



Unit 1: Environmental Biology

1.1 Introduction

1.2 Abiotic factors

1.3 Biotic factors

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Eugene P. Odum (1969)

study of interrelationship between organisms and their environment.

- Biotic (living) and
- Abiotic (nonliving) = physical & chemical

Ecology plays an important role in

agriculture,

forestry,

pest control,

fishery biology

conservation of soil, wildlife...etc.

- ecology has been contributing to policies of the world

Ecological Spectrum

Plants + animals + their environment studied at **4 levels of organization** = **the ecological spectrum**.

- 1. Populations** - individuals of one particular species in a given area
- 2. Communities (Biocoenoses)** - all types of organisms in a given area
- 3. Ecosystem (Biogeocoenoses or Ecological complexes)** - the communities & the abiotic environment in a given area
- 4. Biosphere (Ecosphere)** - comprises all the life supporting regions of the earth.

the atmosphere + the lithosphere + the hydrosphere

- three divisions of the biosphere = **biocycles**.

Subdivisions of Ecology

1. Based on taxonomic affinities –

a) Plant ecology & b) Animal ecology

- specialized fields like ecology of pines, insect ecology, avian ecology, bacterial ecology...etc.

2. Based on habitat –

c) habitat ecology

- study of habitats & their effects upon the Organisms.

3. Based on levels of organization-

d) **Autecology** - study of the **individual species** in relation to their environment

study of its geographical distribution

taxonomic position

morphological characters

reproduction

life cycle and behaviour

Examples

- temperature and sex of the baby

(life cycle and developmental stages of Lizards, crocodiles or reptiles)

- Darwin's finches of Galapagos Island

- Adaptation of organism to higher altitudes - higher number of RBCs.

e) **Synecology** –

study of the **groups of organisms / species** in relation to their environment

population ecology,

community ecology and

study of the ecosystems.

Example

- Side effects of acid rain to a pond ecosystem.
- Concept of Resource Partitioning - Food, space... etc.

BRANCHES OF ECOLOGY

- Population ecology - the growth, trophic structure, metabolism and regulation of a population.
- Community ecology - ecology of different populations in the same habitat and same environmental conditions.
- Taxonomic ecology - ecology of different taxonomic groups, viz. microbial ecology, mammalian ecology, insect ecology
- Habitat ecology - animals and plants in different habitats viz., freshwater ecology, marine ecology, terrestrial ecology, forest ecology and desert ecology.
- Human ecology - effects of human activities on environment and vice versa.

- Applied ecology - application of ecological concepts to human needs
 - wild life management, biological control, forestry and conservation of natural resources....
- Chemical ecology - chemical affinity or preferences shown by different organisms
- Physiological ecology (ecophysiology) - Physiological adaptation according to ecological conditions
- Palaeo-ecology - environmental conditions and life of the past ages
- Evolutionary ecology - evolutionary problems like speciation and segregation

- Gynaecology (ecological-genetics) - Relationship of environment with genetic variability
- Eco-geography - geographical distribution of plants and animals in different environments (biomes)
- Pedology - soil and its nature viz., acidity, alkalinity, humus contents, mineral contents, soil types.....
- Ethology - animal behaviour under natural conditions
- Sociology - ecology + ethology
- System ecology - structure and function of an ecosystem is analysed using applied mathematics, statistics or computer

Scope of Ecology

1. Survival of humans

Proper application of ecological principles will help us to avert & prevent the dangers

- environmental pollution, population explosion, radiation hazards, radioactive nuclear wastes.....

2. Conservation of natural resources

3. Preservation of forests & wildlife

4. Evolution

5. Genetics

- **Wholphin- a male Whale and a female Bottlenose Dolphin**
- **Zorse or zonkey or zebroid - zebra and a horse or a donkey**
- **Beefalo - an American Buffalo and domestic cattle**
- **The liger -a male lion and a female tiger**
- **Tigon - a female lion and a male tiger**
- **Jaglion - a male jaguar and a female lion**
- **Geep - a sheep and a goat**
- **Dzo - domestic cattle and a yak**

1.2 ABIOTIC FACTORS

TYPES OF ABIOTIC ENVIRONMENTAL FACTORS

1. Climatic factors

- (i) Light
- (ii) Temperature
- (iii) Water (including atmospheric water, rainfall or precipitation, soil moisture)
- (iv) Atmosphere (gases and wind)
- (v) Fire

2. Topographic or physiographic factors

- (i) Altitude
- (ii) Direction of mountain chains and valleys
- (iii) Steepness and exposure of slopes

3. Edaphic factors

(soil formation, physical and chemical properties of soil, nutrients).

