ECOLOGY

Ecology is defined as the study of the relationship between living organisms towards one another and with their surrounding environment.

Ecology is a term derived from two Greek words, "Oikos" means living place or house and "logos" means the study of or science of.

There are two types of ecological studies,

- Autecology.
- Synecology.

Autecology is the study of relationship between an organism and its environment. For example studying a single oak tree.

Synecology is the study of the communities and their environment, this involves the study of more than one species and their interactions in an area.

The study of Ecology is significant in the following ways,

- Applied in the field of agriculture, forestry and fisheries.
- To predict incidences of pollution and how they can be prevented.
- Understand the consequences to the environment of construction of dams, diversion of rivers, reclamation of swamps and wet lands, construction of infrastructure like roads, housing, bridges and urban developments.
- In application of biological conservation methods.

An environment refers to all the conditions in which an organism lives, such conditions include, temperature, light, water and other organisms.

Ecology can be broadly studied at various levels which include,

- Species.
- Community
- Population.
- Ecosystem.
- Biosphere.
- Biome.
- Habitat.
- Niche.

Species. This refers to group of organisms with similar characteristics and are capable of interbreeding to produce fertile offerings.

Community. This refers to organisms of different species living together and interacting i in a given area.

Population. This refers to the number of organisms of the same species living in an area at a given period of time.

Biosphere *(Ecophere).* This includes all living organisms and the physical environment with which they interact. All parts of the earth occupies by different living organisms form the biosphere. The Biosphere is often divided into geographical regions called continents of the world. The geographical regions include, Africa, North and South America, Asia, Europe and Australia.

Biome is a region within the Biosphere with its unique set of environmental conditions where specific type of animal species (fauna) and plant species (flora) are adapted to live or supported. Biomes of the world include tropical rain forests, tropical savannah, grass lands, deserts, tundra of arctic and Antarctic regions, temperate regions, oceans, etc. Biomes are divided into smaller units called zones. For example tropical rain forest is divided into ground zones and canopy zones. Within each biome are habitats.

Habitat is a specific locality with a particular set of climatic conditions to which communities of organisms get adapted. For example, fresh water ponds, streams etc. Habitat is further divided into micro-habitats, each with its own particular conditions called micro-climate further divided into micro-habitats, each with its own particular conditions called micro-climate.

Ecological niche is defined as a spatial habitat (an area where an organism lives) and the entire ways of life and roles played in the community. A niche of an organism in absence of predators are called fundamental niche and its niche in presence of predators and other competitors is known as realized niche.

ORGANISM'S ENVIRONMENT.

An environment is a term which refers to all conditions in which organisms lives. It has two broad components,

• Abiotic *component.*

• *Biotic component,*

Abiotic component.

Is the physical and non-living component which contains matter and energy.

Biotic component.

Is the living component of the environment.

Both Abiotic and biotic components affect the distribution and abundance of organisms in different habitats.

ABIOTIC (PHYSICAL) FACTORS AFFECTING DISTRIBUTION AND ABUNDANCE OF ORGANISMS IN A HABITAT.

The main Abiotic (physical) factors include the following,

- Temperature.
- Water.
- Light.
- Humidity.
- Wind and air currents.
- pH.
- Mineral salts and trace elements.
- Water currents.
- Salinity.
- Wave action.
- Topography/altitude/latitude.
- Background.
- Soil (Edaphic factors).

(i) Temperature.

Temperature is the amount of heat in a biological system. It majorly affects the activities of enzymes catalyzing various physiological processes like growth, respiration, photosynthesis, seed germination, transpiration, fruiting and the flowering in plants. Optimum temperatures of 35°C - 40oC favour and increase enzyme activities, which double for every 10°C rise while extreme temperatures far below and above the optimum lowers enzyme activities due to inactivation or denaturation of the enzymes. In an aquatic ecosystem, high temperatures lowers concentration of dissolved oxygen, while low or optimum temperatures increases the concentration of dissolved oxygen. Most organisms tend to be more abundant and having a bigger population size in habitats with relatively stable and optimum temperatures and less abundant and few in habitats with extreme temperatures. For any organism to live and survive in a habitat must adapt to extreme temperature conditions.

For distribution in animals, some bacteria survive in habitats with 100°C and penguins survive in temperatures below -80°C in the Antarctic Ocean.

For distribution in plants, temperate plants are found abundantly in cool regions, tropic plants more abundant in regions with high temperatures, some plants called C4 plants grow more in hot climatic regions with high temperatures while their counter parts the C3 plants grow more efficiently in cooler environments. Some aquatic plants

can withstand I very high temperature and thrive in hot springs, while others can with stand very cold temperatures in snow.
Environmental temperatures can be influenced by the light intensity available. Some metabolic reactions like respiration, fire, etc can also influence environmental temperatures.

(ii) Water.
Water availability is essential for the process of growth and development of plants and animals. Increased water content in the soil increases plant growth and population size and more food is available for primary consumers. This will increase their population j size. Reduced water supply cause low growth rate and death and lowers population size. While increased water supply increases growth rate and leads to high population size. Most organisms are more abundant in areas with good water supply than where water is scarce.

SIGNIFICANCE OF WATER TO ORGANISMS.

- Dispersal of seeds and fruits.
- Habitats for aquatic plants and animals.
- For plant growth because essential mineral salts are carried dissolved in water i.e in solution form.
- For seed germination.
- Regulate body temperatures in plants and animals.
- When water evaporates from the surface of plants or animals, it results into cooling.
- Important in nutrient recycling.
- It is a raw material for photosynthesis, where it reduces carbon dioxide to form sugars in presence of sun light trapped by the chlorophylls.
- Medium for most metabolic reactions, medium through which male gametes are transferred to the female eggs in reproduction.

