 17%, 85 J, is converted into consumer biomass. Only this 85 J is available to the next trophic level.

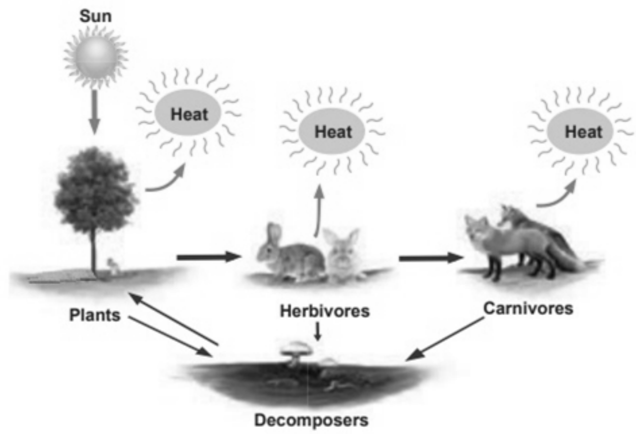


Fig: Diagrammatic representation of energy flow

Ten percent law

This law was proposed by Lindeman (1942). It states that during transfer of food energy from one trophic level to other, only about 10% stored at every level and rest of them (90%) is lost in respiration, decomposition and in the form of heat. Hence, the law is called **ten percent law.**

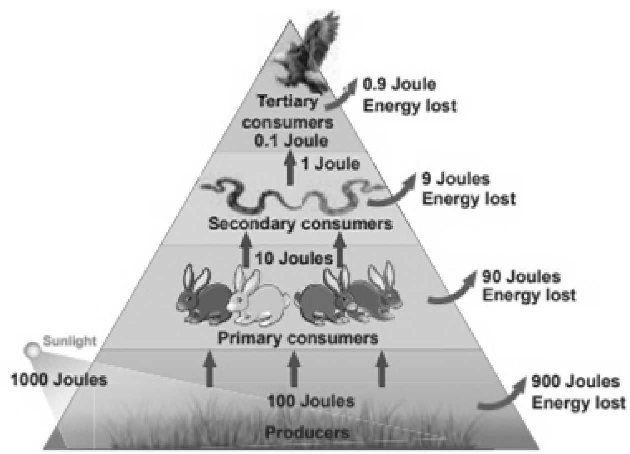


Fig: Ten percent law

Example: It is shown that of the 1000 Joules of Solar energy trapped by producers. 100 Joules of energy is stored as chemical energy through photosynthesis. The remaining 900 Joules would be lost in the environment. In the next trophic level herbivores, which feed on producers get only 10 Joules of energy and the remaining 90 Joules is lost in the environment. Likewise, in the next trophic level, carnivores, which eat herbivores store only 1 Joule of energy and the remaining 9 Joules is dissipated. Finally, the carnivores are eaten by tertiary consumers which store only 0.1 Joule of energy and the remaining 0.9 Joule is lost in the environment. Thus, at the successive trophic level, only ten percent energy is stored.

9 FOOD CHAIN

- ✍ It is a sequence of living organisms due to interdependence in which one organism consumes another.

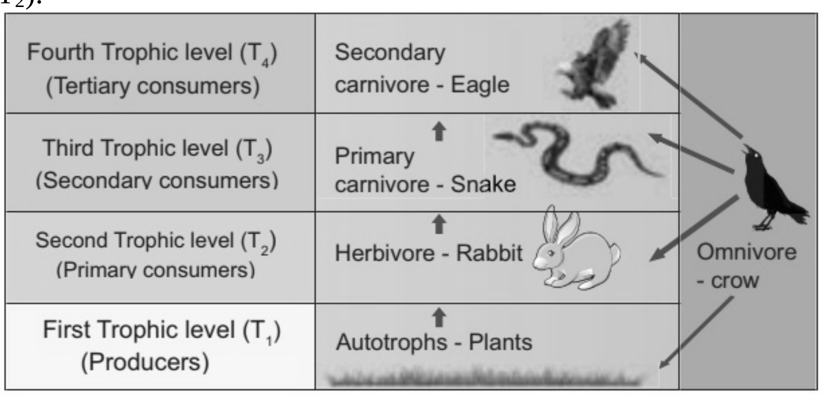
Trophic Level :

- ✍ Organisms occupy a place in the natural surroundings or in a community, according to their feeding relationship with other organism.
- ✍ Every position is called trophic level.
- ✍ It is based on the source of their nutrition.

- ✍ The ultimate source of energy used by all living organisms is the sunlight which is entrapped by green plants, and utilized for the synthesis of complex organic substances (carbohydrates) during photosynthesis.
- ✍ The energy trapped in organic substances by autotrophs is passed on to different living organisms through food.
- ✍ Exchange of both energy and materials thus occurs through food.
- ✍ The sequence of populations or organisms or trophic levels in an ecosystem through which food and its contained energy flows constitutes a food chain.
- ✍ The number of trophic levels in a food chain is equal to the number of steps involving the transfer of food from one organism to the other.
- ✍ Decomposers are not included in food chain as they operate at all trophic levels.

Concept of trophic level in an ecosystem

A trophic level refers to the position of an organism in the food chain. The number of trophic levels is equal to the number of steps in the food chain. The green plants (producers) occupying the first trophic level (T_1) are called **producers**. The energy produced by the producers is utilized by the plant eaters (herbivores) they are called **primary consumers** and occupies the second trophic level (T_2).



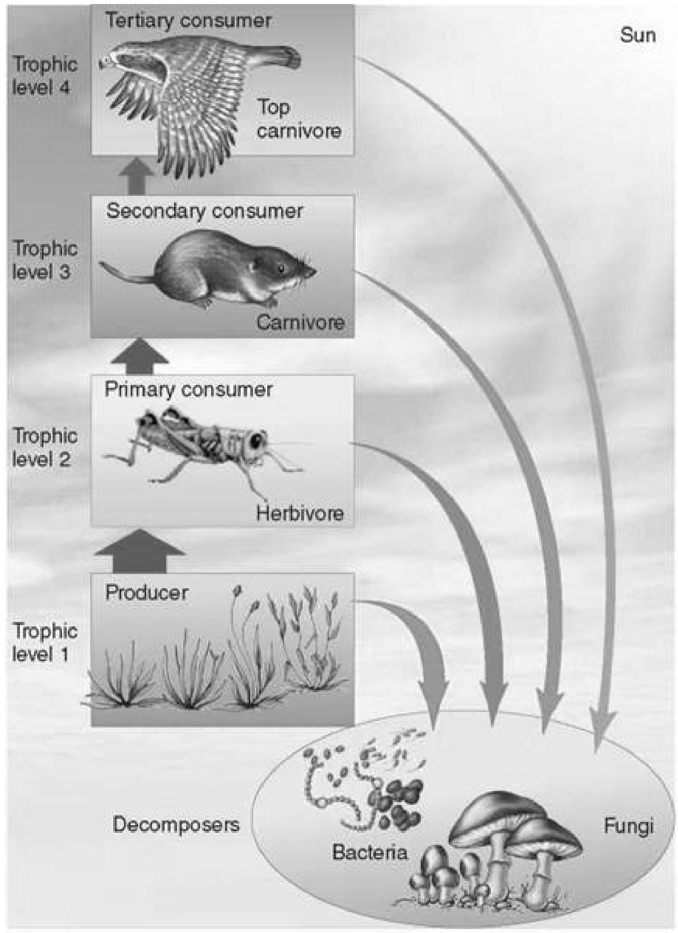


Fig: Fig: Diagrammatic representation of trophic levels

Herbivores are eaten by carnivores, which occupy the third trophic level (T_3). They are also called **secondary consumers** or **primary carnivores**. Carnivores are eaten by the other carnivores, which occupy the fourth trophic level (T_4). They are called the **tertiary consumers or secondary carnivores**. Some organisms which eat both plants and animals are called as **omnivores** (Crow). Such organisms may occupy more than one trophic level in the food chain.

1. **Producers:** They are autotrophs, synthesizing complex organic substances from simple
   (a) Size of organisms commonly increase at higher trophic levels inorganic substances like CO_2 and Hp during photosynthesis. The sunlight provides the energy for the process, the solar energy is converted into chemical energy and is stored in different complex organic substances like carbohydrates, proteins, lipids, etc.
2. **Consumers:** They are heterotrophic organisms incapable of synthesizing their own food. They depend upon plants (producers) for their food requirement directly or indirectly. The consumers are of different types:
   (i) Primary consumers: They are herbivores which feed upon plants or plant products, *e.g.*, rabbit, deer, field mouse, cow, elephant, small fish, tadpoles, several insects, zooplanktons like *Paramecium, Daphnia*, etc. These are called Key industry animals as they convert plant matter into animal matter.
   (ii) Secondary consumers : They do not feed upon plants directly; instead feed upon herbivores, so are primary carnivores *e.g.*, fox, jackal, frog, fish, several birds, etc.
   (iii) Tertiary consumers: They are larger camivores which feed upon smaller

carnivores *e.g.*, wolf feeding upon fox, snake feeding on frog. These carnivores may also become prey to still larger carnivores. The latter are termed top carnivores *e.g.*, tiger, lion, shark, crocodile, eagle, etc. A food chain may vary in length but usually consists of 4 or 5 steps or trophic levels. A few common food chains are given below :

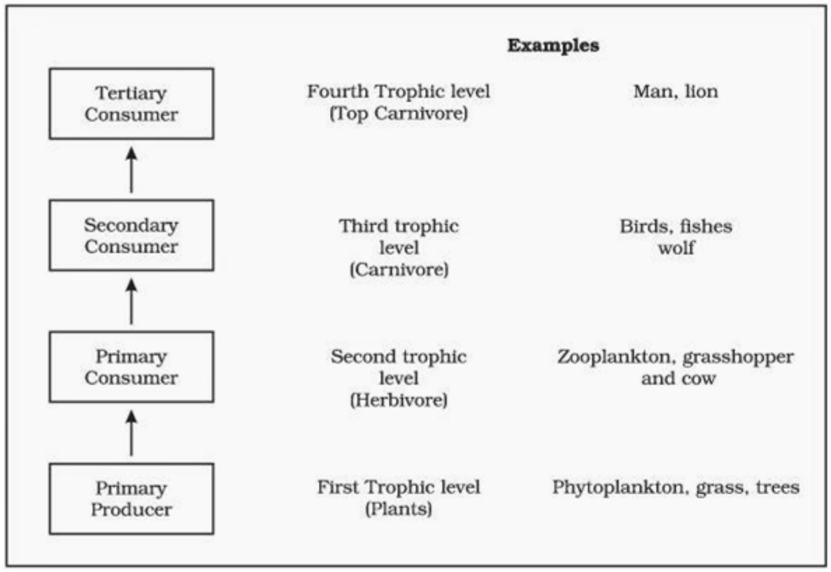


Fig. : Diagrammatic representation of trophic levels in an ecosystem

10 TYPES OF FOOD CHAIN

(i) Grazing Food Chain (GFC)/predator food chain

(b) Major conduit for energy flow in aquatic ecosystems.

(c) Always begins with producers

(d) Sun is the only source of energy

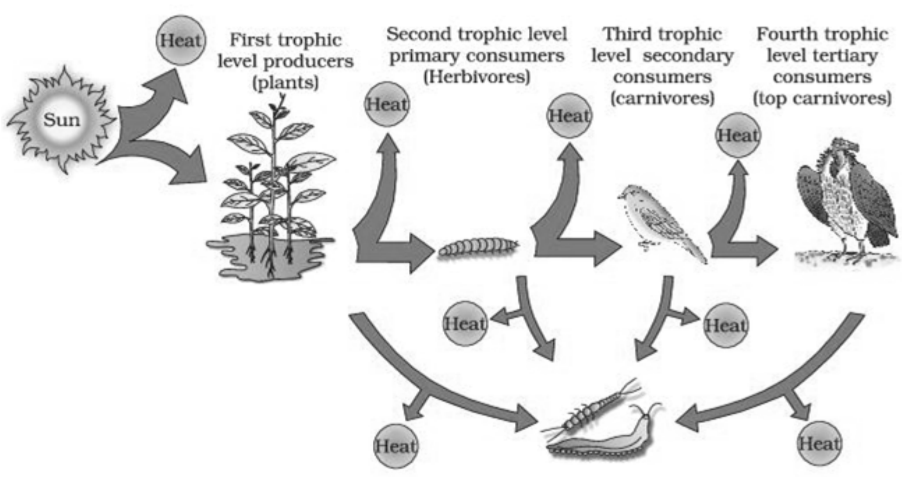


Fig. : Energy flow through different trophic levels

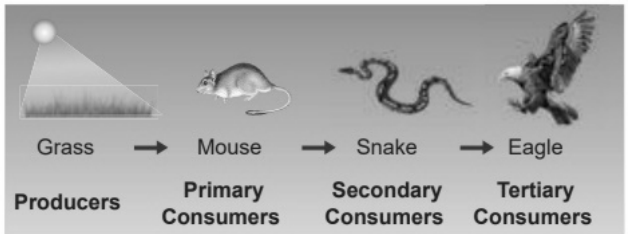


Fig: Diagrammatic representation of Grazing food chain

(ii) Detritus Food Chain (DFC): Death of an organism is the begining of DFC.