Light

- Light - spectrum of electromagnetic radiation
 - UV Rays,
 - **visible light (390-760 nm)**
 - green plants utilize about 0.02%
 - infrared radiation
 - radio waves.
- $6\text{CO}_2 + 12\text{H}_2\text{O} = \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{H}_2\text{O} + 6\text{O}_2$

- Light influences the organism both by its quality and quantity.
- quality of light
 - On land, no much difference
 - In water, varies - effect on the photosynthesis
- Water filter red and blue colours - resultant greenish light (hardly absorbed by the chlorophyll)
- Only red algae (pigment phycoerythrin) - utilize greenish light.

- The **quantity** or the intensity of light
 - optimum level - on rate of photosynthesis
 - only some sun loving plants(corn) exhibit maximum rate of photosynthesis only in full sun light.
- Duration of light - periodic migration of animals (birds).
 - increased day light stimulates gonads development.
 - decreased light regress the gonad.
 - Nocturnal and diurnal activities of animals.

Effect of Light on the Plants

Light influences almost all the aspects of plant life directly or indirectly

viz., plant's structure, form, shape, physiology, growth, reproduction, development, local distribution...etc.

Based on light- plants are classified into

Sciophytes (shade loving or photophobic plants)

Heliophytes (sunlight loving or photophilous plants)

A. Direct effects of light on plants.

- **formation of chlorophyll pigment**
- **number and position of chloroplasts**
- **in photosynthesis**
- **growth hormones**

- **Leaf structure**
- **development of flowers, fruits and seeds**
- **Duration of light-**
 - **Short day** - *Chrysanthemum indicum*, *Canabis sativa* (hemp)...etc.
 - **Long day-** *Alium cepa* (onion), *Beta vulgaris* (beet root), *Daucus carota* (carrot), *Papaver somniferum* (opium poppy), *Vicia faba* (broad bean), *Brassica rapa* (turnip), *Avena sativa* (oat), *Secale cereale* (rye), *Sorghum vulgare* (sorghum)...etc.
 - **Day neutral plants** - *Cucumis sativus* (cucumber), *Gosypium hirsutum* (cotton), *Solanum tuberosum* (potato)...etc.
- **movement in plants**

B. Indirect effects of light on plants

- opening and closing of stomata
- the permeability of plasma membrane
- transpiration
- respiration
 - respiratory rate increases (e.g., Canna, Nerium, Bougainvillea) / respiration rate is decreased slightly in intense light.

Effect of light on animals

- **on protoplasm**
- **on metabolism**
- **on pigmentation**
- **on animal movements**
- **Photoperiodism and biological clocks (Biorhythms)**
- **on reproduction**
- **on development**

Effect of light on animal movements

- **Phototaxis**

+ve - Euglena, Ranatra, Moths...etc.

-ve - planarians, earthworms, slugs, copepods, siphonophores ...etc.

- **Phototropisms (in sessile animals)**

responsive movement of some active animals body part to the light stimulus (flagellum of Euglena, polyps of many coelenterates).

Velocity or Speed of the movement

Photokinesis - non-directional

when responding to light reduce their velocity of movement

Rheokinesis - in linear velocity

Klinokinesis - in the direction of turning.

- **Photoklinokinesis** - only a part of the body deviates away from the source of light (Eg. Larvae of *Musca domestica*).
- **Phototropotaxis** - When animals are confronted with two lights of equal brightness.
- **Telotaxis** - Attraction of males towards the flash of the female.
- **Light compass reaction** or **celestial orientation** – Movement at a constant angle towards the source of light.

- **Celestial orientation**

Utilization of their time sense as an aid to find their way from one area to another.

- use of sun, moon or stars as a compass.