(iii) Light

Light availability when adequate, it favours the growth of plant population through the process of photosynthesis. More primary producers will highly support survival of many primary consumers like the herbivores; this will favour the survival of other animals directly or indirectly. In adequacy of light or its absence limits the plant populations. More organisms are distributed where light intensity is adequate than where light intensity is low.

The amount light intensity can determine the temperature of a particular habitat.

EFFECTS OF LIGHT ON A HABITAT/ECOSYSTEM.

(a) Positive effects.

- Provides energy for photosynthesis, for transpiration and for stomata opening.

- Provides vision or sight, important in the search for food, mates and escape from predators.

- Regulates internal body temperature, for example ectotherms like lizards busk in sun to gain energy.

- Stimulates growth of leaves, internode growth, synthesis of chlorophylls, photoperiodism.

- Stimulates flowering, fruiting/photoperiodism.

- Stimulates breaking of seed dormancy, induces seed germination.

- Stimulates formation of vitamin D in animals.

- Stimulates mating, reproduction, migratory behaviour.

(b) Negative effects.

- Ultra violet light causes skin cancer.

- Ultra-violet light inhibits growth. Light breaks hydrogen bonds of biological molecules.

- Excessive light bleaches the chlorophyll.

- Radiations of less energy than red light is absorbed by water bodies leading to increased temperatures of the water, which causes some animals to migrate; it also reduces the amount of the dissolved oxygen in aquatic environment.

- Provides visibility which enables predation to take place.

(iv) Humidity.

Is the amount of water vapour in the atmosphere. High humidity lowers the rate of evaporation of water from the surfaces organisms, in plants rate of transpiration is reduced, this encourages water conservation in drought conditions and the ability of many organisms to survive is increased.

Low humidity promotes high rate of evaporation and excessive water lose. This leads to few organisms to survive in conditions of drought.

Many terrestrial organisms are distributed more where humidity is high than where humidity is low.

(v) ***pH.***

Is the acidity or alkalinity of a given medium. It influences the distribution of plants in soil and fresh water. Some plants thrive in acidic conditions, for example Tobacco is

distributed more in acidic soil, other plants thrive more in alkaline soils. However, most plants are sensitive to changes in pH.

(vi) Air and wind.

Air contains the gases oxygen and carbon dioxide. They affect mainly abundance and distribution of aquatic organisms. Availability of dissolved oxygen in sufficient amounts in aquatic environment favours growth of population size of aerobic aquatic organisms and its absence or insufficient amounts limits population size of some aquatic organisms. Oxygen is essential for respiration. While carbon dioxide is a raw material for photosynthesis required by phytoptanktons and other photosynthetic organisms like bacteria. Big population size of aquatic photosynthetic organisms is achieved where concentration of dissolved carbon dioxide is adequate. However, a level of dissolved carbon dioxide in aquatic environment determines the pH levels of the water. High levels of carbon dioxide lowers pH (acidic solution) and low levels increase the pH (alkaline solution). Photosynthesis by phytoplanktons and atmospheric air mixing with water are the main sources of dissolved oxygen. Meanwhile, respiration is the main source of dissolved carbon dioxide in aquatic environment.

The aspect of wind applies only to plants, only plants with strong root system and tough stems can live in exposed places with too much wind. Wind also increases the rate of evaporation rate and is also important in dispersal of spores and seeds. Windy conditions permit more air to mix with water and increase concentration of dissolved oxygen in aquatic environment.

(vii) Mineral salts and trace elements.

These particularly affect the distribution of plants in the soil. Sufficient minerals favours growth and development of plants and increase in population size and deficiency of the mineral salts leads to low growth and death of some plants and hence decrease in population size.

Some minerals are more abundant than others for certain reasons; they react more readily than others, more soluble and can easily be leached out by the rain and carried into the water bodies, evaporation of water also increases the concentrations of the mineral salts, selective reabsorption, minerals being more essential to particular plants. Sources of mineral salts in aquatic environment include the following,

- Salts that dissolve in the rain water are carried into the water bodies. Salts that dissolve in river water can also be carried into sea water.
- Minerals obtained from deposition of marine organic materials.
- Minerals deposited into the water bodies by run water washed down from the neighboring land masses.
- Dust particles carried into the water bodies.
- From the dissolution of minerals from the underlying rocks in the water bodies.

In the terrestrial environment the mineral salts can be obtained in the following ways, -- -

- Weathering or mineralization of rocks.
- Decomposition of organic materials.
- Use of fertilizers in agricultural land.
- Rain dissolves minerals in the atmospheric gases.
- Nitrification process and nitrogen fixation by nitrogen fixing bacteria.
- From pesticide and insecticide sprays.

The mineral salts favour growth and increase in population size in required quantities, high concentration of mineral ions are toxic to particular plant species and this limits their distribution and population size.

(viii) Water currents.

These are more pronounced in rivers and streams. Organisms which live in such environment with turbulent water currents must be adapted to survive in such turbulent environment, these adaptations include,

- Ability to live under stones or in crevices along the banks.
- Ability to burrow in small holes.

(ix) Salinity.

Refers to the salt content of a given aquatic environment. It influences the distribution of estuarine animals. These have special physiological or behavioral adaptations to withstand fluctuations in salinity and these are,

- Possession of more salt containing body b animals. This prevents the loss of the water from the animal's body to the surrounding by osmosis.
- Active pumping of the mineral salts into the organism’s body from the surrounding.

(x) Water waves.