(a) In terrestrial ecosystems, a much larger fraction of energy flows through the DFC than through the GFC.

(b) Source of energy is detritus not sun.

(c) Composed of a long chain of detritus eating organisms (detritivores)

(d) In some ecosystems (e.g., Tropical rain forest) more energy flows in this chain than grazing food chain.

(e) DFC may be connected with the GFC at some levels, as some of the organisms of DFC are prey to certain GFC animals and in a natural ecosystem, some organisms like cockroaches, crows etc. are omnivores.

Fig: Diagrammatic representation of Detritus food chain

(iii) Parasitic food chain/Auxiliary food chain : *Size of the organisms finally reduces at higher trophic level (parasite). e.g., Tree; herbivore birds ; lices and bugs.*

Terrestrial food chains

1. Grass → Rabbit → Cat → Wolf →Tiger
2. Grass → Grasshopper → Frog → Snake → Peacock →Falcon.
3. Vegetation → Insect → Predator bird → Hawk.

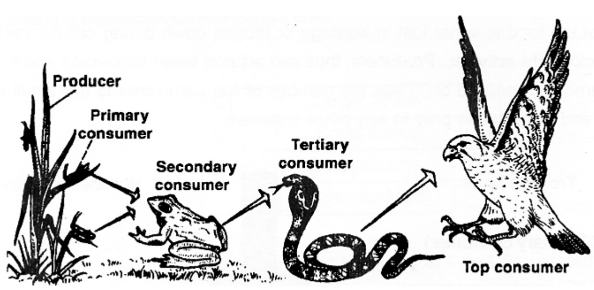


Fig. : A food chain - 1. Producer-Grass 2. Primary consumer-Grasshopper 3. Secondary consumer-Frog 4. Tertiary consumer-Snake 5. Quaternary top consumer-Eagle. Aquatic food chains

1. Phytoplanktons → Zooplanktons → Crustaceans → Predator insects → Small fish → Large fish.
2. Phytoplanktons →Zooplanktons →Crustaceans → Predator insects → Kingfisher →Stork.

11 FOOD WEB

✓ In ecosystem, linear food chains as shown above seldom exist, because every organism has alternate source of food.

- ✓ An animal may have preference for a particular prey, but if the latter has a small population, it may feed upon some other prey.
- ✓ Single animal may be eaten by different animals and thus different food chains get interconnected and one animal may be a link in more than one food chain.
- ✓ The network of interconnected food chains at different trophic levels in a biotic community is termed food web.
- ✓ Occurrence of food webs provides stability to ecosystem.
- ✓ Food webs operate because of taste preference for particular food and unavailability of food.
- ✓ One animal may feed upon organism of ever different trophic level like -Snakes may feed upon mice (herbivore) and frogs (carnivore), jackals are both carnivores and scavengers.
- ✓ Only 10% of the gross productivity of producers is entrapped by herbivores for their body building.
- ✓ Similarly 10% of the herbivore productivity is available for raising productivity of primary carnivores.
- ✓ Higher carnivores are also able to retain only 10% of energy present in primary carnivores.
- ✓ It is called 10% law (Lindemann, 1942).
- ✓ It is due to this fact, the number of trophic levels in the GFC is restricted as the energy transfer follows this law.
- ✓ Respiratory loss gradually increases in successive trophic levels. It is 20%, 30% and 60% respectively at producer, consumer and top carnivore level.
  - ➢ **Standing State or Standing Quality:** Amount of all the inorganic substances present in an ecosystem per unit area at a given time.
  - ➢ **Standing Crop:** Amount of living material present in different trophic levels at a given time. It is commonly expressed as the number of organisms per unit area.

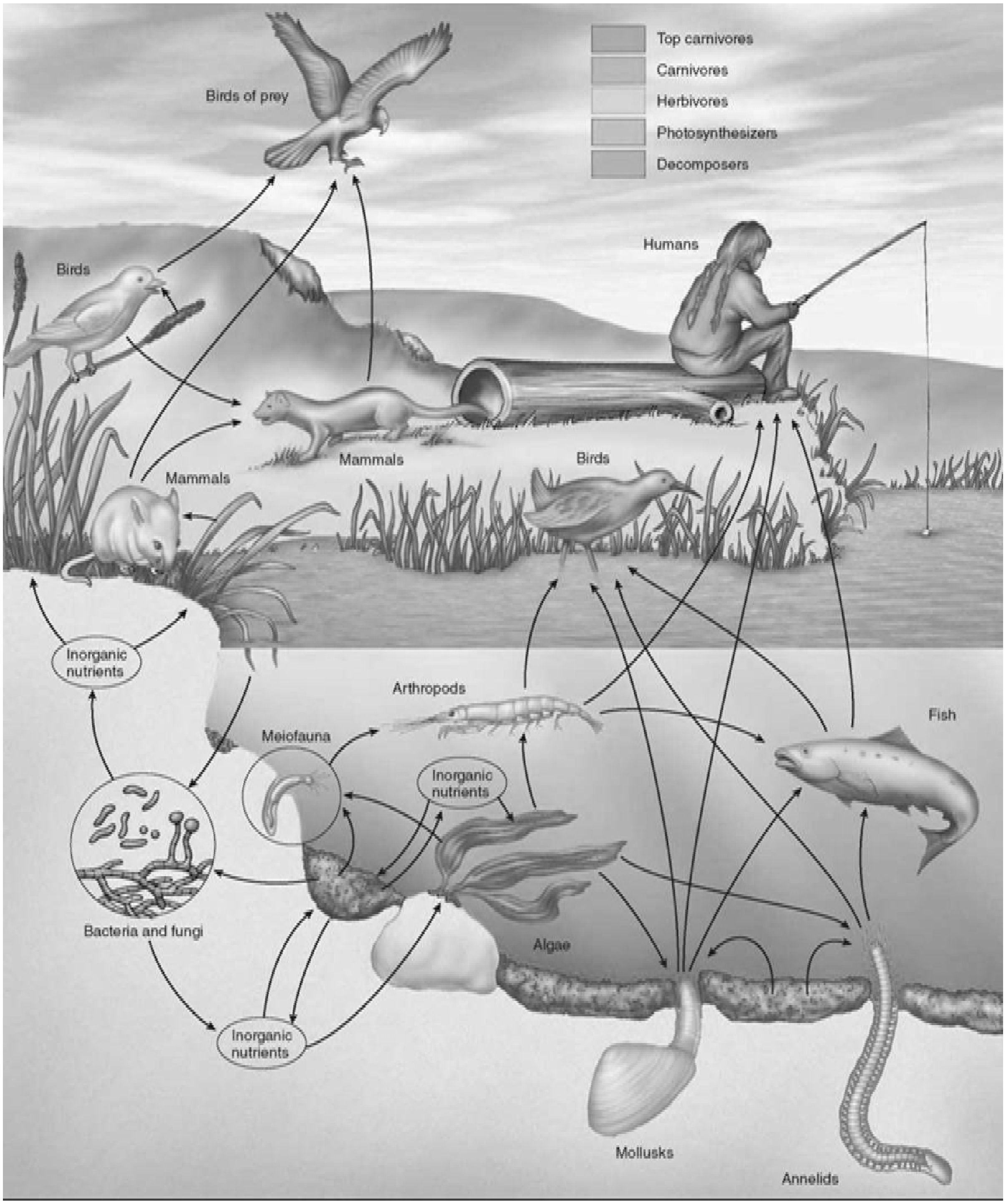


Fig. A food web.
A food web is much more complicated than a linear food chain. The path of energy passes from one trophic level to another and back again in complex ways.

- Ecosystem is a dynamic (functional) system because continuous interaction is going on in between biotic or abiotic components so ecosystem is present in an equilibrium position.
- Ecosystem is also self maintainable and self regulatory system, it means an ecosystem maintains a balance in between different trophic levels.
- Each trophic level controls the other trophic level in an ecosystem. If any change take place in any trophic level of ecosystem, the other trophic levels of this ecosystem may react according to it. So ecosystem always remain in equilibrium. This feature of system is known as homeostasis.

13 ECOLOGICAL PYRAMIDS

✍ An ecological pyramid is the graphic representation of, trophic levels of a food chain.

✍ Ecological pyramids were developed by Charles Elton (1927) and are, therefore, also called **Eltonian pyramids.**

✍ Three types of ecological pyramids are recognized, viz., (i) pyramid of number, (ii) pyramid of biomass, and (iii) pyramid of energy, giving graphic representation to three important parameters at different trophic levels in food chain respectively, number of individuals, amount of biomass and amount of energy.

(i) Pyramid of number:

✍ In most ecosystems, the number of producers is maximum.

✍ During transfer of food at any trophic level, only 10% of the food present in one trophic level becomes part of the next trophic level.

✍ 90% of the food is either lost in wastage or broken down during cellular respiration for providing energy for various life activities.

✍ Producers, thus can support fewer herbivores and herbivores can support still fewer carnivores and so on.

✍ Thus the number of top carnivores is too small to support any other trophic level and don't act as prey to any other organism.

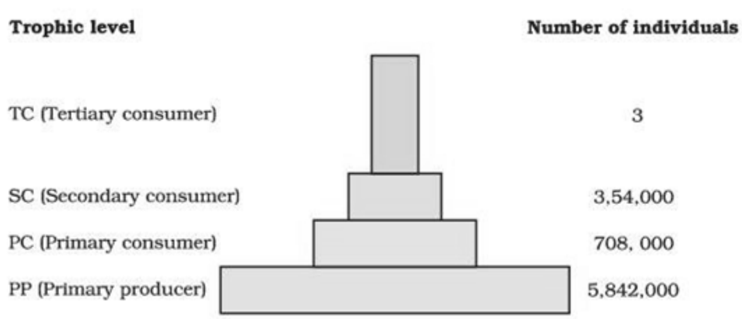


Fig. : Pyramid of numbers in a grassland ecosystem. *(For example, only three top-carnivores are supported in an ecosystem based on production of nearly 6 millions plants)*

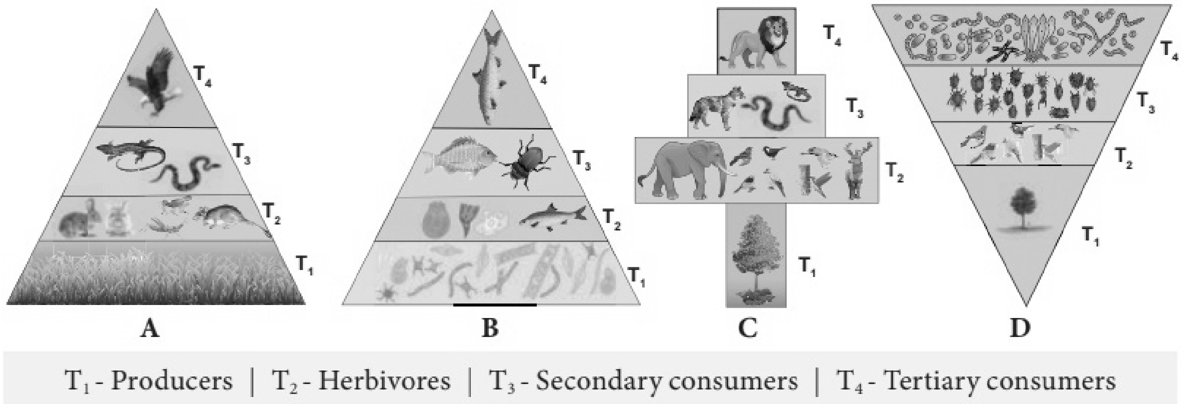


Fig: Pyramid of numbers (individuals per unit area) in different types of ecosystems. Upright - A. Grassland Ecosystem; B. Pond ecosystem – Spindle shaped; C. Forest ecosystem - Inverted; D. Parasite ecosystem

- ✍ Pyramid of numbers, though upright in most cases, like a pond or a grassland but may not be so always.
- ✍ In some cases it may be inverted, *i.e.,* the number of the organisms at each successive trophic level is higher than that in preceeding one and the size decreases gradually at each successive level; *e.g.,* a large-sized tree (producer) may support and provide nourishment to several birds (herbivores).
- ✍ The number of ectoparasites like mites, ticks, lices, -bugs etc., dependent upon birds for nourishment is much larger than birds.
- ✍ The number thus increases at each successive level.
- ✍ The pyramid of number may become spindle-shaped for a tree as herbivorous birds are usually eaten by eagle or falcon.
- ✍ The number of eagles is much less than that of birds feeding upon tree.
- ✍ The number of organisms thus increases at lower trophic levels and finally decreases at higher trophic levels.

(ii) Pyramid of biomass :

- ✍ Biomass is the amount of living matter (expressed as weight) at any particular trophic level at a given time.
- ✍ Pyramid of biomass in terrestrial ecosystems is usually upright
- ✍ For upright pyramid, total biomass of plants (producers) in a specific area is more than that of herbivores (primary consumers) and it gradually decreases at each successive trophic level.
- ✍ It is least in top carnivores. It is upright for tree and grassland ecosystems.