- biological clock and observations on the azimuthal position

fishes, turtles, lizards, birds and invertebrates as ants, bees, wolf spiders, sand hoppers...etc.

Photoperiodism and biological clocks (Biorhythms)

Photoperiodism - The response of different organisms to environmental rhythms of light and darkness.

- **Photoperiod** - Each daily cycle.

Photophase - period of light

Scatophase - period of darkness

Biorhythms - by external environmental stimuli (zeitgebers or entrainers)

- **Circadian**- rhythms matched to 24 hours cycle of light and dark

Crepuscular animals - most active at sunrise and sunset times

Nocturnal animals - active during the night

Diurnal animals - active during the day time

- **Circatidal**- 12.4 or 24.8 hours tide cycle

➤ bivalve molluscs (pearl oysters) increase filtration in high tide

➤ sea anemones increase body expansion and contraction in high tide

- **Circalunar or Circasynodic**- 29 days lunar cycle

➤ marine polychaete Nereis (*Platynereis dumerii*)

➤ breeding season- Heteronereis

➤ during full moon, perform nuptial dance and spawn

- **Circanular**- the yearly seasons
 - most birds peak breeding season- spring
 - Deer mating season - fall
 - hibernate, aestivate or migrate
- The larvae of many insects show two phases every year
 - (i) **active** and (ii) **inactive** or **diapause**
 - e.g., Larvae of pink cotton ball worm, parasitic wasp, flesh fly...etc.
- **Semilunar or Circasyzygic**- 14.7 days time between successive **spring tide** and **neap tide**
 - gastropod mollusc periwinkle, *Littorina rudis* lives in burrow high up on the shore and shows 14.5 day periodicity in its locomotory activity only during spring tides.

Animals recognised based on reproductive activities to day length

a) Day long animals- during summer

Eg. Birds.

b) Short day animals- during winter

Eg. sheep, deer.

c) Indifferent animals- not affected

Eg. Cow, ground squirrel.

Effect of light on reproduction

- many animals light is necessary for the activation of gonads and in initiating annual breeding activities
 - birds

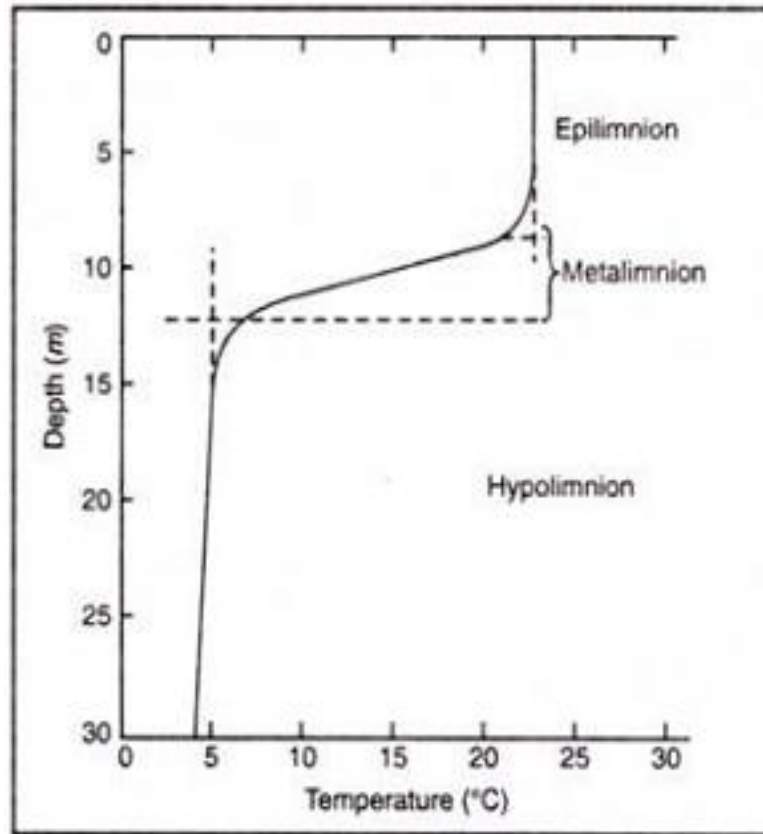
Effect of light on development.