This affects organisms living in the intertidal zone. To withstand the waves action conditions, special adaptations are needed. These include,

- Sessile habits e.g. In sea anemones.
- Burrowing by shrimps and sand hoppers.
- Firm attachment to rocks and general seaweeds e.g. Fucus and laminaria.

(xi) Topography/altitude/latitude.

Topography refers to the altitude of the slope and aspect of a place. Topography causes differences in illumination, moisture and temperature etc. These differences cause differences in the distribution of living organisms along area different in topography. For example the population size of organisms on the side well illuminated will be greater than on

the side not well illuminated. This is because of better climatic conditions on the illuminated side.

The population size of organisms and the number of species is higher at lower altitudes and latitudes, lower altitudes and latitudes have favourable temperatures, high partial pressures of oxygen and atmospheric pressures. This provides favourable climatic conditions which favour plant growth throughout the year, providing enough food, shelter/habitats for many animals.

At high altitudes and latitudes, the population size of organisms and number of species of organisms is low. High altitudes and latitudes have unfavourable climatic conditions these include, cold temperatures, low partial pressures of oxygen and atmospheric pressure. This reduces plant growth and reduces plant population size, providing little food for other organisms and the population size is low.

(xii) Background.

This is the overall coloration of the environment in which particular organisms live. The population size is high and organisms are well distributed where the organisms resemble the background, they camouflage and survive selective predation. In the other hand, the population size is low and organisms are scantly distributed where they do not resemble their environment, such organisms cannot camouflage and easily spotted by the predators and consumed at higher rates.

(xiii) Soil factors.

Soil is a complex mixture of in-organic, organic and organic decaying matter that occurs above the earth's crust. Soil factors affecting plants and animals life are referred as edaphic factors. They are physio-chemical factors. Soil is important for plants in the following ways,

- Provides water and mineral salts.
- Provides anchorage (support) to the plants.
- For root aeration.
- Habitat for some animals. For example, earthworms, beetles, insects etc.

EDAPHIC FACTORS AFFECTING POPULATION SIZE AND DISTRIBUTION OF PLANTS AND ANIMALS.

These include the following,

• Soil *micro-organisms.*

These include Bacteria and fungi. They affect the lives of organisms in the following ways,

- Cause rapid decomposition of organic matter in the soil, releasing nutrients that promote plant growth.

- Increase soil aeration since the process of decomposition release gases and more room for air is created.
- Break seed dormancy, promoting plant growth.
- Promote nitrogen recycling by working as nitrogen fixing organism..

• Soil *moisture.*

- Dissolve mineral salts in the water so that they are rapidly absorbed and utilized by plants.
- Activate the process of seed germination.
- High water content of the soil lowers rate of absorption of mineral salts, reduces aeration and decomposition of organic matter. Some plants may dry up in conditions of water logging.

• Soil *texture.*

This is the proportion of sand and clay particles. Soil texture influences drainage and water retention of the soil, determining survival of plants. Good soil texture favour large population size of plants and their distribution than poor soil texture.

• Soil *structure.*

Is the arrangement of soil particles, it influences drainage, aeration and soil erosion.

• Soil *temperature.*

It influences physical, chemical and biological processes.

A physical process affected is soil formation. Chemical process influenced is decomposition, while the biological processes affected by the temperature are respiration, water absorption, seed germination, root growth and activities of the microorganisms. At optimum temperatures of 35°C upto 40°C the physical, chemical and biological processes are increased, while at temperatures below and above the optimum, these processes are lowered. Soil temperatures is affected by,

- Colour of the soil.
- Soil texture.
- Water content.
- Humus content.
- Vegetation covers of the soil.

- Soil pH.

It affects the following,

- Activities of nitrifying bacteria and other soil organisms.
- Solubility of solutes such as Fe2+, Fe3+, B43-.

- Vegetation distribution of some crops. Some plants prefer acidic conditions while others prefer alkaline.

- **Soil *aeration.***

This is the amount of air in the soil and it is determined by the following, Number of air spaces in the soil. Size of air spaces in the soil. Water content of the soil. Humus content of the soil

IMPORTANCE OF SOIL AIR,

- For seed germination.
- Respiration of soil micro-organism.
- Respiration of plant roots.
- Decomposition of organic matter.

(xiv) FIRE.

This is another important ecological factor that can affect the population size and distribution of plants and animals.

CAUSES OF FIRE.

- Human carelessness or intentions.

In tropics, pastoralists are known to start fire in order to clear the old unpalatable vegetation to pave way for the young, soft palatable vegetation.

- Natural causes.

This is brought about by lightening, volcanic activity, extremely high temperatures in some areas. These conditions can spark off fire naturally in many forests, grass lands like in California and British Colombia.

ASPECTS OF FIRE AS AN ECOLOGICAL FACTOR.

- ***Source of fire.***

Fire can be wild. This is fire whose source is unknown or prescribed, this is fire whose source is well known often set by ecologists on some schedule.

- **Season *of burn.***

Fires can be early burn. This is set at the beginning of the dry season. While the late burn fires are set up at the end of the dry season.

- Fire intensity.

It is the heat content of the fire and it depends on the type of fuel, amount of fuel present, environmental temperatures, wind and humidity.

• Fire duration and spread.

It refers to how much area has been covered by the fire (spread) and how long a fire has spent burning in an area (duration).

• Fire frequency.

It refers to the number of times per year an area is burnt.

Reasons for burning vegetation at a suitable frequency include the following,

- Removing top old unpalatable vegetation to pave way for fresh, young and palatable vegetation.
- To prevent accumulation of litter which could harbor pests.
- It can be applied to enhance weeding.
- To give way to wood vegetation so that stable climax community can be maintained.