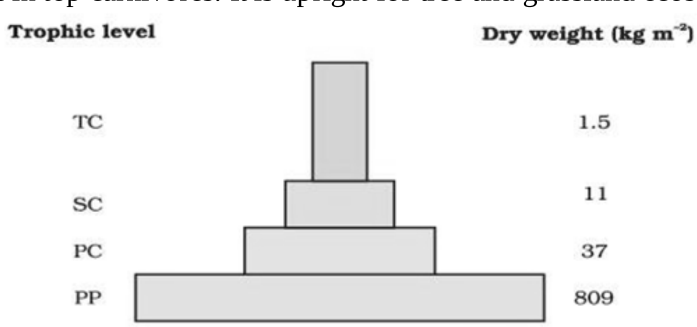


Fig. : Pyramid of biomass. *Showing a sharp decrease in biomass at higher trophic levels*

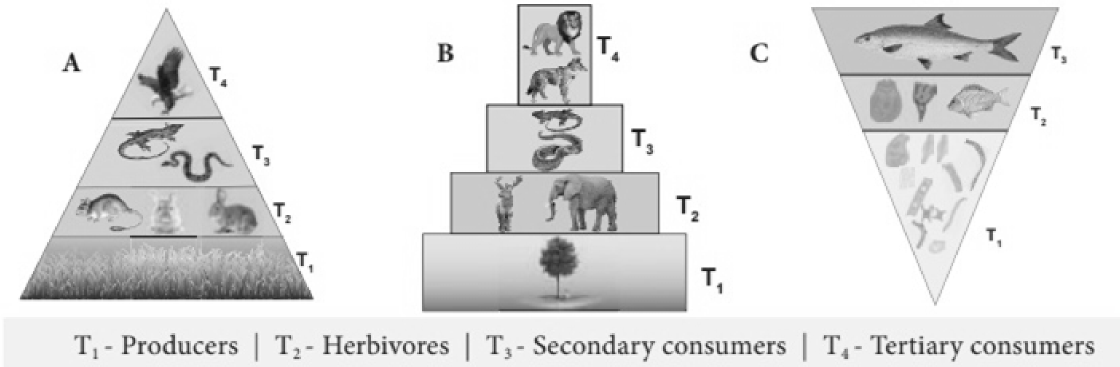


Fig: Pyramid of biomass (dry weight per unit area) in different types of ecosystems. Upright – A. Grassland ecosystem; B. Forest ecosystem; Inverted – C. Pond ecosystem

- ✍ **In aquatic ecosystem,** the pyramid of biomass may be inverted, *e.g.*, biomass of zooplanktons is higher than that of phytoplanktons as life span of former is longer and the latter multiply much faster though having shorter life span.
- ✍ A number of generations of phytoplanktons may thus be consumed by single generation of zooplanktons.
- ✍ Biomass of fish may still be larger as fish are larger in size with longer life span and a number of generations of zooplanktons can be consumed by fishes.
- ✍ However during transfer, only 10% of the biomass of one generation is passed on to next trophic level.

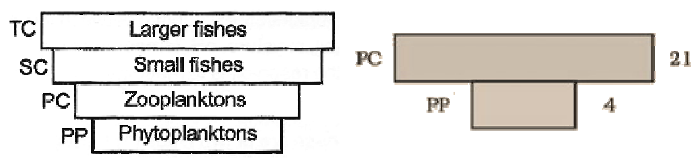


Fig. : Inverted pyramid of biomass – small standing crop of phytoplankton supports large standing crop of zooplankton. (in Pond Ecosystem)

(iii) Pyramid of energy:

- ✍ The pyramid of energy is **always upright** because the flow of energy is **unidirectional** from producer to consumer level.
- ✍ The energy content is maximum in producers.
- ✍ The energy decreases at each trophic level of food chain, as part of the energy is lost as heat and major part of energy is liberated during respiration for use in various activities.
- ✍ Only 10% of the energy of previous trophic level is received by next trophic level, as proposed by **10 per cent law of Lindeman** (1942).
- ✍ Just to illustrate 1,000 calories of solar energy is needed to produce 10 calories of energy stored in a plant (if plants trap 1 % solar energy).
- ✍ Herbivores, feeding upon plant, will retain 1 cal of available stored energy and carnivores feeding upon them will gain only 0.1 cal of usable energy

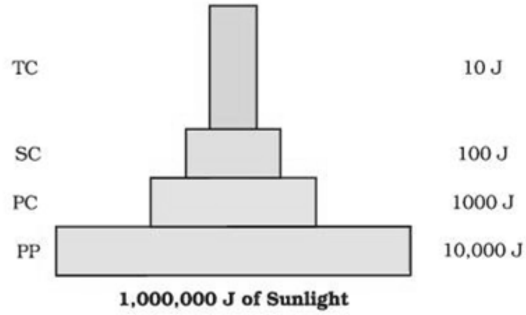


Fig. : An ideal pyramid of energy. *Observe that primary producers convert only 1 % of the energy in the sunlight available to them into NPP*

Limitations of ecological pyramid

(i) It does not take into account the same species belonging to 2 or more trophic levels, *e.g.*, insectivorous plants.

(ii) It assumes a simple food chain and does not accommodate a food web.

(iii) Saprophytes, decomposers, microbes and detrivores are not given any place in ecological pyramids.

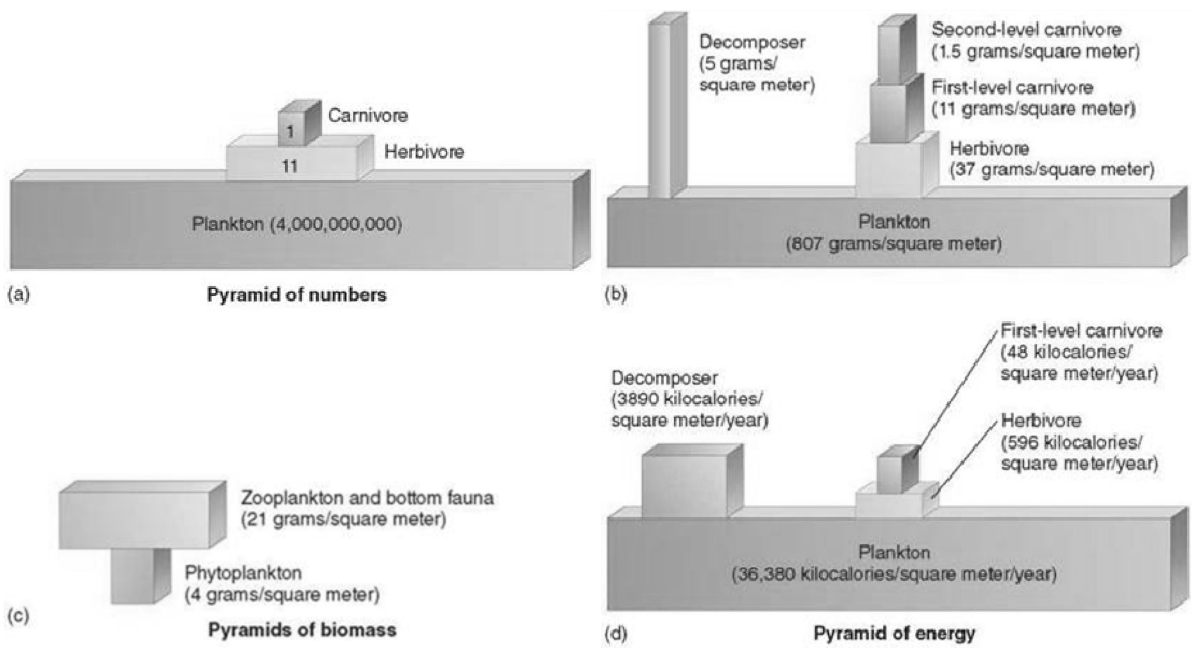


Fig. Ecological pyramids.

Ecological pyramids measure different characteristics of each trophic level. (a) Pyramid of numbers. Pyramids of biomass, both normal (b) and inverted (c). (d) Pyramid of energy. In the above aquatic examples, the producers are plankton.

NOTE ON BIOMASS:

(i) Standing crop . Total amount of living organic matter present in particular area in particular time in an ecosystem is known as standing crop. It may be expressed in terms of weight per unit area. Biomass is the standing crop expressed in terms of weight (i.e. organism mass). Biomass is measured by bombcalorimeter.

(ii) Standing quality or Standing state . Total amount of inorganic substances such as P, S, N, H present in particular area at a particular time in an ecosystem is known as standing state.

Note : The pyramids of biomass show the standing crop of ecosystem

- ✍ The essential elements or inorganic substances are provided by earth and are required by organisms for their body building and metabolism, so they are called **biogenetic nutrients** or **bio-geochemicals**.
- ✍ All the three subdivisions of the earth contribute these elements as such or in the form of compounds.
- ✍ However, as the earth is a closed system for matter, the supply of biogenetic nutrients is finite or limited.
- ✍ It is estimated that amount of living matter (made up of biogenetic nutrients) contained in all the past and present organisms is several times more than the total mass of earth.
- ✍ This is possible only if biogenetic nutrients do not remain locked up in the body of organisms but are released, during excretion and after death, back into the nonliving world so that they can be used again and again.
- ✍ Circulation or exchange of biogenetic nutrients between the living and the nonliving components is called **cycling of matter** or **biogeochemical cycling** (at global scale).
- ✍ However, the whole of biogenetic nutrients are not always in circulation.
- ✍ The nutrients occur in two states-reservoir pool and cycling pool.
  - (i) Reservoir pool is the reservoir of biogenetic nutrients from which they are very slowly transferred to the cycling pool, *e.g.*, metal phosphates, nitrogen gas of the atmosphere.
  - (ii) Cycling Pool is the pool of biogenetic nutrients which are repeatedly exchanged between the biotic and abiotic components of the biosphere
- ✍ Environmental factors, *e.g.*, soil, moisture, pH, temperature etc. regulate the rate of release of nutrients into the atmosphere.
- ✍ The function of the reservoir is to meet with the deficit which occurs due to imbalance in the rate of influx and efflux.

Bio-geochemical cycles: These are of two types (1) Gaseous cycle (2) Sedimentary cycle

1. In **gaseous cycles**, materials involved in circulation are gases. Four most abundant elements present in living organisms, *i.e.*, C(CO_2), H (water vapours), O and N have predominantly gaseous cycles. The main reservoir pool for gaseous cycles is atmosphere or hydrosphere (water). Gaseous cycles are quick and are relatively perfect systems as the elements remain in circulation more or less uniformly.
2. In sedimentary cycles, biogenetic materials involved in circulation are non-gaseous. The reservoir pool for these cycles is lithosphere, *e.g.*, phosphorus, calcium, sulphur. Recycling of sulphur involves both gaseous and sedimentary phase (mixed type). Sedimentary cycles are very slow and are less perfect systems as the elements may get locked and go out of circulation for longer duration .

Different biogeochemical cycles are discussed below:

1. THE CARBON CYCLE:

- ✓ Carbon is constituent of almost all organic compounds of the cell such as carbohydrates, proteins, lipids, enzymes, nucleic acids, hormones, etc., and thus may be considered basis of life.
- ✓ Carbon constitutes 49% of dry weight of organisms and is next only to water.
- ✓ Infact, 71 % of total global carbon is found dissolved in oceans.
- ✓ This oceanic reservoir regulates the amount of CO_2 in atmosphere.
- ✓ According to an estimate 4×10^{13} kg of carbon is fixed in the biosphere through

photosynthesis annually.

- ✓ Carbon in the atmosphere is present as CO_2, in hydrosphere as dissolved CO_2 or carbonic acid or bicarbonates and in lithosphere as fossil fuels or carbonates and graphite in rocks.
- ✓ Carbon present in lithosphere is not readily available, as it becomes available to the living world only when it is either burnt or changed chemically.
- ✓ There is however, regular exchange of carbon between atmosphere and hydrosphere and is readily available to the living world in the form of free or dissolved carbon dioxide.
- ✓ Carbon passes into living components mainly during photosynthesis in the form of CO_2 by autotrophs, but atmosphere and hydrosphere do not get depleted of their carbon content because of its return through two major processes: (i) Biological-respiration by living organisms and decomposition of organic matter. (ii) Non-biological-combustion of carbon containing fuel that releases CO_2 in the atmosphere.
- ✓ Human activities have significantly influenced the carbon cycle
- ✓ Rapid deforestation and massive burning of fossil fuel for energy and transport have significantly increased the rate of release of CO_2 into the atmosphere.