- Light accelerates development
 - e. g., *Salmon* larvae
- Light retards development
 - e. g., *Mytilus* larvae

Temperature

- Biokinetic zone (10°C to 45°C)
- minimum effective temp
 - less- inactive stage - chill coma
- maximum effective temp
 - more- heat coma
- Eurythermal - wide ranges of tolerance of temp
 - eg. amphibians, lizards etc.
- Stenothermal - narrow ranges of tolerance of temp
 - eg. corals.

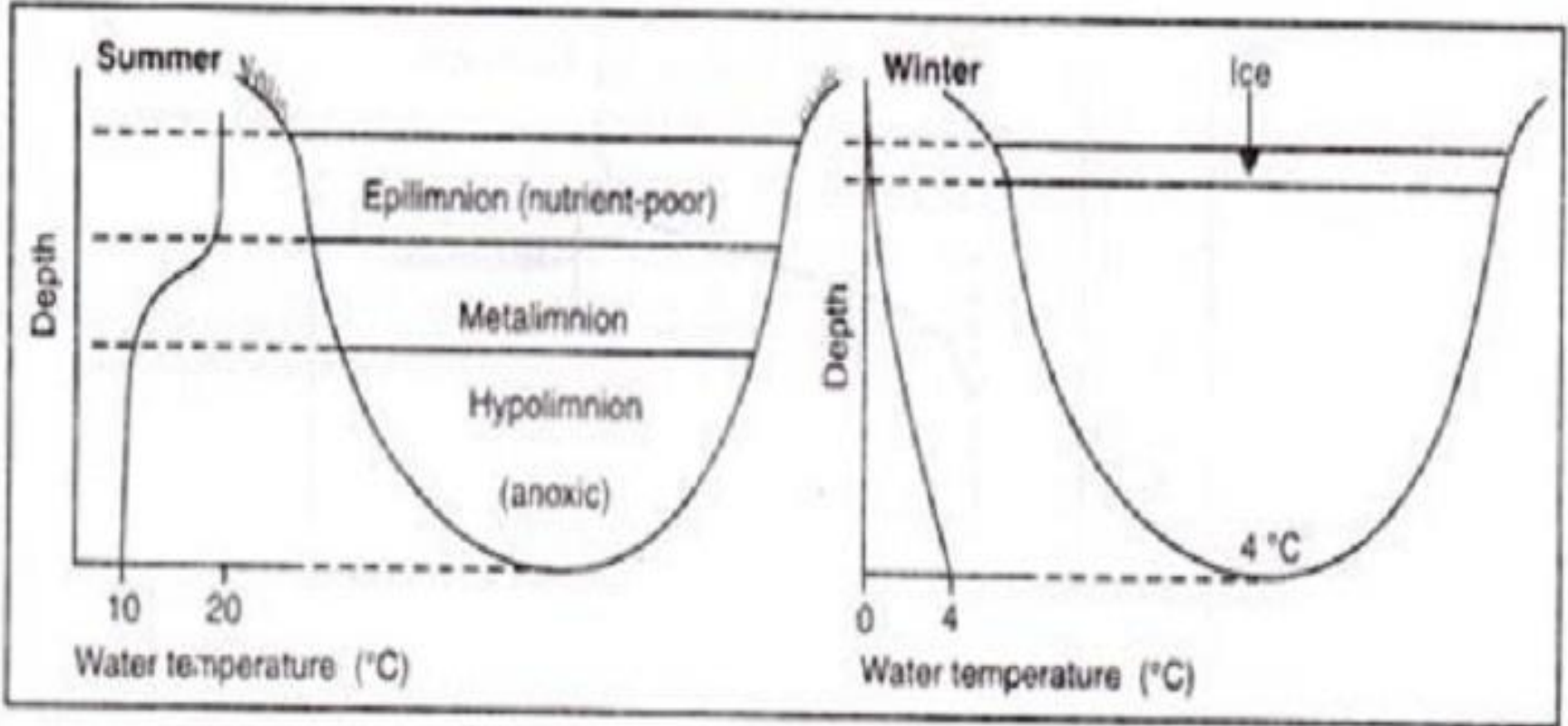
Thermal Stratification



- **Thermal Stratification of a Lake**

- **Winter**

- **Spring-** spring over turn or spring turnover



- **Extremes of temperature**

- The lethal maximum temperature is about 89°C.