ADAPTATION OF SOME PLANTS TO SURVIVE IN FIRE STRESSING CONDITIONS.

- Possession of thick bark not easily destroyed by fire.
- Succulent stem with high water content. E.g Banana plantations. However, stem succulent plants are not common in deserts because of the following reasons, their tissues are not heat resistant, stem succulent plants have high water content with low rate of transpiration and are liable to overheating.
- Possession of underground vegetative propagation structures which are hidden from direct effects of fire and rapidly sprouts after fire. It is noted that fire favours grasses at the expense of the tress. This is because grasses have meristems at leaf bases, at the levels of the soil but well protected by the leaf bases and the thin layers of the soil. Trees grow from cambium and buds which are exposed to high temperatures during fire and die off.
- Lack of branching at lower parts but lateral branching more pronounced at the top. This protects the plant from fires since they hardly reach the top.

DISADVANTAGES OF FIRE.

- It leads to soil erosion as it removes the top vegetation on soil surface leaving the land bare and exposed to the agents of erosion such as wind, water etc.
- It destroys the soil micro-organisms and the slow moving animals like snails, chameleons, earthworms, etc.

- It destroys crops which are food sources to many organisms. This leads to food shortage and starvation.
- It leads to development of fire resistant species which may be poor and hard pasture for grazing animals.
- It may destroy most of the palatable species of vegetation.
- It leads to changes in the characteristics of the vegetation. For example development of the grasslands from the shrubs. Woody plants from the grass land.

ADVANTAGES OF FIRE.

- It reduces overcrowding in any given area, preventing competition for natural resources like food, space or shelter, water, etc.
- It improves soil fertility, the burnt plant materials add organic matter into the soil. It destroys pests and parasites.
- Fire improves visibility of animals in bush land which is important for predator-prey relationships.
- It promotes regeneration of fresh, young, moist and palatable pastures.
- It leads to recycling of nutrients. For example nitrates in ash and carbon dioxide in smoke.

THE BIOTIC ENVIRONMENT.

This is the living component of the environment. It is made up of all the other organisms interacting together.

BIOTIC FACTORS AFFECTING POPULATION SIZE AND DISTRIBUTION OF ORGANISMS.

They include the following,

(i) Predation.

A predator is an organism which hunts, attacks and feeds on other animals. The animals which are fed on are called the preys. In this case, the distribution of predator and prey are related. Predators are found where there are suitable preys, i.e the herbivores are only found where there are suitable plant food and carnivorous plants are found where there are insects. The large number of predators in an area results into decrease in population size of preys because more preys are being fed on by the large number of predators, while a large number of prey in area results into an increase in number of predators because of the adequate available food, this increases the biotic potential of the predators.

Predation is an interspecific relationship where only one organism benefits (the predator, while the other losses.

(ii) Competition.

Competition is a relation where two or more species of organisms try to or struggle to obtain the same limited natural resources.

Organisms of different species frequently compete with one another for natural resources such as food, light, water and breeding sites (space), mates and shelter. The relationship is harmful to both species because they are unable to exploit the resources as fully as they would in the absence of competition.

Competition among organisms may cause organisms to starve to death, migrate to occupy other habitats or change their mode of feeding. These reduce their population size in an area. Competition is divided into two types,

- Interspecific competition.
- Intraspecific competition.

Interspecific competition is the one that exists between organisms of different species. While intraspecific competition is the one that exists between organisms of the same species. There are certain factors that may increase the levels of competition among organisms,

- Shortage of natural resources.
- Increase in population size.
- When organisms of different species occupy the same ecological niche.

It is impossible for any organisms of two different species to occupy exactly the same ecological niche. This is a biological or ecological principle referred to as Competitive exclusion principle. It states, No two different species of organisms competing for the same natural resources will occupy exactly the same ecological niche. Co-existence between the two different species cannot occur, the better adapted organism, will have better mode of feeding, more tolerant to high temperatures and toxic conditions than the less adapted one. The better adapted will continue to survive and reproduce more rapidly and its population size increases more rapidly as it out competes the less adapted one. The less adapted organism will continue to die and its population size decreases more rapidly until extinction.

ECOLOGICAL SIGNIFICANCE OF COMPETITION.

- It has enabled organisms of the same closely related species to evolve into different distinct species of organisms in order to occupy different ecological niche (adaptive radiation).
- It leads to colonization of wide range of habitats.
- A better quality and better adapted species of organisms develop since selection pressure tends to favour only the better competitors over the weak competitors.
- Leads to polymorphism. This is the existence of the same species of organisms in two or more genetically discontinuous forms or morphs living within the same habitat. This results into maximum utilization of resources in a wide range of environment.

(iii) Parasitism.

Parasitism is the relationship between two organisms of different species where one organism called the parasite lives on or in another organism called the host where it obtains all its nutrients and shelter. While the host organism does not benefit from this relationship at all and may even be harmed. The host organism is one from which nutrients and shelter is derived by another organism called the parasite. Parasites are distributed in large numbers where suitable hosts are present. For example, ticks are always found where there are cattle, Tsetse flies are found in areas where grazers like and Buffalos are present.

ECOLOGICAL SIGNIFICANCE OF HOST-PARASITE RELATIOSHIP.