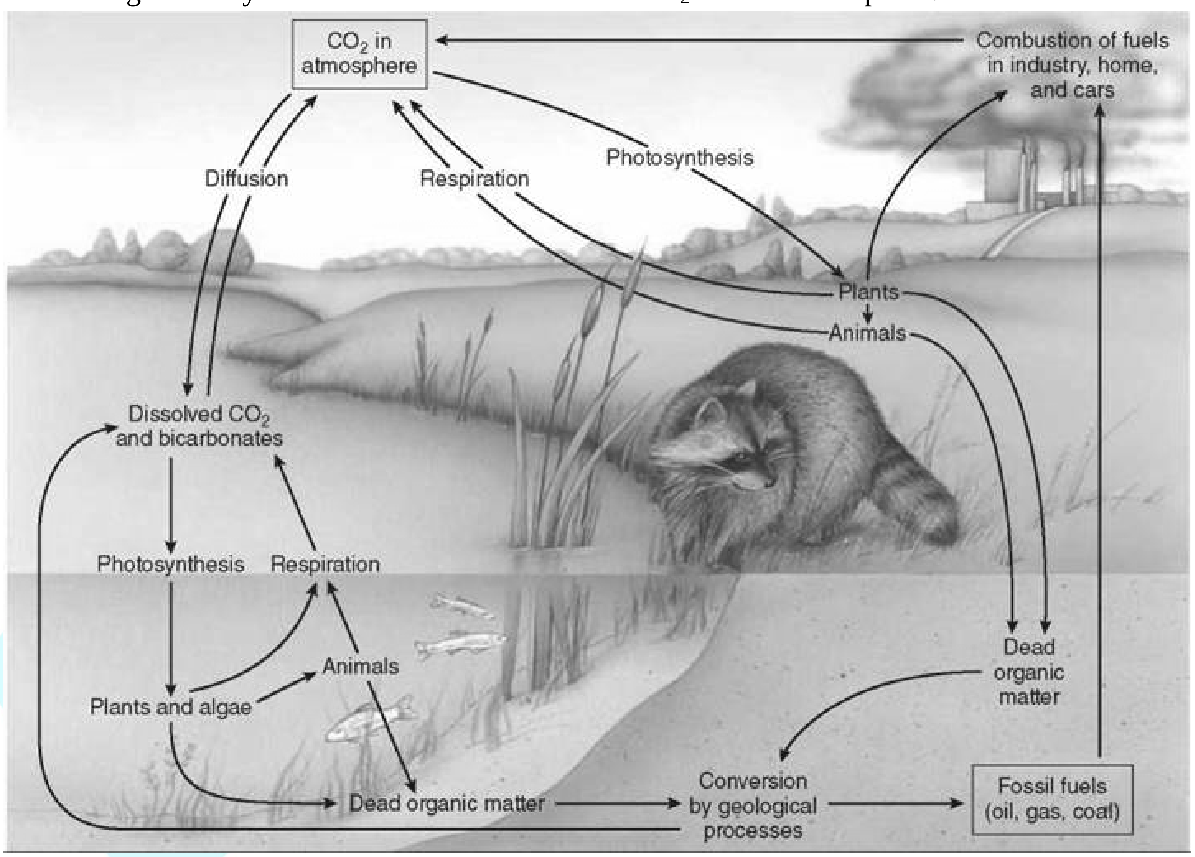


Fig. The carbon cycle.

Carbon from the atmosphere and from water is fixed by photosynthetic organisms and returned through respiration, combustion, and erosion.

2. THE OXYGEN CYCLE :

- ✓ Oxygen is constituent of important biomolecules in the cell and is also required for respiration in aerobes.

- ✓ It is present in natural gaseous form (molecular O_2) in atmosphere and constitutes about 21% of the air. In combined form it is component of CO_2, water and number of oxidised salts.
- ✓ Terrestrial organisms take oxygen directly from the air and aquatic organisms take oxygen either from water present in it, in diffused or dissolved state or directly from the atmosphere to be used in respiration.
- ✓ It is returned to the atmosphere in the form of CO_2 and H_2O.

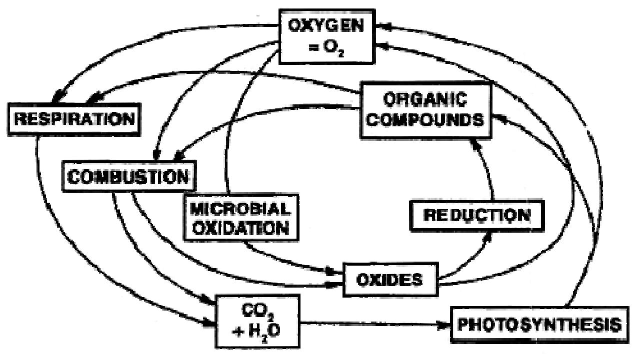


Fig. : Oxygen cycle

- ✓ Carbon dioxide and water produced during respiration are used by plants during photosynthesis and molecular oxygen is released into the atmosphere for reuse in respiration
- ✓ The oxygen in the atmosphere thus remains in state of natural dynamic equilibrium.
- ✓ Oxygen is also added to the atmosphere in terms of carbon dioxide, water, sulphur dioxide, nitrogen oxides, etc., during burning or combustion of wood, coal, petroleum, natural gases.
- ✓ Oxides are also produced during microbial oxidation. Chemical or biological oxidation of oxides releases molecular oxygen.

3. THE NITROGEN CYCLE :

- ✓ Nitrogen is component of amino acids, proteins, enzymes, nucleic acids and nucleotides, which are essential structural and functional components of living organisms.
- ✓ Main source of nitrogen is air, as about 3/5 of the total air is molecular nitrogen (N_2).
- ✓ Sufficient required amount of nitrites and nitrates are made available to the plants through a number of processes involving microorganisms either from air or from organic nitrogen locked up in dead remains of living organisms.

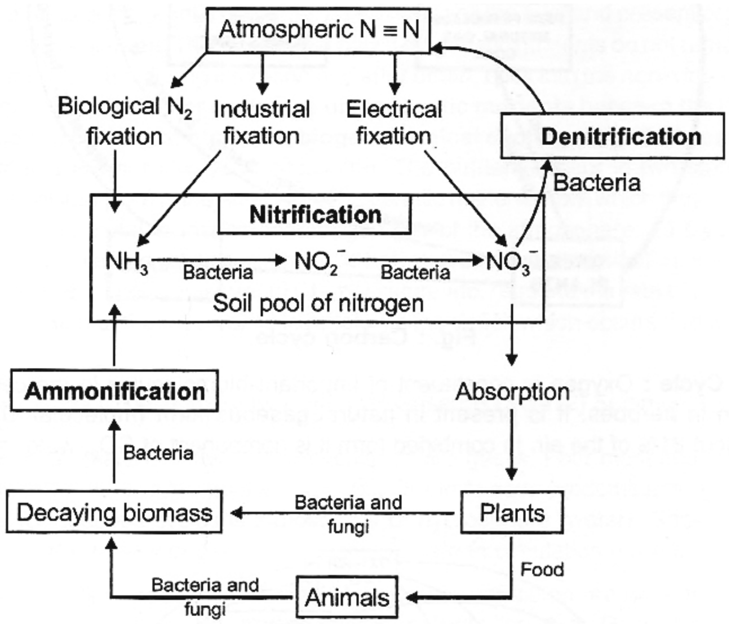


Fig. Nitrogen Cycle

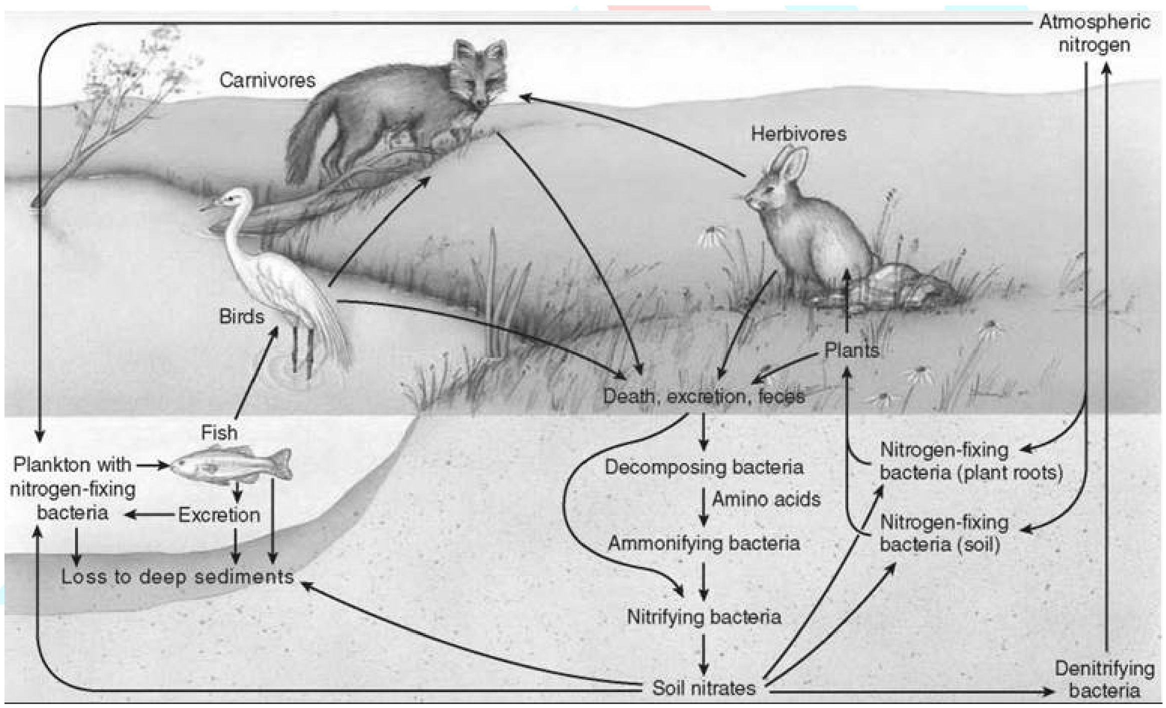


Fig. The nitrogen cycle.

Relatively few kinds of organisms—all of them bacteria—can convert atmospheric nitrogen into forms that can be used for biological processes.

(a) **Nitrogen fixation.** The conversion of molecular nitrogen into nitrogenous compounds like ammonium salts or oxides of nitrogen is termed nitrogen fixation, which is of three types:

(i) Biological nitrogen fixation

(ii) Atmospheric nitrogen fixation

(iii) Industrial nitrogen fixation

(b) *Decay and decomposition of dead remains of living organisms and of their excretory products.*

- ✓ Plants mainly absorb nitrogen in the form of nitrate ions which are reduced to NH_3 in plant cells.
- ✓ NH_3 is used up in synthesis of amino acids
- ✓ Animals synthesize proteins and other nitrogenous compounds from amino acids obtained through digestion of plant proteins.
- ✓ During protein metabolism, a number of nitrogenous waste products like ammonia, urea and uric acid are produced which are excreted and nitrogen present in them is recycled.
- ✓ A bulk of organic nitrogen remains locked up in plants and animals.
- ✓ The nitrogen present in dead remains of plants and animals in the form of organic compounds is converted into amino acids by a number of saprophytic micro-organisms.
- ✓ Anaerobic breakdown of proteins is termed putrefaction.
- ✓ Amino acids are converted into ammonium salts by **ammonifying bacteria** *(Bacillus* sp.) and some fungi.
- ✓ Some ammonium salts are directly absorbed by plants.
- ✓ However, most of these are converted into nitrites by nitrifying bacteria as plants prefer absorption of these in comparison to ammonium salts.
- ✓ Ammonium salts are converted into nitrites by *Nitrosomonas* and *Nitrococcus* and nitrites are converted into nitrates by *Nitrobacter, Nitrocystis* and *Penicillium* species.
- ✓ Some nitrates and nitrites in the soil are lost through leaching and precipitation and become constituent of rocks, going out of cycle.
- ✓ This nitrogen is slowly released for recycling in nature after an interval of millions of years during weathering of these rocks only when these get exposed.
- ✓ Some nitrogen present in nitrates is released to the atmosphere as molecular nitrogen by certain denitrifying bacteria *(e.g., Thiobacillus denitrificans, Pseudomonas aeruginosa)* in water logged soils or other areas having anaerobic environment.
- ✓ These utilize O_2 of the nitrates for their requirement and thus N_2 is released in molecular form and escapes in the atmosphere in gaseous state.

4. The Water Cycle:

- ✓ Water is the only substance on the surface of earth that exists in all the three states of matter.
- ✓ Water is essential for photosynthesis and above all O_2 of the atmosphere is derived from photolysis of water during photosynthesis, which is absolutely essential for the existence of animal life.
- ✓ Water or hydrological cycle is made up of two overlapping cycles-the larger global cycle, not involving living organisms and the smaller local or biological water cycle, involving exchange between environment and living organisms.
  - **(i) Global water cycle.** Water is continuously lost from oceans, lakes, rivers and moist soil through evaporation. Clouds are formed by cooling and condensation of water vapours. The clouds move along the land over long distances, get cooled and precipitate as rain, snow or hail. Rain water may directly fall into ocean and may return to the atmosphere again through evaporation.