- The lethal minimum temperature is approximately 0°C.

- **Cyclomorphosis**

Eg- **Daphnia** (crustacean) helmet development

Starts - spring,

maximum - summer

disappears (round shape) – winter

Thermal Adaptation of Animal

- **Behavioral Adaptations:**

Eg:

- sand snakes- side winding(a lateral movement)
- lizards - run quickly on all fours or their back legs.
- African ground squirrels use bushy tails to shade them.

- **Anatomical Adaptations:**

- ostriches adapted to not grow feathers on their abdomen, legs, neck and Instead, they only grow feathers on the large part of their backs.
- Desert hares (jackrabbits) - with their long ears and numerous blood vessels

- **Physiological Adaptations:**
- abilities to obtain and retain water.
- kangaroo rats - eating dry seeds, produce extremely concentrated urine and faeces.
- Desert amphibians absorb water through their skin.

- **Dormancy- Estivation and Nocturnal Animals:**
- Winter dormancy - **hibernation**.
Eg. Hedge hog ground squirrel.
- Summer dormancy - **aestivation**.
eg. The African lung fish Protopterus.
The desert tortoise
- Nocturnal - bats, owls, snakes, rodents and foxes.

- **Thermal Migration-** to escape themselves from extremely low or high temp.
eg. birds.
- **Homeothermy-** maintain more or less constant internal temp.
eg. birds and mammals

Soil

The study of soil - pedology (soil science)

Soil may be defined as

the weathered layer of earth's crust, with which are associated living organisms & the products of their decomposition.

general roles that soils play

- media for growth of plants.
- modify the atmosphere by emitting and absorbing gases and dust.
- provide habitat for animals.
- Soils absorb, hold, release, alter, and purify the water.
- Soils process recycled nutrients (eg. Carbon) so that living things can use them over and over again.
- Soils serve as engineering media.
- act as a living filter to clean water before it moves into an aquifer.

Soil Formation (Pedogenesis) - accomplished mainly by 3 processes.

1. Fragmentation- the mechanical breakdown of rock.
(roots of plants)

2. Corrosion- weathering of rocks
by Physical & Chemical processes

Physical- wetting-drying, heating-cooling, freezing (frost-shatter), glaciations, solution (agents like water), sand blast....etc.

Chemical- hydration, hydrolysis, oxidation-reduction, carbonation, chelation (dissolving of chemical by microbial activity)... etc.