- Parasites can be used as biological control agents to eradicate harmful organisms.
- Reduces competition since parasites lead to death of organisms.
- May lead to development of new species which may become resistant lo parasites or parasites that can withstand the immune response of the host and this will lead to increased biodiversity.
- It influences distribution of parasites. For example Tsetse flies can be found in areas with grazers like the cattle and Buffaloes.
- It leads to rapid production of the offsprings of the parasites since the immune defence responses of the hosts tend to destroy many of the parasites.
- Development of the resistant stages in the life cycle of the parasites to survive under harsh environmental conditions. For example the eggs of the round worms are believed to stay in the soil for a period of 2 years.
- Many parasites occupy strategic locations in the host, to ensure maximum utilization of the available resources which increase their chances for survival.

For example the gut parasites are found in the duodenum and ileum where soluble products of digestion are found. Liver flukes are found in the liver where end products of digestion are stored.

(iv) Mutualism.

Is the close association between organisms of different species where both organisms benefit equally from the association. For example, ***the lichen*** which is an association between fungi and algae. Algae are photosynthetic and provide food (carbohydrates) and oxygen for aerobic respiration to the fungi while the fungi offer shelter and protection to the algae. The fungi also absorb mineral salts and water for the algae.

Another example is the nitrifying bacteria in the root nodules of legumes, bacteria fixes nitrogen for the plants, while the legumes provide shelter for the bacteria. The population size of nitrifying bacteria is large and distributed more where leguminous plants grow than where legumes are absent or few. Other examples of mutualism include the following,

- Cellulase secreting bacteria, protozoa and the ruminants for example, goats, rabbits. The Ruminants obtain glucose from the breakdown of cellulose; they also obtain proteins from the digestion of the bacteria, while the micro-organisms get shelter and protection. They also get free carbohydrates.
- The green algae and green hydra (chlorohydra). The green algae obtains shelter and protection, also obtains carbon dioxide for photosynthesis, carbon dioxide released from the respiration of it's host, They also obtains nitrates and phosphate from the excretory activities of the hydra. In the other hand, the green hydra obtains oxygen for respiration from the photosynthetic activities of the algae, obtains carbohydrate food, gains camouflage from the green algae, the green colour of the algae attracts zooplanktons on the which the hydra feeds.
- The hermit crab and sea anemones. The hermit crab gains defense from stinging cells of the anemones, these anemones camouflage the crab from potential predators, obtains free transport through unfavourable medium where it could not have transported itself.

Mycorrhiza. Is a mutualistic relationship between the roots of the plants and a fungus. The fungal hyphae grow on the surface of the root or may penetrate into the plant tissues. The fungal hyphae in the soil break down organic matter to release soluble mineral nutrients such as phosphates, calcium salts and potassium ions. S

ome of the soluble products are absorbed by the fungus and the remaining ones are obtained by the plants. The extensive network of the fungal hyphae increases surface area greater than those of the plant roots alone. The fungus also provides carbon dioxide. The plant in turn benefits by utilizing the soluble nutrients for growth and carbon dioxide to synthesize carbohydrates such as glucose through the process of photosynthesis. So, the fungus is provided with food inform of carbohydrates (sugars).

(v) Commensalism.

This is an interspecific association between two different species, where by one species of organism benefits and the other species of organism neither benefits nor losses or harmed. For example, young epiphytes and host plants, vectors and the pathogens they carry. Lion and hyena, white egrets and buffaloes.

(vi) Antibiosis and Allelopathy.

Antibiosis is an association where one species inhibits growth and survival of another but does not exploit it for food. The organism produces antibiotics that deter other organisms from its surrounding. There are two types of antibiosis,

- Interspecific antibiosis.
- Intraspecific antibiosis.

Intraspecific antibiosis.

This is an association where organisms of the same species produce pheromones that are used to mark their territories and prevent other organisms of the same species entering their territories. For example male Rabbits secrete pheromones from their salivary glands to mark their territory, cat families also secrete pheromones contained in their urine.

Interspecific antibiosis.

This is an association where by organisms of different species are prevented from living together by antibiotics secreted by one of them. For example the saprophytic *penicillium notatum* produce antibiotics which kill or prevent growth of bacteria.

Allelopathy. Is an interspecific interaction where one organism releases a chemical substance into the environment that has a harmful effect on another organism of different species. This interaction benefits individual of one species but is harmful to those of the other species. For example sunflower plants release chemicals from their roots and fallen leaves which prevent seed germination in other plant species but not seeds of the sunflowers. Allelopathy has a strong effect on the plant community.

ECOLOGICAL SIGNIFICANCE OF ANTIBIOSIS.

- Some organisms which produce antibiotics are used to biologically control pests, pathogens and weeds.
- It influences the distribution of organisms in a habitat where pheromones are produced.
- Interspecific antibiosis is important in that it prevents growth of individuals of the different species hence causing harm one organism but ensuring the survival of another.

(vii) ***Pollination and dispersal.***

Certain plants rely on insects and other smaller animals for pollination or dispersal, i.e Bees, moths are always found in areas where flowering plants grow.

(viii) ***Camouflage.***

Camouflage is where some animals possess body colorations that resemble closely the colour patterns of their environment (background) so that they are not easily spotted by their predators and successfully hide or closely resemble parts of a plant or specific insects/some animals. This offers protection against predation. In such cases the plant species concerned form the most important part of the insect's biotic environment. Most organisms will prefer to stay in habitats with a background resembling the colour patterns of their bodies.

(ix) ***Mimicry.***

This is where some animals resemble other harmful or unpalatable animals to predators I in order to escape predation. The unpalatable species generally possess distractive colours or markings (warning colourations). Predators learn to recognize these signs and avoid attacking this particular species. For example The African swallow tail Butterfly *(Papilio dardanu)* mimics another butterfly *(Amaurus abimaculata)* which is distasteful to predators.