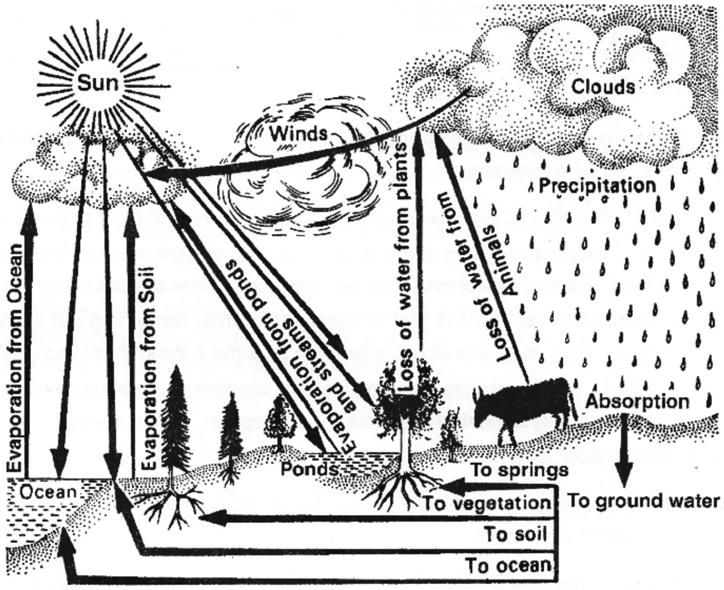


Fig. : The Water Cycle

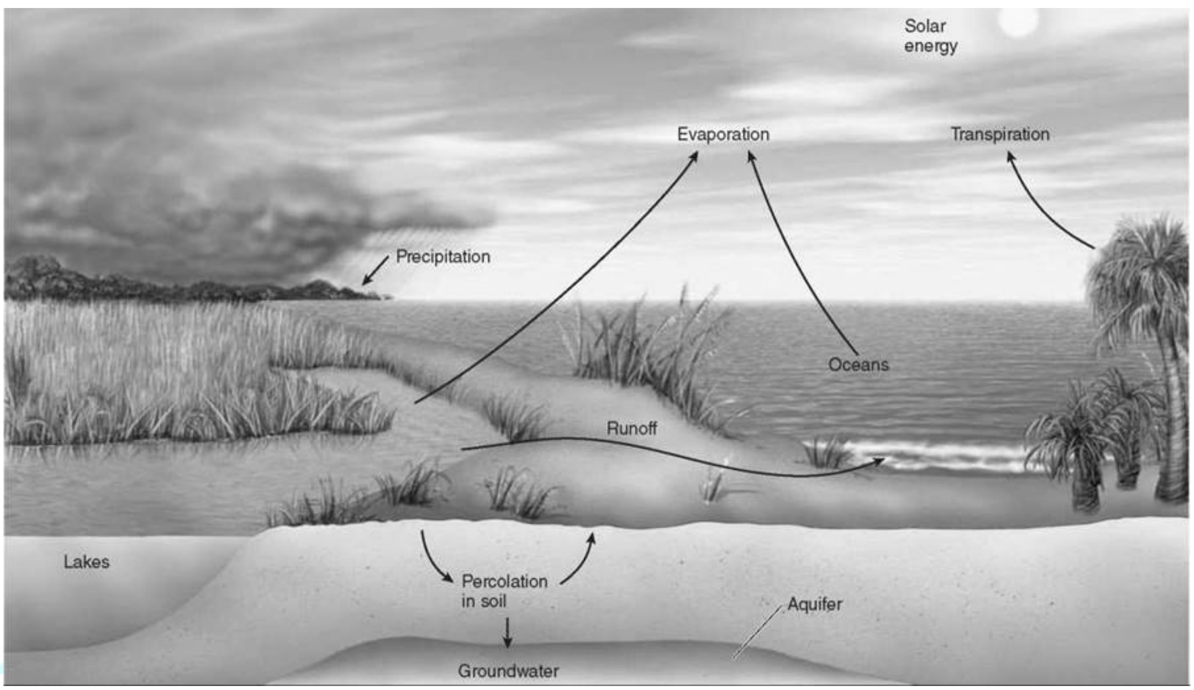


Fig. The water cycle.

Precipitation on land eventually makes its way to the ocean via groundwater, lakes, and finally, rivers. Solar energy causes evaporation, adding water to the atmosphere. Plants give off excess water through transpiration, also adding water to the atmosphere. Atmospheric water falls as rain or snow over land and oceans, completing the water cycle.

(ii) **Local or biological cycle.** It involves the entry of water into living organisms and its return to the atmosphere.

5. Phosphorus cycle :

✓ Phosphorus has a natural reservoir in rocks as phosphates.

- ✓ Atmospheric inputs of phosphorus through rainfall are much smaller than carbon inputs and gaseous exchange of phosphorus between organisms and environment are negligible.
- ✓ Phosphorus present in insoluble form in soil is converted into soluble form by chemicals secretions of microorganisms and plant roots.
- ✓ Dissolved phosphate is absorbed by plants and is used to built organic compounds like phospholipids, nucleotides, nucleic acids, etc.
- ✓ Phosphorus moves from plants to animals of different trophic levels in ecosystem through food chains.
- ✓ The phosphorus present in plants and animals (organic form) is returned to the soil (inorganic form) through decomposition of excreta of animals and dead remains of plants and animals by micro-organisms; to be reused by plants.
- ✓ The phosphorus present in bones and teeth of animals is resistent to decay and thus remain out of the cycle for a long time.
- ✓ Some amount of phosphorus washed down into sea, entering the food chain of aquatic ecosystem comes back to the soil.
- ✓ Phosphorus in sea water is absorbed by sea weeds and finally passes into fish and seabirds through food chains.
- ✓ Phosphorus rich faeces (**guano**) are deposited on land by sea-birds.
- ✓ However, significant amount of phosphorus is lost in deep sediments, remaining out of the cycle for a long time
- ✓ Some sulphates seep into the soil and others reach ponds and lakes or carried by rivers to sea.

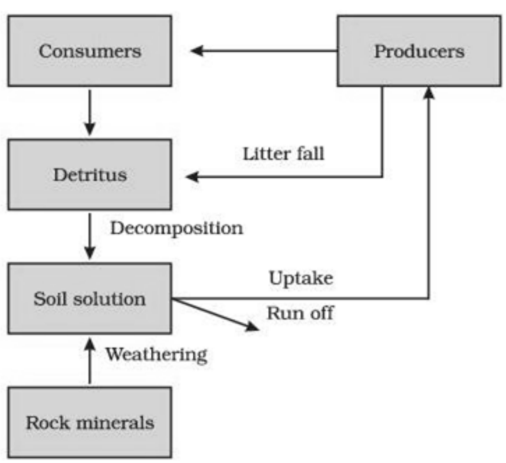


Fig: A simplified model of phosphorous cycling in a terrestrial ecosystem

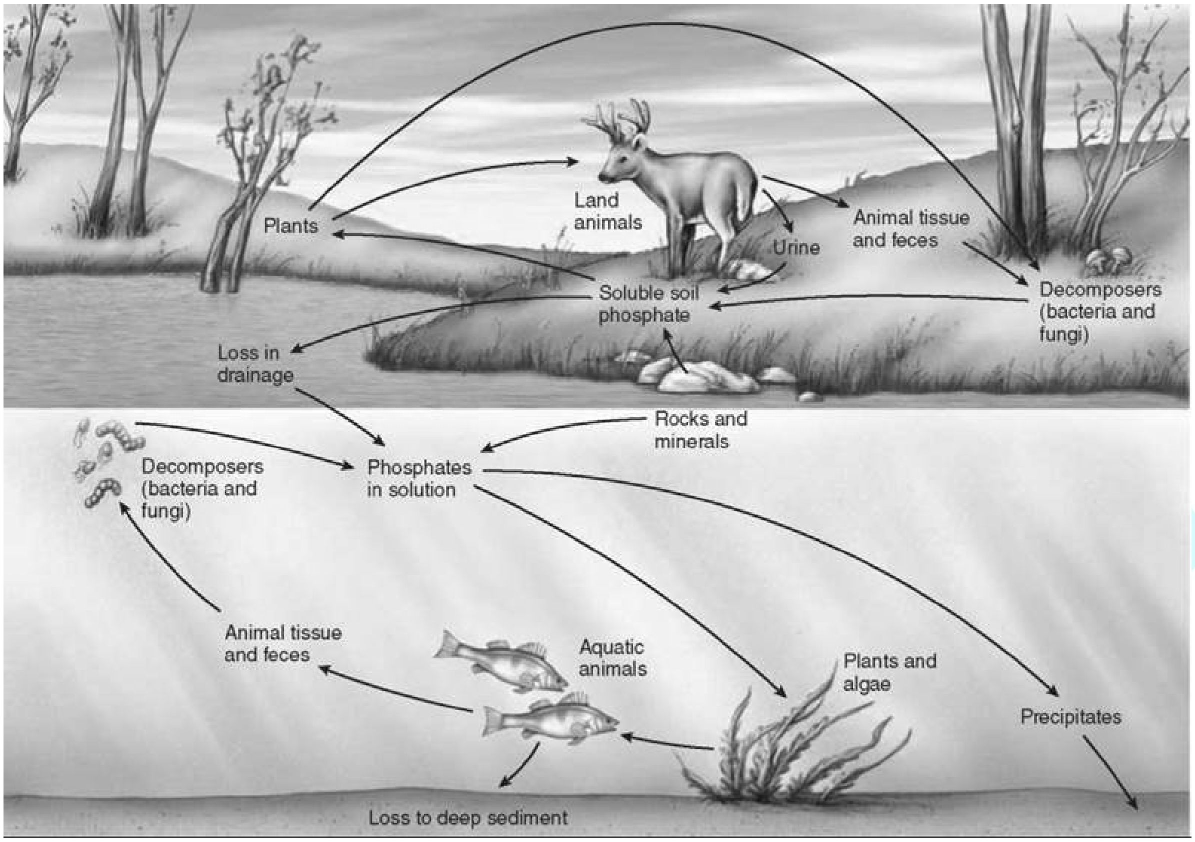


Fig. The phosphorus cycle.

Phosphorus plays a critical role in plant nutrition; next to nitrogen, phosphorus is the element most likely to be so scarce that it limits plant growth.

- ✓ It becomes available when deep sea strata is brought to surface through mining or some natural disturbances.
- ✓ Some phosphate in soil combines with metals like aluminium, calcium and iron to form their insoluble salts which are not readily available to plants for absorption.
- ✓ It thus appears that phosphorus is being lost from the available pool faster than it is returned to it.

Difference between Carbon and Phosporus cycle

1. Atmospheric inputs of phosphorus through rainfall are much smaller than carbon.
2. Gaseous exchanges of phosphorus between organism and environment are negligible.

6. Sulphur cycle:

- ✓ Main source of sulphur to the plants are sulphates and to some extent elemental sulphur present in soil, water and rocks.
- ✓ Sulphur absorbed from soil is incorporated into amino acids and subsequently into proteins by plants.
- ✓ Organic sulphur is transferred to animals of different trophic levels through food chains.
- ✓ Some animals may get sulphur from water as well.
- ✓ Organic sulphur present in dead remains of plants and animals and animal excreta is converted into sulphates during decomposition by bacteria and fungi under aerobic conditions which are added to the soil and water for reuse by plants.
- ✓ SO_2 is also released into atmosphere through combustion of fossil fuels.
- ✓ It gets dissolved in water to form H_2SO_4 during rainfall which combines with certain metals in soil to form sulphates.

- ✓ Some bacteria *(e.g., Beggiatoa)* and fungi convert H_2S and element sulphur into sulphates which are recycled through plants in the biosphere.
- ✓ Rocks may also be erroded by wind and the materials including sulphur are blown into air as dust.
- ✓ These materials are transferred to soil during rain.
- ✓ Sulphates are also added to the soil and air by volcanic erruptions.
- ✓ Sulphates from the rocks are also brought to the soil by rain water running over them.
- ✓ Some sulphates seep into the soil and others reach ponds and lakes or carried by rivers to sea.
- ✓ In sea, it may get deposited in sedimentary rocks and move out of the cycle.
- ✓ It may get back into cycle through food chains or geological disturbances

15 ECOSYSTEM SERVICES

- ✓ The products of ecosystem processes *e.g.* healthy forest ecosystems purify air and water, mitigate droughts and floods, cycle nutrients, generate fertile soils, provide wildlife habitat, maintain biodiversity, pollinate crops, provide storage site for carbon and also provide aesthetic, cultural and spiritual values.
- ✓ Researchers like **Robert Constanza** *et. al.*, have put an average price tag of US $ 33 trillion a year on these fundamental ecological services (i.e. nearly twice the value of a global GNP -US $ 18 trillion).
- ✓ Out of total cost, soil formation accounts for about 50%, recreation and nutrient cycling less than 10% each, climate regulation and habitat for wildlife are about 6% each.

✍ Healthy ecosystems are the base for a wide range of economic, environmental and aesthetic goods and services.

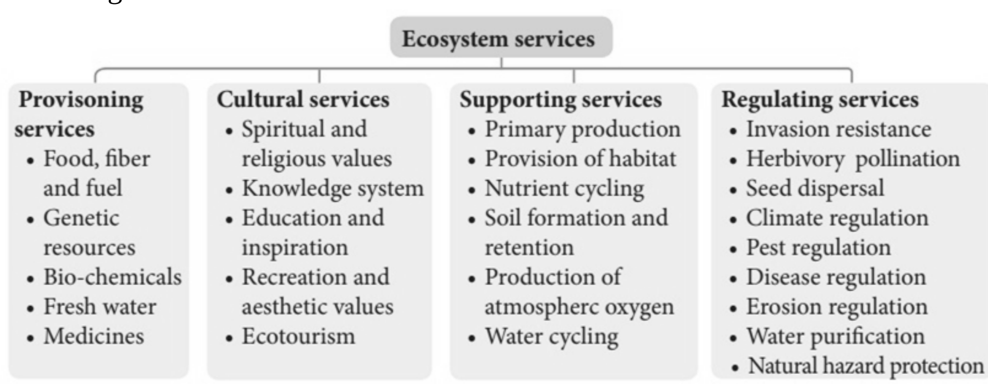


Fig: Types of Ecosystem services

✍ The products of ecosystem processes are named as Ecosystem services, for example, healthy forest ecosystems purify air and water, mitigate (minimise) droughts and floods, cycle nutrients, generate fertile soils, provide wildlife habitat, maintain biodiversity, pollinate crops, provide storage site for carbon and also provide aesthetic, cultural and spiritual values. Though value of such services of biodiversity is difficult to determine, it seems reasonable to think that biodiversity should carry a hefty (bulk) price tag.