3. Addition of organic matter-
- by products of plants & animals- bodies after death.

include

➤ soil texture

➤ soil air – air in the **spaces between the soil particles**

➤ soil temperature

➤ soil water

Hygroscopic water- a thin film of water around each soil particle

Capillary water- water held in the spaces between the soil particles

Gravitational water- water drains downwards through the soil

➤ soil solution and pH

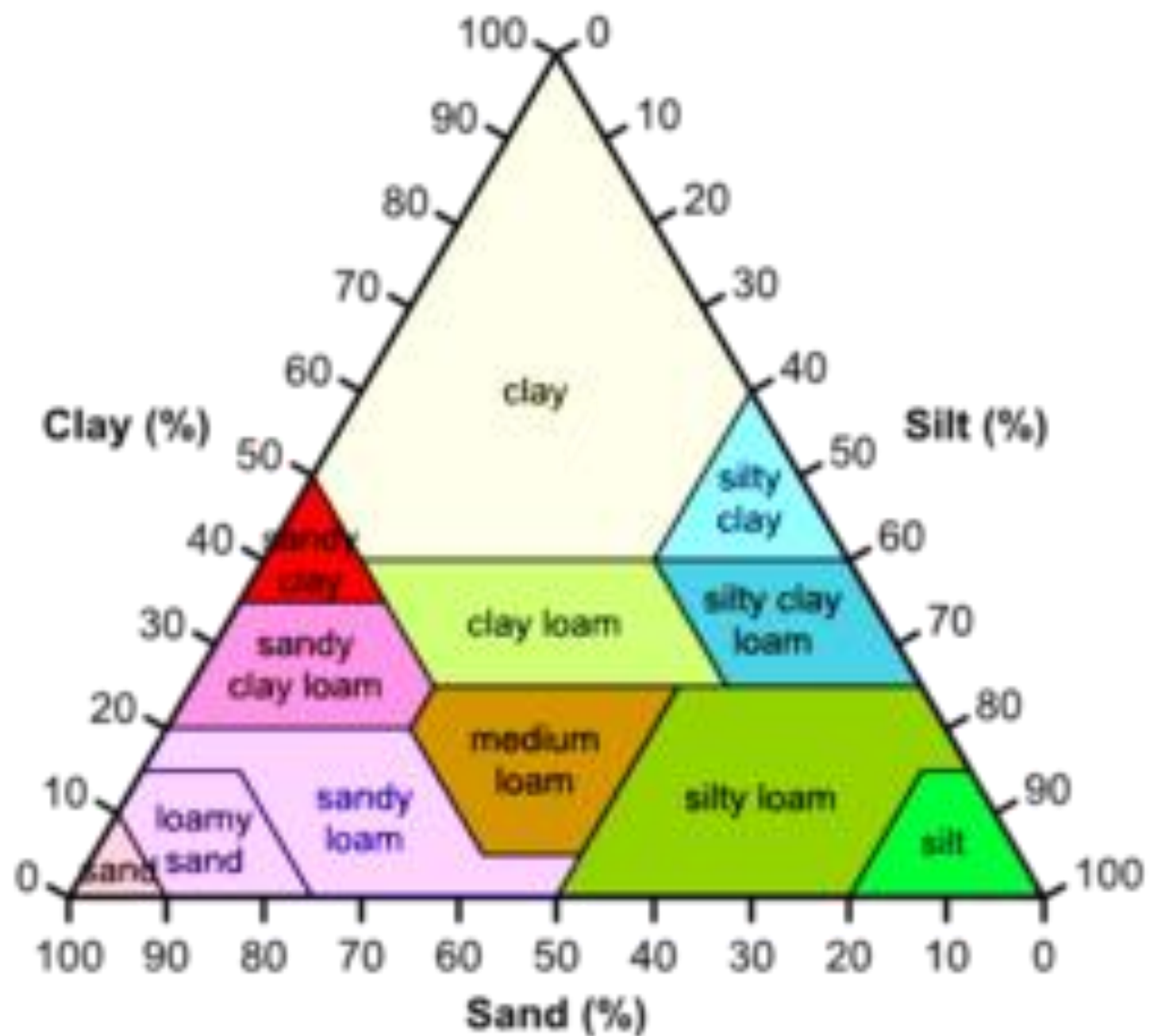
ferns species grow best in acid soils (pH below 7)

xerophytes grow better in alkaline soils (pH above 7)

➤ soil organisms and decaying matter

Soil based on texture

- **Gravel** < 2mm
 - **Sand** = 0.02 – 2mm
 - **Silt** = 0.002- 0.02mm
 - **Clay** > 0.002).
-
- Based on % particles present
 1. Sand-.85% or more sand & less than 15% clay or silt
 2. Loamy Sand- 15-20% clay or silt
 3. Sandy Loam- 21-50% clay or silt will be present.
 4. Loam or Silt Loam - 51% or more clay or silt
 5. Clay-Loam- clay present is 20-30%
 6. Clay- clay is always more than 31%



Soil Organisms

➤ 'biological system' of soil

➤ classified based on size.

1. Microbiota- body size within $20\mu\text{m}$ to $200\mu\text{m}$.

soil-algae, bacteria, fungi & protozoa.

dominant- green, blue green algae & bacteria.

decomposers - bacteria & fungi.