(xi) ***Human influence.***

Is the most powerful biotic factor. It's interaction with other species of organisms can affect their distribution and abundance within certain habitat. Man achieves this through his work of cultivation of crops, bush burning, reclamation of wetlands and swamps, pollution of land, air, lakes and rivers, industrialization, urban development. Man can change habitats and create new ones i.e new reservoir creates a new aquatic habitat for new aquatic species.

PREDATOR-PREY RELATIONSHIP.

This is interspecific association where by the predator hunts, captures, kills and feeds on another organism called the prey.

The biological significance of the predator-prey relationship is that, it determines the distribution and abundance of prey, it can applied in the biological pest control, may result into evolution of new species, and may lead into dispersal of fruits, seeds since it involves movement of organisms from one place to another.

ADAPTATIONS OF THE PREDATOR TO CAPTURE THEIR PREY

- The ability to camouflage in their environment and not easily seen by the preys.
- They have high locomotory speed to chase and capture the preys.
- They possess long, pointed and curved canine teeth which pierce and kill the prey.
- Possession of strong visual acuity and ability. For example the eagles very high up in the sky can easily distinguish the chicks on the ground from the vegetation.
- Some predators are nocturnals, they hunt, capture and feed at night when their preys are resting. Most preys have poor vision at night.
- Development of tentacles in lower animals like the hydra and squids which trap and direct the prey into the mouth of the predator.
- Some have stinging cells for paralyzing the prey. For example the sea anemones.
- Possession of sensitive olfactory cells for detecting the smell of the preys from a distance and of those hiding.
- Making specific traps for capturing their preys. For example the webs made by spiders.
- High intelligence due to relatively large size of the brain, so have the ability to use foot marks, sounds, droppings to locate their preys.
- Group hunting to increase chances of capturing preys.

- Possession of soft pads in the soles, this enables them to locomote without making noise and not easily detected by the preys.
- They possess strong curved claws for capturing and holding the prey. For example eagles.

ADAPTIONS OF THE PREY TO ESCAPE PREDATORS.

- Possession of colours which blend with that of their environment and they can camouflage from predators. For example chameleon has skin containing pigments that will reflect colours of the background.
- Mimicry. This is where some animals resemble other animals harmful and unpalatable to predators in order to escape the predators.
- This is where some palatable and harmless animals develop inconspicuous colour patterns to confuse their predators. For example black and yellow markings on the bees, wasps, salamanders.
- Warning calls. This is a sound made by some animals to warn about approaching predators. Warning calls are made by mainly birds and mammals which exhibit parental care. It is an altruistic type of behaviour.
- Protective resemblances where by insects and other animals resemble objects in their environment which confuse their predators.
- Some secrete poisonous chemicals that can kill or drive away their predators. For example toads secrete poison from the poison glands.
- Possession of protective body covers. For example shells of snakes and tortoises.
- Production of mucus on the body, their body becomes slippery and they can easily escape from their predators. For example fish.
- Possession of defence devices. For example spines on the limbs of insects, porcupine, hedgehogs, and well developed canine teeth in warthogs and tusks in elephants.
- Production of nasty smell which irritate the predators. For example hedgehogs, cockroaches, etc.
- High speed of locomotion by some preys so that they can out swims, out run, out fly their predators.
- Group defence which is common animals that live in herds. For example zebras, Buffaloes etc.

ADVANTAGES OF THE PREDATOR-PREY RELATIONSHIPS.

(a) TO THE PREDATORS.

- Availability of food for the predators, increase their biotic potential and population size.
- Intraspecific competition eliminates the less adapted organisms.
- Leads into existence of better adapted species of predators.

- Leads to formation of new species with better adaptive features.

(b) TO THE PREY.

- Lowers the levels of intraspecific competition.
- Decreases overcrowdness among the prey species.
- Food resources, breeding sites, habitats become sufficient.
- Selection pressure exerted eliminates the less adapted and better adapted species evolve.
- Better adapted mechanisms for survival evolve among the prey species. -Decreased intraspecific aggression.
- Colonization of new ecological niches or localities occurs,

BROWSING (GRAZING).

This is a form of predation in which animals feed on plant materials. Such animals are called Browsers if feed on branches (thorny branches) of shrubs. They are called grazers if they feed on grasses. For example, cows, goats, etc.

ADAPTATIONS OF PLANTS TO DETER BROWSERS AND GRAZERS.

- They possess thorns, hairs which reduce on palatability and also used as defence devices.
- Some are brightly coloured which does not attract the browsers and the grazers.
- Some secrete moulting hormones that interrupt the life cycles of insects such as butterfly.
- Some secrete toxic chemicals. For example carcinogens and others which cause hemorrhage and tumors in mammals. Others secrete chemical substances that results into nasty smells that offend the grazers.
- Secretion of bitter sap which deter the grazers.
  Some plants like the *Mimosa pudica* fold their leaves in response to touch and this threatens the animals.
  Some plants open their leaves at night and close them during the day. This makes grazing by the animals impossible.

ADAPTATIONS OF HERBIVORES TO OBTAIN PLANT MATERIALS.

- Possession of very flexible tongue that can move in all directions to easily pluck off the vegetation.
- Some possess horny pad which is very hard and minimizes the piercing effect of the thorns.
- Some have long snout to probe through the thorns in order to get leaves. For example giraffes.
- Some have long necks to enable them graze on leaves high up on the canopy.

- Herbivores have well developed teeth that crash plant materials. For example large molars and premolars of the cattle.
- Herbivores have Cellulase secreting bacteria in their guts for digestion of cellulose in the plant materials.

ECOLOGICAL SIGNIFICANCE OF THE PLANT-GRAZER RELATIONSHIP.