✍ Robert Constanza and his colleagues have very recently tried to put price tags on nature's life-support services. Reserchers have put an average price tag of US $ 33 trillion a year on these fundamental ecosystems services, which are largely taken for granted because they are free. This is nearly twice the value of the global gross national product GNP which is (US $ 18 trillion)

✍ Out of the total cost of various ecosystem services, the soil formation accounts for about 50 percent, and contributions of other services like recreation and nutrient cycling, are less than 10 percent each. The cost of climate regulation and habitat for wildlife are about 6 percent each

16 ENVIRONMENTAL ISSUES (POLLUTION)

Fig: Environmental issues

- ✓ "Any undesirable change in physical, chemical or biological characteristic of air, water and land which is harmful
- ✓ to the man directly or indirectly through his animals, plants, industrial units or raw materials is called pollution".
- ✓ Pollutants :- "Any material or act on the part of man, or nature which leads to pollution is called pollutants."

USUALLY POLLUTANTS ARE DIVIDED INTO FOLLOWING CATEGORIES

1. Non-biodegradable pollutants :- Many of such pollutants are usually not degraded or degraded partially in environment. Such as aluminium packs, Mercury compounds, Iron, Compounds of phenols, Glass, D.D.T. benzene, BHC pesticides, etc.

- They are collected in the environment and cause pollution. These pollutants are harmful even in low concentration and harm increases with their increasing concentration. No treatment is found in the nature for their recycling.
- There are two methods by which we can stop the pollution caused by pollutants
  - (i) Such type of substances should be banned by law,
  - (ii) Use their alternative substances.

2. Biodegradable pollutants . If much of domestic sewage papers, woods, garbage, live stock wastes, etc. Are easily degraded completely by microorganisms, it becomes useful. But if these materials enter the environment in such large quantities, that they can not be degraded completely then addition of these materials causes pollution in environment.

a) ***Primary pollutants .*** These persist in the form in which they are added to the environment. e.g. DDT, CO etc.

b) ***Secondary pollutants .*** These are formed by chemical reaction among primary pollutants e.g. Photochemical smog, London smog, PAN, O3 etc.

c) **Synergism .** Formation of secondary pollutants is known as synergism. secondary pollutants are more toxic than primary pollutants.

d) ***Quantitative pollutants :-*** These are the substances which occur in nature but become pollutant when their concentration reaches beyond a threshold value in the environment e.g. CO2, Nitrogen Oxide etc.

e) ***Qualitative pollutants .*** These are the substances which do not occur in the environment but are passed in through human activity. e.g. fungicides, herbicides, D.D.T., etc.

Other type of pollution :

i. ***Natural pollution .*** Caused by natural sources like, CH4 from paddy fields and cattle, marsh, forest fire.

ii. ***Anthropogenic pollution .*** Caused by human activities.

iii. ***Negative pollution .*** Loss of soil productivity. e.g., Overgrazing, Soil erosion. Removal or absence of desirable substances at right place which results in loss of soil productivity.

iv. ***Positive pollution .*** Presence or addition of undesirable substances at wrong place which results in reduction of soil fertility e.g. more use of fertilizer, Land filling by wastes

17 DIFFERENT KINDS OF POLLUTION: AIR POLLUTION

- ✍ The air pollution is caused due to addition of unwanted substances or gases. The atmospheric pollution is mainly caused by the activities of man and concentrated to the inhabited and the industrial complexes in cities.
- ✍ There are two main categories of air pollutants Gases (ii) Particulates
- ✍ Gases : The gaseous materials include various gases and vapours of volatile substances or the compound with a boiling point below 2000C.

MAJOR AIR POLLUTANTS AND THEIR EFFECTS

1. Carbon monoxide (CO) .

- **Source .** It is the main air pollutant released from smoke of automobile and burning of fossil fuels (Petrol, diesel, coal)
- **Effect .** Carbon monoxide is highly toxic gas, it combines with haemoglobin of the blood and blocks the transportation of oxygen. Thus, it impairs respiration and it cuases death due to asphyxiation when inhaled in large amount.

2. Unburnt Hydrocarbons . (3,4 Benzopyrine, Benzene)

- **Source .** These are mainly released from automobiles and burning of fossil fuel (petrol, diesel, coal). Methane (CH_4) is the most abundant hydrocarbon in atmosphere and its main source is marshy area and paddy field.
- **Effect .** Hydrocarbons causes lung cancer.

3. Ethylene .

- **Source .** Ethylene released in air during fruits ripening.
- **Effect .** Falling of leaves without particular reason, falling of flowering bud before time.

4. Nitrogen oxide . (NO, NO_2)

- **Source .** Burning (combustion) of fossil fuel in automobiles.
- **Effect .** These nitrogen oxide form photochemical smog in atmosphere and release ozone. Nitrogen oxide also responsible for acid rain. Entry of these nitrogen oxide causes respiratory trouble such as emphysema, bronchitis, swelling of lungs and lung cancer etc.

5. Sulphur oxide . (SO_2 , SO_3)

- **Source .** Main source of sulphur oxides are coal burning, smelters, oil refineries.
- **Effect .** Lichen and mosses do not grow in SO_2 polluted areas. Lichen and mosses are indicator of SO_2 pollution. Sulphur oxides causes chlorophyll destruction. Taj Mahal also get affected.

6. Smoke . (SO_2, SO_3, NO_2, NO, CO, CO_2)

SECONDARY POLLUTANTS

A. Smog (Smoke + Fog) .

- This word was given by Desvoeux. Smog/Smoke is measured by Ringlmann method.
- **Smog is two types:** Los Angeles Smog or Photo Chemical smog .
- It was first observed in Los Angeles. In this process smoke, fog, nitrogenoxide, hydrocarbons, oxygen, UV light and high temperature are essential. These components react with each other and form reddish brown smog (PAN + O3 + Nitrogen oxides) or brown haze/brown air. Los angles smog is light induced smog.
- **Effect .**
- Photochemical smog causes irritation in eyes and harms the lungs. Due to smog elastic substances (rubber/tyers) also affected.
- Ozone causes harm to mucous membrane.
- During smog peroxyacetyl nitrate (PAN) is formed. PAN stops or inhibits the photolysis of water in hill reaction of photosynthesis and affect or inhibit the photosystem -II. PAN also inhibit the chlorophyll formation in plants.
- **London smog or sulphur smog .**
- It was first observed in London. In this process coal, smoke, fog, sulphur oxide and low temperature are essential. These components react with each other and form vapour (fog) of H2SO4 which is known as
- **London smog.**

  Effect . Due to inhalation of H2SO4 vapour with fog 4000 people died in London in 1952.

B. Acid rain .

- This word was given by Robert August. NO2 and SO2 released from different sources in form of smoke and dissolved in atmospheric water vapour to form acid (H2SO4 + HNO3). These acids come down on earth with rain water this is called acid rain.

  (a) Wet deposition :- If acid comes down on earth with rain, fog and smog, it is known as wet deposition.

  (b) Dry depositon :- If acid settled on earth surface through solid dust particles with nitrate or sulphate, this is called dry deposition.

Memories

NOTE

- The pH of acid rain is lesser than < 5.6
- In acid rain the ratio of H2SO4 and HNO3 is 7 : 3 (70% H_2SO_4 + 30% HNO_3)
- **Effects .**

  (1) Due to acid rain acidity of soil and water increases.

  (2) Acid rain also causes damages historical monuments. e.g. Taj Mahal, Red Fort

CONTROL OF AIR POLLUTION

(1) Control of particulate matter . Two devices are use to remove particulate air pollutants

(a) Arresters (b) Scrubbers

(a) ARRESTERS : These are used to separate particulate matters from contaminated air.

Arresters are of different types :

(i) ***Cyclonic separators and Trajectory separators :-*** These are commonly used to separate out particulate matters from industrial emissions with minimum moisture content. These separators work on the principle of dust separation by centrifugal force.

(ii) ***Electrostatic precipitator :-*** It is the most efficient device to remove fine particulate pollutants. Electrostatic precipitation device work on the principle of electrical charging of the dust particles and collecting it on a differently charged platform. There are several ways of removing particulate matter; the most widely used of which is the electrostatic precipitator, which can remove over 99 per cent particulate matter present in the exhaust from a thermal power plant. It has electrode wires that are maintained at several thousand volts, which produce a corona that releases electrons. These electrons attach to dust particles giving them a net negative charge. The collecting plates attract the charged dust particles. The velocity of air between the plates must be low enough to allow the dust to fall.

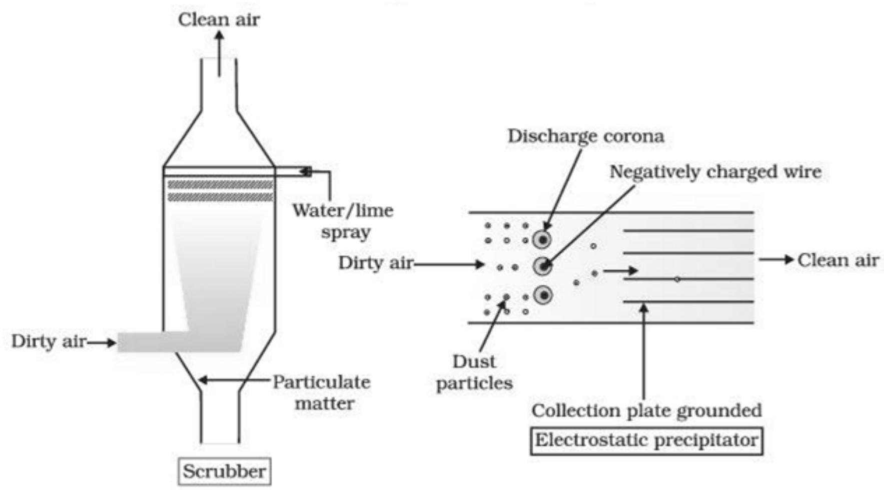


Fig: Electrostatic precipitator

(b) ***SCRUBBERS :*** A scruber can remove gases like sulphurdioxide. In a scrubber, the exhaust is passed through a spray of water or lime.

(2) Control of Gaseous pollutants . Combustion, absorption and adsorption technique are used to control gaseous pollutants.

(a) ***Combustion .*** In combustion process, oxidisable gaseous pollutants are completely burnt at a high temperature. Petrochemical, fertilizer, paints and varnish industries used combustion control of gaseous pollutants.

(b) ***Absorption :-*** In this technique, gaseous pollutants are absorbed in suitable (liquid) absorbent materials.

(c) ***Adsorption :-*** This technique is applied to control toxic gases, vapours and inflammable compounds that could not be efficiently removed or transferred by a fore said technique. Such air pollutants are adsorbed on large solid surface

18 GREEN HOUSE EFFECT

- ✓ Usually carbon dioxide is not considered as pollutant, but its higher concentration forms a thick layer above the earth's surface, checks the radiation of the heat from the earth surface. Because of this, temperature of the earth's surface increases, this is called "green-house effect" or global warming.

- ✓ Main green house gases are CO_2, CH_4, CFC, N_2O, excluding this SO_2, O_3, water vapour are also released from industries and NO_2 released from agriculture which are responsible to increase the green house effect.
- ✓ In this phenomenon cover of CO_2 layer around the earth, allow the short wavelength incoming solar radiation to come in but does not allow the long wavelength of out going heat radiation from warm surface of earth and surface keep the earth warm. The consequent increase in the global mean temperature is referred to as global warming.

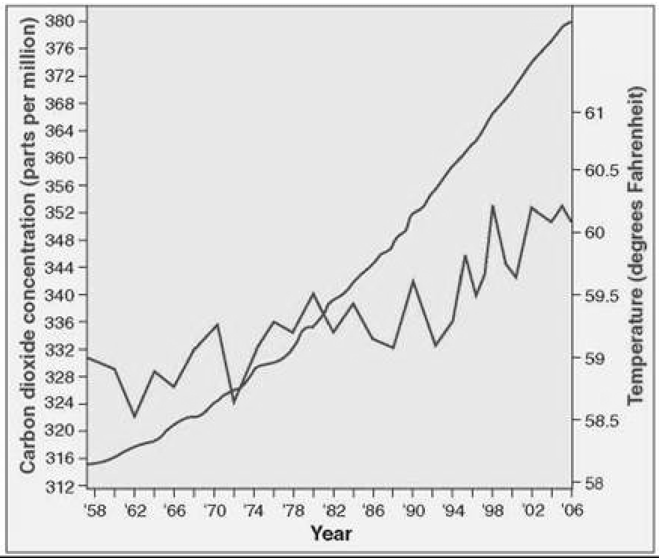


Fig. The greenhouse effect.

The concentration of carbon dioxide in the atmosphere has shown a steady increase for many years (blue line). The red line shows the average global temperature for the same period of time. Note the general increase in temperature since the 1950s and, specifically, the sharp rise beginning in the 1980s. Data from the National Center for Atmospheric Research and other sources.