2. Mesobiota - body size within $200\mu\text{m}$ to 1cm.

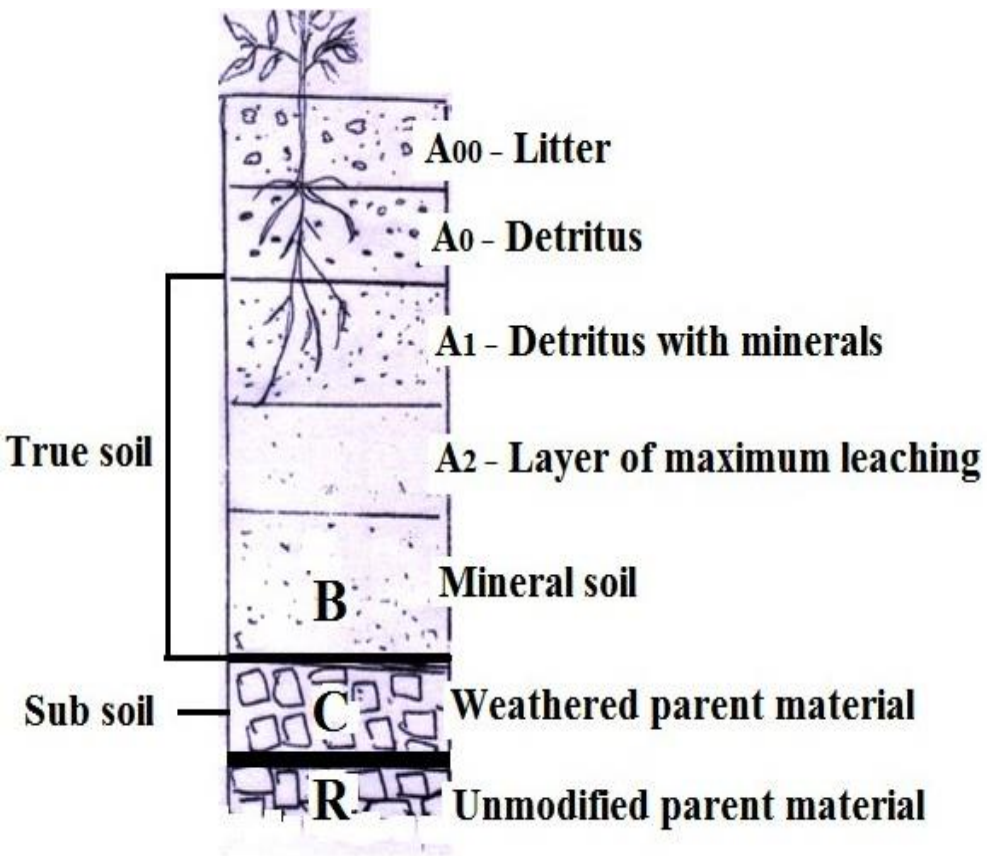
nematode worms, small oligochaete worms, small insect larvae, insects (spring tails, rove-beetles, scarabaeid beetle's...etc) & soil mites, Small millipede & centipede.

3. Macrobiota - body size greater than 1 cm.

roots of living plants, larger insects, earthworms, larger millipedes & centipedes, Burrowing vertebrates (moles, hedgehogs, hares, ground squirrels, bamboo rats etc)

Soil profile

- soil horizon- a distinct layer of soil.
- soil surface to the parent rock material.
- The **regolith** - weathered material within the profile.
 - The regolith = the **solum** and the **saprolite**.
 - The solum - upper horizons with the most weathered portion of the profile.
 - The saprolite- least weathered portion of the profile above the bedrock.



1. The 'A' horizon (Top Soil)

- a) A00 region- dead organic matter.
- b) A0 region- micro-organisms & decomposition (detritusto.....the duff).
- c) A1 region- rich in organic matter + mineral = **humus** (dark brown or black colour).
- d) A2 region- mineral & organic chemicals drained in = zone of leaching (eluvial zone).

2. The 'B' horizon- dark colour & coarse textured (silica-rich clay organic compounds, hydrated oxides of aluminium, iron...etc).

3. The 'C' horizon - weathered parent material (Sub soil).

4. The 'D' horizon (R horizon)- unmodified parent unweathered bedrock and collected water.

Water

- covers more than 72% of the earth surface.
- prerequisite for cells biochemical reactions (hydrolysis and biological oxidation).
- In higher animals- cells-intercellular fluid.
- simple organisms - live in direct contact with water.
- plants are classified on adaptation to water
 - a) Hydrophytes- inhabit wet regions.
 - b) Mesophytes- inhabit land surface with moderate water supply.
 - c) Xerophytes- inhabit dry regions (desert).
- Animals maintain water balance to prevent desiccation & also affect water conservation.