- It determines the distribution of grazers since they tend to be more abundant where there are suitable pastures.
- Man uses grazers to biologically control plant species that may compete with the crops. For example the cactus moths o control the cactus plants (prickly pea).
- It may lead to dispersal of fruits, spores, seeds, parasites since grazers move from place to place in search of pastures.

ECOSYSTEM.

An ecosystem is a natural unit composed of living and non-living components whose interactions result in a stable, self-perpetuating system.
An ecosystem is stable when it adjusts to changes in different environmental conditions within itself. The tendency of the system to maintain a stable state, a balance between biotic and abiotic components is known as homeostasis (self-regulation).Small changes will normally be countered by a feedback processes. An ecosystem is said to be self-perpetuating when it can continue on its own without the necessity for humans or other interference.

STRUCTURE OF THE ECOSYSTEM.

The overall structure of an ecosystem consists of the *Biotic* and *abiotic* components. The biotic components (living components) consists of autotrophic and heterotrophic organisms. Heterotrophs are dependent on the autotrophs for their existence.

Autotrophic organisms are the primary producers and are typically green plants and Algae. Some bacteria such as blue-green bacteria also photosynthesize and are thus producers.
Heterotrophic organisms are the primary consumers. They are also called herbivores. Some primary consumers do not eat the producers but live as plant parasites. E.g aphids and some fungi.

An ecosystem also consists of carnivores which are the flesh eaters. They are the secondary, tertiary and other top consumers. Secondary consumers feed on herbivores, while the tertiary consumers feed on the secondary consumers. Secondary

and tertiary consumers may be predators which hunt, capture and kill their prey, or carrion feeders which feed on corpses, or parasites which lives on and obtain all nutrients from the host organism. Generally, the carnivores become larger and fewer in number at each successive trophic level, while parasites get smaller and increase in numbers.

There are also decomposers and detritivores. Decomposers are micro-organisms mainly fungi and bacteria which live as saprotrophs on dead organic matter. Detritivores feed on small fragments of decomposing or dead materials called detritus.

The abiotic components of an ecosystem include soil, water and climate. Soil and water contain a mixture of in-organic and organic nutrients. The organic nutrients include mainly proteins and carbohydrates. In-organic substances include carbon, nitrogen, oxygen and carbon dioxide.
Climate include such environmental variables as light, temperature, humidity and rain or snow which influences the population size, types of organisms and distribution of organisms in an ecosystem.

In terrestrial Ecosystem, the primary producers are mainly dominated by large plants like the trees, herbs and grasses. The primary consumers are the herbivores which include, insects, reptiles, birds and mammals. The small animals are the detritivores such as earth worms, wood lice, mites, centipedes, millipedes, etc. Detritivores may be eaten by carnivores. Decomposers are micro-organisms mainly fungi and bacteria which live as saprotrophs on dead organic matter. They secrete digestive enzymes onto dead or waste material and absorb the products of digestion.

In aquatic Ecosystem, the primary producers are mainly dominated by microscopic algae and blue-green bacteria together referred to as ***phytoplanktons.*** The herbivores are typically small crustaceans, such as water flea, crab larvae, barnacles and mollusks, they are filter feeders and extract producers from water, the other herbivores are protozoans. The aquatic herbivores form the primary consumers referred to as *zooplanktons.* The aquatic detritivores include rag worms in estuarine environment, sludge worms in fresh waters. Decomposers are micro-organisms mainly fungi and bacteria which live as saprotrophs on dead organic matter. They secrete digestive enzymes onto dead or waste material and absorb the products of digestion.

PROPERTIES/CHARACTERISTICS OF AN ECOSYSTEM.
An Ecosystem exhibit the following properties,

- Energy flow/Energy transfers.
- Feeding relations.
- Cycling of materials/ nutrient recycling.
- Succession and climax (changes in an ecosystem).
- Productivity in an ecosystem (changes in an ecosystem).
- Self-regulating systems (Homeostasis) or control. Evolution (Speciation).

ENERGY FLOW IN AN ECOSYSTEM.

The energy flow in an ecosystem is basically non-cyclic. It is passed along a feeding hierarchy in a chain called food chain. Each feeding stage (feeding level) in a food chain is called trophic level.

The source of energy in an ecosystem is the sun. Sun energy is received inform of electromagnetic radiations. About 40% of the sun's radiation is reflected or absorbed immediately from the clouds, dust, soil, water or vegetation in the atmosphere and the earth's surface. Only 1% of the sun's radiation is trapped by the green plants which are the primary producers (autotrophic organism) and converted into chemical energy in a process of photosynthesis. The rate at which this chemical energy is formed and stored by the primary producers (Green plants) per unit area per unit time is known as gross primary productivity (GPP). Some this chemical energy is utilized by green plants and in the process lost as heat through respiration and photorespiration. The remaining energy stored inform of carbohydrates per unit area per unit time after respiration and photorespiration is known as Net Primary productivity (NPP). The NPP becomes available to the primary producers which are the herbivores at the next trophic level. The herbivores feed on the primary producers to acquire this chemical energy. The rate at which primary consumers (the herbivores) accumulate and store this chemical energy per unit area per unit time is called Secondary productivity (SPP). Some energy is lost in the primary consumers as heat through respiration, excretion, growth, repair, reproduction, un eaten plant parts, egestion, etc. The remaining energy is passed into the secondary and tertiary consumers in the next trophic levels when they feed on the herbivores. In the process energy is again lost as heat through the same processes. Decomposers which include bacteria and fungi utilize energy from every trophic level when the organisms in each stage of the feeding relations die and begin to decompose.