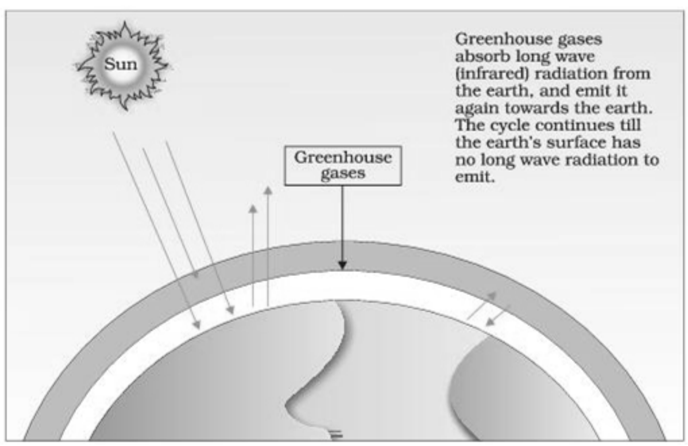


Fig: Sunlight energy at the outermost atmosphere

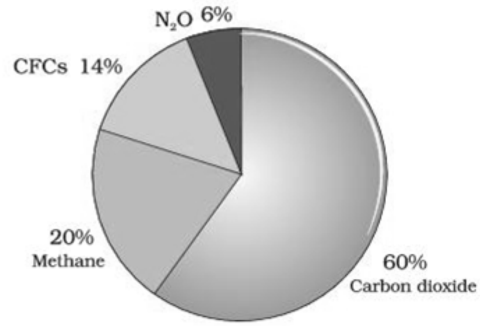


Fig: Relative contribution of various greenhouse gases to total global warming

19 OZONE DEPLETION

- ✓ Ozone is present in less quantity in atmosphere. But at the height of 16 km to 25 km on earth, concentration of ozone is maximum in stratosphere.
- ✓ At normal temperature and pressure thickness of ozone layer is 3 mm. (But at poles thickness of ozone layer is 4 mm).
- ✓ Ozone hole was first discovered in 1985 over Antarctica by Nimbus-7 satelite.
- ✓ Due to depletion of ozone layer harmful UV radiations are penetrating to the earth which causes skin cancer (Melanoma) and also acts as strong mutagens. UV radiation of wavelengths shorter than UVB, are almost completely absorbed by Earth.s atmosphere, given that the ozone layer is intact. But
- ✓ UV-B damages DNA and mutation may occur. It causes ageing of skin, damage to skin cells and various types of skin cancers. In human eye, cornea absorbs UV-B radiation, and a high dose of
- ✓ UV-B causes inflammation of cornea, called snow-blindness, cataract, etc. Such exposure may permanently damage the cornea. UV radiation causes a disease, xeroderma pigmentosum.
- ✓ The aerosols like C.F.C. (Chloro flouro carbon) release into the atmosphere from the refrigerators air conditioners and jet planes deplete or reduce the ozone layer. This is called ozone depletion and these substances are called O.D.S. (ozone depleting substances). This thin layer ozone is also known as ozone holes.

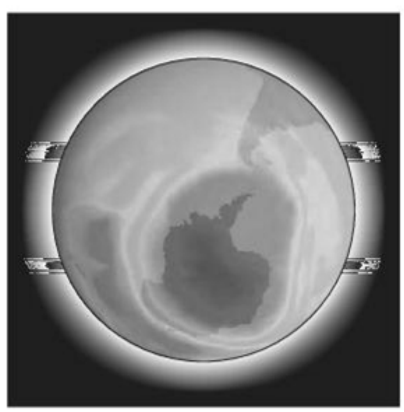


Fig: Ozone hole in the area above Antarctica

20 DIFFERENT KINDS OF POLLUTION: WATER POLLUTION

- The water pollution is caused by the addition of organic and inorganic chemicals as well as the biological materials which change the physical and chemical properties of water. This harmful process is called water pollution.
- The water pollution is caused by many sources such as sewage matter, industrial wastage, agricultural wastage, domestic wastage, hot water of thermal plant and nuclear reactors etc.
- Domestic sewage primarily contains biodegradable organic matter.
- Water hyacinth (Eichhornia crassipes), the world's most problematic aquatic weed, also called 'Terror of Bengal'.
- Unlike domestic sewage, waste water from industries like petroleum, paper manufacturing, metal extraction and processing, chemical manufacturing, etc., often contain toxic substance, notably heavy metals (defined as elements woth density > 5 g/cm3 such as mercury, cadmium, copper, lead, etc.) and a variety of organic compounds.
- Water having DO content below 8.0 mgL.1 may be considered as contaminated and below 4.0 mgL.1heavily polluted.
- DO is measured by oximeter.

1. Biochemical Oxygen Demand (BOD) :

- The water pollution by organic wastes is measured in terms of Biochemical oxygen demand. It is the amount of dissolved oxygen (DO = Dissolved Oxygen) needed by bacteria in decomposing the organic wastes present in water.
- BOD increased = water polluted
- BOD µ input of organic wastes
- If B. O. D. is increased dissolved oxygen is decreased in water. Higher amount of organic waste increase the rate of decomposition in water. O2 is rapidly consumed by microbes, thereby causing drop in DO content in water.
- Note :
  Daphnia is the indicator of BOD

2. Chemical Oxygen Demand (COD) :

- COD is the oxygen requirement by chemical K2Cr2O7 for oxidation of total organic matter (biodegradable + non-biodegradable) in water.
- Note : COD value is always higher than BOD value.

3. Biological magnification :-

- Water Phytoplankton ZP Small fish Large fish Fish eating birds
- (DDT = 0.003 ppb) (0.003 ppm) (0.04 ppm) (0.5 ppm) (2 ppm) (25 ppm)
- The non biodegradable pollutant like Al, Hg, Fe, DDT, pesticides, phenolic compound ABS (Alkyl benzene sulphonate) are not decomposed by micro-organisms.
- They get accumulated in tissue in increasing concentration along the food chain is called biological magnification. The highest concentration occurs in top consumer.
  Eg. (i) The concentration of DDT is increased at successive trophic levels; say if it starts at 0.003 ppb (ppb = parts per billion) in water, it can ultimately can reach 25 ppm (ppm = part per million) in fish-eating birds, through biomagnification.
- Note : High concentration of DDT distrub calcium metabolism in birds, which causes thinning of egg shell and their permature breaking, eventually causing decline in bird populations.
- Fish-eating birds: (DDT 25 ppm)
- Large fish: (DDT 2 ppm)
- Small fish: (DDT 0.5 ppm)

- Zooplankton: (DDT 0.04 ppm)
- Water: (DDT 0.003 ppb)

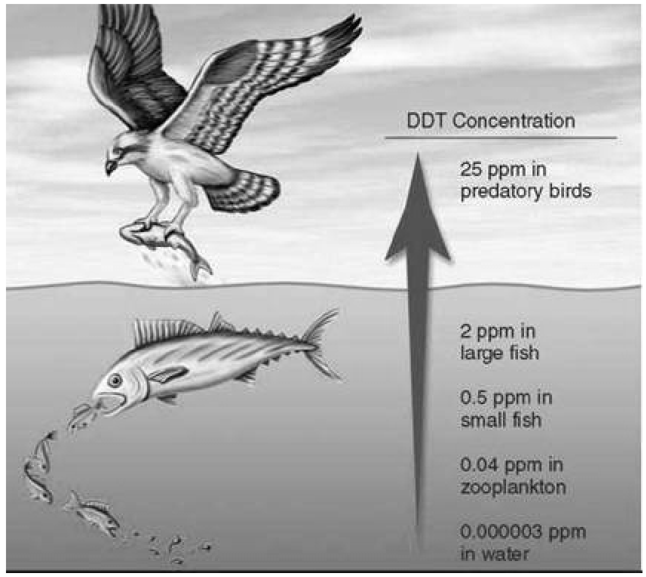


Fig. Biological magnification of DDT.
Because DDT accumulates in animal fat, the compound becomes increasingly concentrated in higher levels of the food chain.

BIOMAGNIFICATION

Because energy transformations are only ~10% efficient, higher trophic levels must consume more prey to meet energy needs

If a pollutant is ingested by living organisms, it will become concentrated at higher trophic levels as they eat more exposed prey

- The increase of a substance (such as a pollutant) in a particular organisms is called **bioaccumulation**
- The increase in the concentration of a substance at a particular trophic level is called **biomagnification**

Bioaccumulation refers to how pollutants enter a food chain, whereas *biomagnification* refers to the tendency of pollutants to concentrate as they move from one trophic level to the next

Because pollutants become concentrated by biomagnification, higher trophic levels are more susceptible to their toxic effects

- The pesticide DDT caused egg-shell thinning and population declines in species of birds that fed on exposed insects
- Heavy metals (like mercury) released into waterways via industrial processes may become concentrated in fish.
- Minamata disease is cause in humans in Japan by biomagnifications of mercury (Hg)

4. Eutrophication :-

- The process of nutrient enrichment of water and consequent loss of species diversity (or death of aquatic animals) is referred to as eutrophication and lake is known as eutrophic lake. In this process presence of nutrients in lake stimulates growth of algae (algal bloom) increase organic loading and bring about reduction in the oxygen content of water causing death of aquatic animals.
- Eutrophication can be caused by the following man made source :-
  (i) House hold detergents, (ii) Industrial waste, (iii) Sewage

- ***Sewage :***

Sewage contains highest amount of carbonic materials and biological material, as pollutants. These carbonic materials increase the number of decomposers like bacteria and fungus. The acceleration of microbial activity increases BOD of water.

- BOD is very less in pure water. The higher BOD is the indication of water pollution and the water of polluted reservoir can not be utilized and very bad smell spreads around the locality. The infections or infectious diseases also takes place.

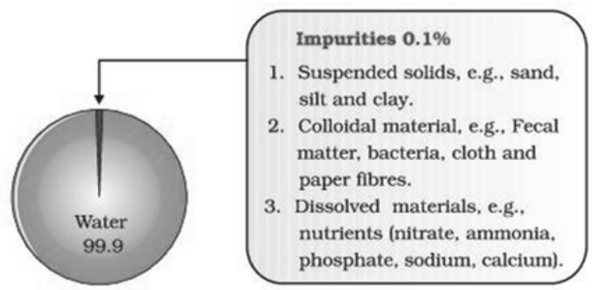


Fig: Composition of waste water

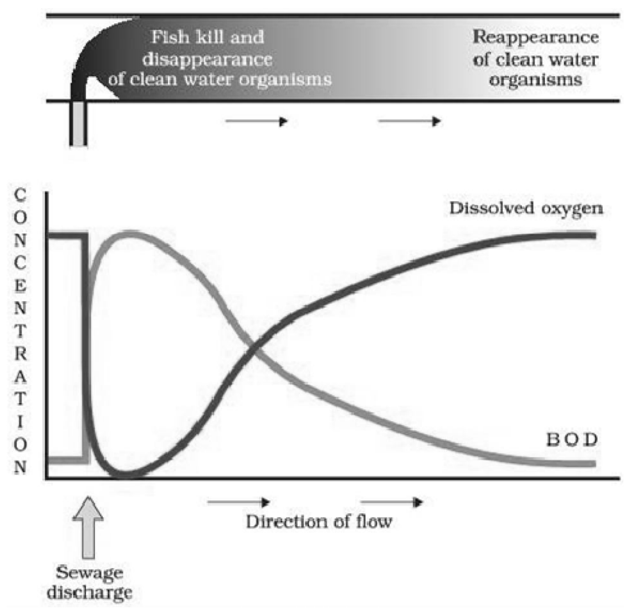


Fig: Effect of sewage discharge on some important characteristics of a river

- Eutrophication is the natural aging of a lake by biological enrichment of its water. Natural aging of a lake may span thousands of years and lake finally converted into land due to deposition of silt. Pollutants from man's activities like effluents from the industries and homes can radically accelerate the aging process, this phenomenon is called accelerated eutrophication or cultural eutophication.

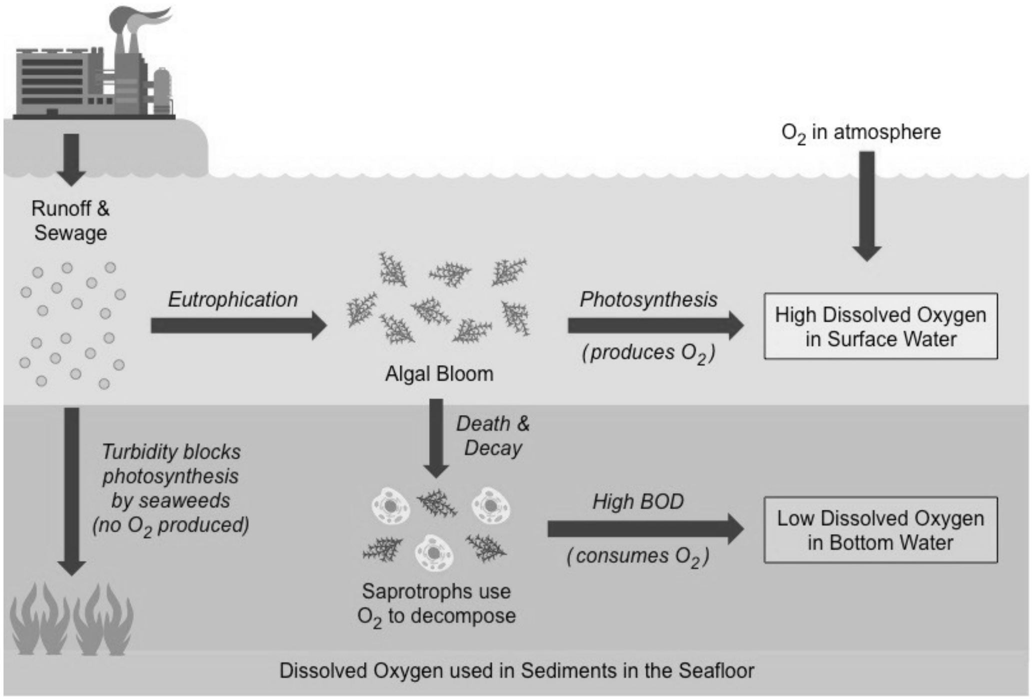


Fig: Eutrophication

Types of Lakes .