Oxygen

Atmosphere dry air- about 20.94% oxygen by volume.

Carbon di-oxide

Atmosphere dry air- about 0.03% carbondioxide by volume.

➤ cellular metabolism & energy

Photosynthesis in plants & Respiration

➤ Important in the survival & distribution of aerobic organisms

Wind

- Air in motion is called wind.
- directly involved in transpiration
- in dissemination of pollen, seeds & fruits.
- affects plants life
- Physical effects- breakage & uprooting, deformation, logging, abrasion (eroded), erosion & deposition, salt spray (sea coast) etc.
- Anatomical & physiological effects- desiccation - due to increase in the rate of transpiration, dwarfing- due to dehydration & consequent loss of turgidity, compression wood-develops a dense, reddish type of xylem etc.
- The velocity of wind is affected by factors such as geographic situations, topography & vegetation masses, & position with respect to sea shores.

Fire

- mostly man caused & sometimes natural.
- Fires classified as
 1. Ground fire- generally smoulder for longer periods.
flameless and subterranean
 2. Surface fires- sweep over the ground surface rapidly.
 3. Crown fire- burning the forest canopy & surface debris.
- Fire alter environmental factor - light, rainfall, nutrient cycles, fertility of soil, litter & humus content of the soil & soil fauna.
- Fire remove competition in surviving species.
- Increase of fire tolerant species at the expense of fire sensitive species.

Biotic factor

- Intraspecific interaction
- Interspecific interaction- beneficial, harmful or neutral.
- may be positive or may be negative.
- Positive interaction:
 - **Mutualism** and **Commensalism**
- Negative interaction:
 - Exploitation:
 - **Parasitism**
 - **Predation**
 - **Amensalism**
 - **Competition**

Mutualism

- both the species gets benefit.
- sea anemone (cnidarians) + hermit crabs.
- Intimate mutualisms- **symbiosis** (intense mutualism)
 - species cannot live without each other
- Termite and their intestinal flagellates.
- Pollination by the bees.
- Lichens (fungus and photosynthesizing algae or cyanobacteria)
- Mycorrhizae (fungi and the roots of higher plants).

Commensalism

- one gets benefit and other is neither harmed nor benefited.
- Sucker fish (Remora) + shark
- Dung beetles + Cow dung (provides food and shelter). The beetles have no effect on the cows.
- sea anemone (stinging tentacles) + clown fish.

Parasitism

- one species is harmed and the other benefits.
- dodder plant (*Cuscuta*) and mistletoe (*Loranthus*) are parasites on flowering plants.
- Tap worm, round worm, malarial parasite, many bacteria, fungi and viruses are parasites of humans.
- Ectoparasites - feed on the external surface of the host
Eg. Lice on humans.
Many marine fish are infested with ectoparasitic copepods.
- Endoparasites- live inside the host body at different sites (liver, kidney, lungs, red blood cells,... etc.).
- Brood parasitism- Eg. cuckoo (koel).

Amensalism

- One species harms/restricts/inhibits the other species without itself being adversely affected or harmed by the presence of the other species.
- Organisms that secrete antibiotics and the species that get inhibited by the antibiotics.

Eg.

- *Penicillium* (Bread mould fungi) – penicillin (antibiotic) - inhibits the growth of a variety of bacteria.
- Big tree shades small plant (retarded growth in small plant). The small plant has no effect on the large tree.

Predation

- Prey – Predators relationship is Predation.
- Predators – carnivores - use speed, teeth and claws to hunt and kill their prey.
- Less prey specific
- They keep prey populations under control -homeostasis.
- Introduced exotic species become invasive and start spreading fast – because not having its natural predators.
- variety of chemical (nicotine, caffeine, quinine, strychnine, opium, etc.,) are produced by plants actually as defences against grazers and browsers.

Competition

- an interaction between two populations in which both species are harmed to some extent.
- Competition for vital resource that is in short supply.
 - food, water, shelter, nesting site, mates or space.

Competition types-

- Interspecific competition
- Intraspecific competition