(i) Eutrophic lake . They are shallow water lakes which contain high amount of organic materials and nutrients. They have little O2 because decomposers rapidly use it up. Chironomous larva are commonly present in it. e.g. Dal lake of Kashmir

(ii) Oligotrophic lakes . These are deep lakes which have less amount of organic materials and nutrient.

Plastics are a type of synthetic polymer found in certain types of clothes, bottles, bags, food wrappings and containers

- Most plastics are **not** biodegradable and persist in the environment for many centuries (bioremediation is not effective)

Large visible plastic debris (> 1 mm) is defined as **macroplastic**, while smaller debris (< 1 mm) is defined as **microplastic**

- Macroplastic debris can be degraded and broken down into microplastic debris by UV radiation and the action of waves
- Ocean currents will concentrate plastic debris in large oceanic convergence zones called *gyres*

Plastic debris will leach chemicals into the water and also absorb toxic contaminants called persistent organic pollutants

- Microplastics will absorb more persistent organic pollutants (POPs) due to their smaller size (more available surface area)
- Both macroplastic and microplastic debris is ingested by marine animals, which mistake the debris for food
- This leads to the bioaccumulation and biomagnification of persistent organic pollutants within marine animals
- It may also damage the stomach of animals or cause them to stop feeding (by taking up space in the digestive tract)

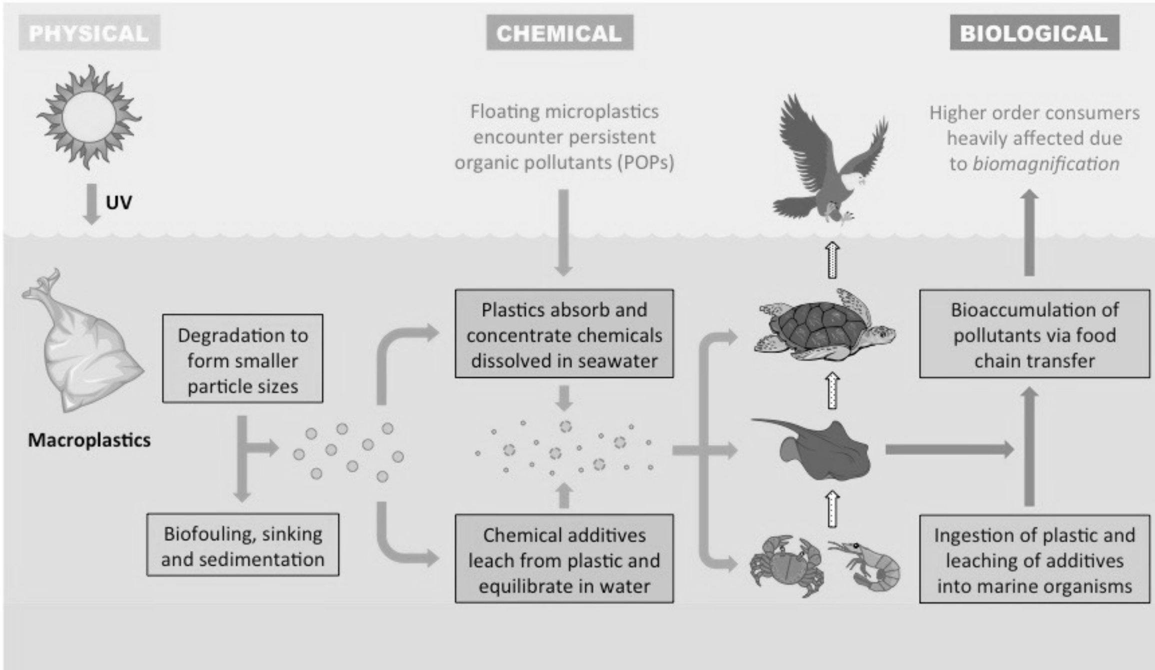


Fig: Plastic Pollution in Marine Environments

SEWAGE TREATMENT

- ***Primary treatment :*** These treatment steps basically involve physical removal of particles-large and small from the sewage through filtration and sedimentation. These are removed in stages; initially, floating debris is removed by sequential filtration. Then the grit (soil and small pebbles) are removed by sedimentation. All solids that settle, form the primary sludge, and the supernatant forms the effluent or primary effluent. The primary effluent from the primary settling tank is taken for secondary treatment.
- ***Secondary treatment or biological treatment :*** The primary effluent is passed into large aeration tanks where it is constantly agitated (mix) mechanically and air is pumped into it. This allows vigorous growth of useful aerobic microbes into flocs (masses of bacteria associated with fungal filaments to form mesh like structures). While growing, these microbes consume the major part of the organic matter in the primary effluent.

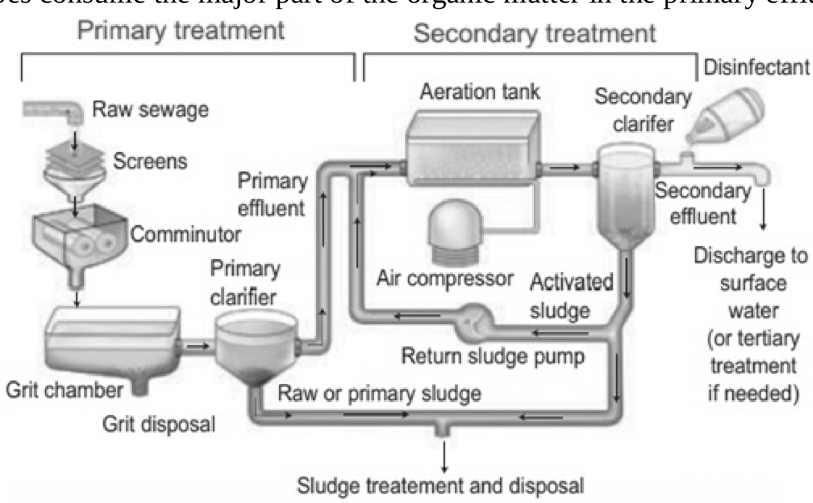


Fig: Sewage treatment plant process flow diagram polluting

-
- Increase in the noise in the atmosphere is called noise pollution or sound pollution. Noise is a loud and unwanted or unpleasant sound. The common things which are responsible for noise pollution are – industries and mills, means of transportation, television stereo, loud speaker and jet plant etc.
- ***Intensity :-*** The intensity of sound is measured in bel or decibel [1 bel = 10 decibel]. Normally at 25 decibel, the atmosphere may be peaceful. Above 80 decibel intensity of sound is called noise pollution

22 SOME OTHER DIFFERENT KINDS OF POLLUTION

SOLID WASTES

- ✓ Solid wastes refer to everything that goes out in trash. Municipal solid wastes are wastes from homes, offices, stores, schools, hospitals, etc., that are collected and disposed by the municipality. The municipal solid wastes generally comprise paper, food wastes, plastics, glass, metals, ruber, leather, textile, etc. Burning reduces the volume of the wastes, although it is generally not burnt to completion and open dumps often serve as the breeding ground for rats and flies. Sanitary landfills were adopted as the substitute for open-burning dumps.
- ✓ In a sanitary landfill, wastes are dumped in a depression or trench after compaction, and covered with dirt everyday.
- ✓ Landfills are also not really much of a solution since the amount of garbage generation specially in the metros has increased so much that these sites are getting filled too. Also there is danger of seepage of chemicals, etc, from these landfills polluting the underground water resources

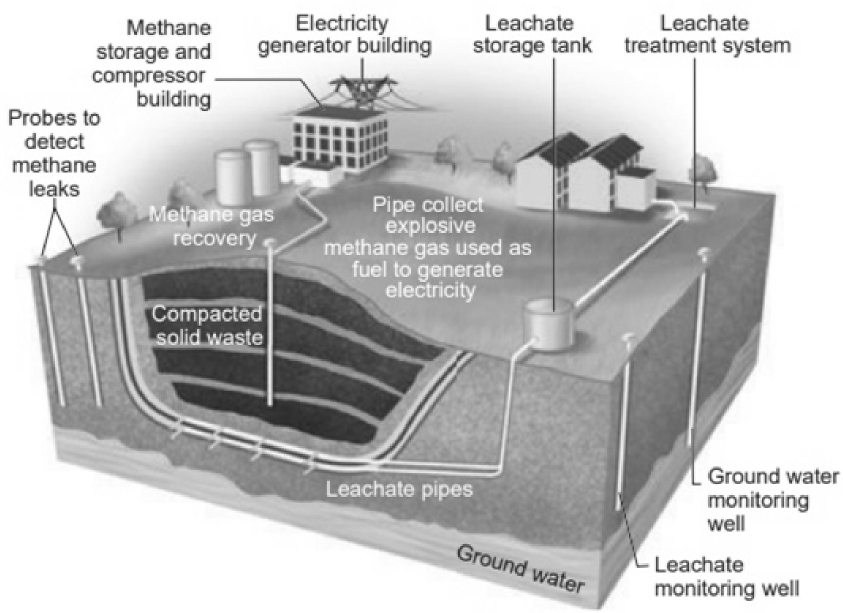


Fig: Sanitary landfill

RADIOACTIVE POLLUTION

The various sources of radioactive materials as follows

(1) Natural sources :- Cosmic rays, radiation from the earth such as Radium - 224, Uranium 235, Uranium 238, Thorium 232, Radon 222.

(2) Man-made Radiation :- The radiations are released in the atmosphere during mining and purification of Thorium and Plutonium, and in producing nuclear weapons etc. Nuclear reactor and nuclear fuel causes pollution by radioactive radiation. The nuclear fuel and coolants are the sources of radioactive radiation. Radioactive waste is also most important radioactive pollutants because these wastes are not dumped at particular or right place.

(3) Other sources :- Some of the radioactive elements (isotops) are used in experimental laboratories for scientific researches which causes radio active pollution. X-rays are also proved to have harmful effects.

- ✓ The first is accidental leakage of radiation occurred in the Three Mile Island and Chernobyl.
- ✓ It has been recommended that storage of nuclear waste, after sufficient per-treatment, should be done in suitably shielded containers buried within the rocks, about 500 m deep below the earth's surface.

ENVIRONMENT LAW FOR CONTROLLING POLLUTION

1. The National Environment (Protection) Act (NEPA) 1986 :- This act clearly brings the protection of water and soil quality, and the control environmental pollutants.

2. The insecticide Act, 1968 :- This act deals with the regulation of import, manufacture, sale, transport, distribution and use of insecticides with a view of preventing risk to human health and other organisms.

3. The water (Prevention and control of pollution) Act, 1974 :- This act deals with the preservation of water quality and the control of water pollution with a concern for the detrimental effects of water pollutants on human health.

4. The air (Prevention and control of Pollution) Act, 1981 :- This act deals with the preservation of air quality and the control of air pollution with a concern for the detrimental effects of air pollutants on human health and also on the biological world

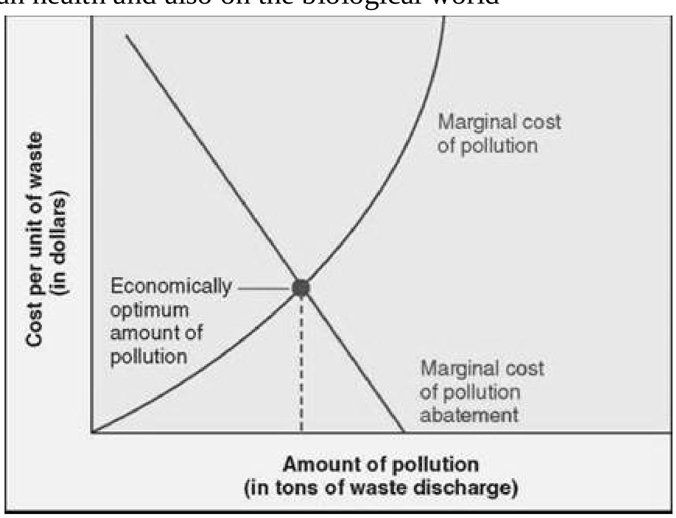


Fig. Is there an optimum amount of pollution?

Economists identify the "optimum" amount of pollution as the point at which eliminating the next unit of pollution (the marginal cost of pollution abatement) equals the cost in damages caused by that unit of pollution (the marginal cost of pollution).