Energy flows out of the trophic levels in the following ways,

- Lost as heat.
- In structures synthesized by the plant but not contributing to increase in biomass. For example shedding leaves, bark, flowers and production of seeds for dispersal.
- Death of plants and animals.

- Plants eaten by herbivores

FEEDING INTER-RELATIONSHIPS IN AN ECOSYSTEM.

This is biotic factor which influence an environment, they include, Food chains. Food webs. And ecological pyramids.
The feeding inter-relationships arise due to grazing, predator-prey relationship, parasitism, mutualism, symbiosis, etc.

FOOD CHAINS.

Food chain is a linear sequence or series of organisms existing in an ecosystem through which chemical energy formed and stored (Carbon compounds produced) by the green plants and other photosynthetic organisms are systematically transferred. Each organisms in the series feeds on and derives energy from preceding one, it is also consumed by another organisms following it and provides energy for that organism. The energy in the food chain is passed along the hierarchy in a chain called food chain. Each feeding level in a food chain is called trophic level. Some energy is lost when it passed from one level to another; this is why food chains are short.

TYPES OF FOOD CHAINS.

There are two types of food chains,
(i) *Grazing food chains.*
(ii) *Detritus food chains.*

GRAZING FOOD CHAINS

Is the linear nutritional sequence of organisms in an ecosystem where the chemical energy is passed in which the first trophic level is occupied b a green plant or green algae and the second trophic level is a grazing animal (Herbivore) and the subsequent levels by the carnivores.

EXAMPLES.

(i) **Grass** ⇒ Grass hopper ⇒ **Frog** ⇒ **Snake** ⇒ Eagle.
(Primary producer) (Primary consumer) (Secondary Consumer) (Tertiary consumer) (Quaternary consumer)

(ii) Plant ⇒ Fly ⇒ Spider ⇒ **Shrew** ⇒ Owl

(iii) Grass ⇒ Deer ⇒ Jaguar

DETRITUS FOOD CHAINS

Is the linear nutritional sequence of organisms in an ecosystem through which a chemical energy is passed and in this case the first trophic level is occupied by the detritus, second by detritivores and the subsequent levels by the carnivores.
EXAMPLES.
(i) Leaf litter ⇒ earthworm. ⇒ Black bird ⇒Sparrow snake.
(ii) Dead animal ⇒ Blowfly maggots ⇒ Common frog⇒Grass snake.

Fragments of decomposing materials are called detritus and many small animals feed on them, contributing to the process of breakdown (decomposition), these animals are called detritivores. Examples of detritivores include,
(i) Wood land detritivores.
Earth worms, wood lice, blow fly maggot,

(ii) Sea shore detritivores.
Rag worm, dog whelk, sea cucumber.

(iii) Terrestrial detritivores.
Earth worms, wood lice, millipedes, mites, nematodes, termites, springtails etc.

HOW SOME DETRITIVORES INFLUENCE THE COMPONENTS OF TERRESTRIAL ECOSYSTEM.

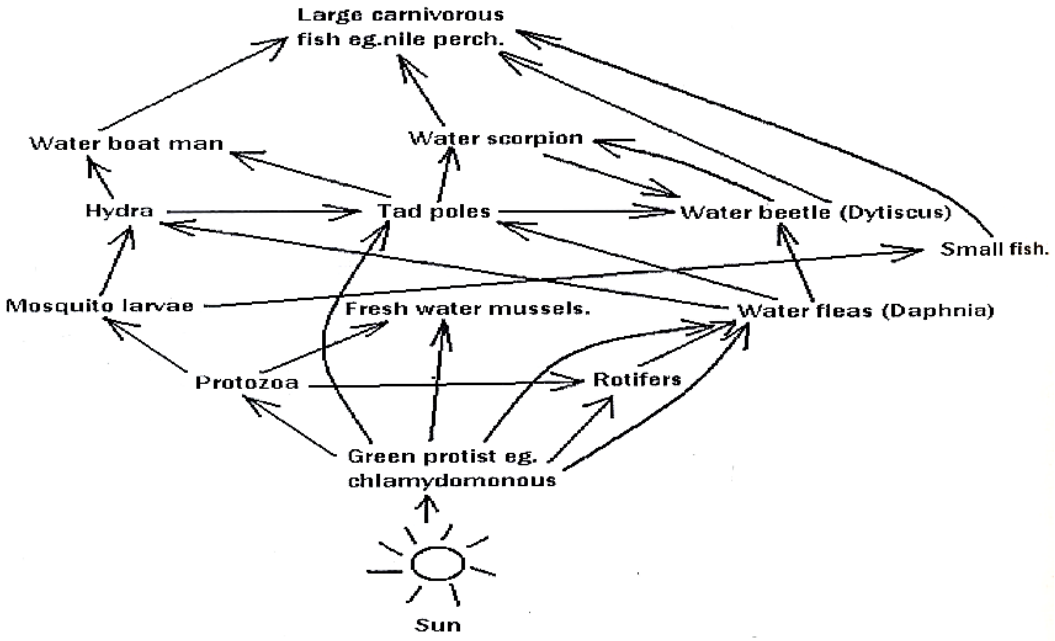
Termites live in nests called termitaria, they build galleries below the soil surface with cemented walls, and this prevents free aeration in the soil and reduces proper drainage of the soil. Termites also carry plant materials into the soil and break them into smaller fragments, increasing their surface area for the process of decomposition by aerobic bacteria. This releases nutrients to the soil. Termites eat other organisms, lowering organic matter content of the soil. Their faecal materials contain uric acid which is incorporated into the termitarion but also adds into the humus content of the soil.

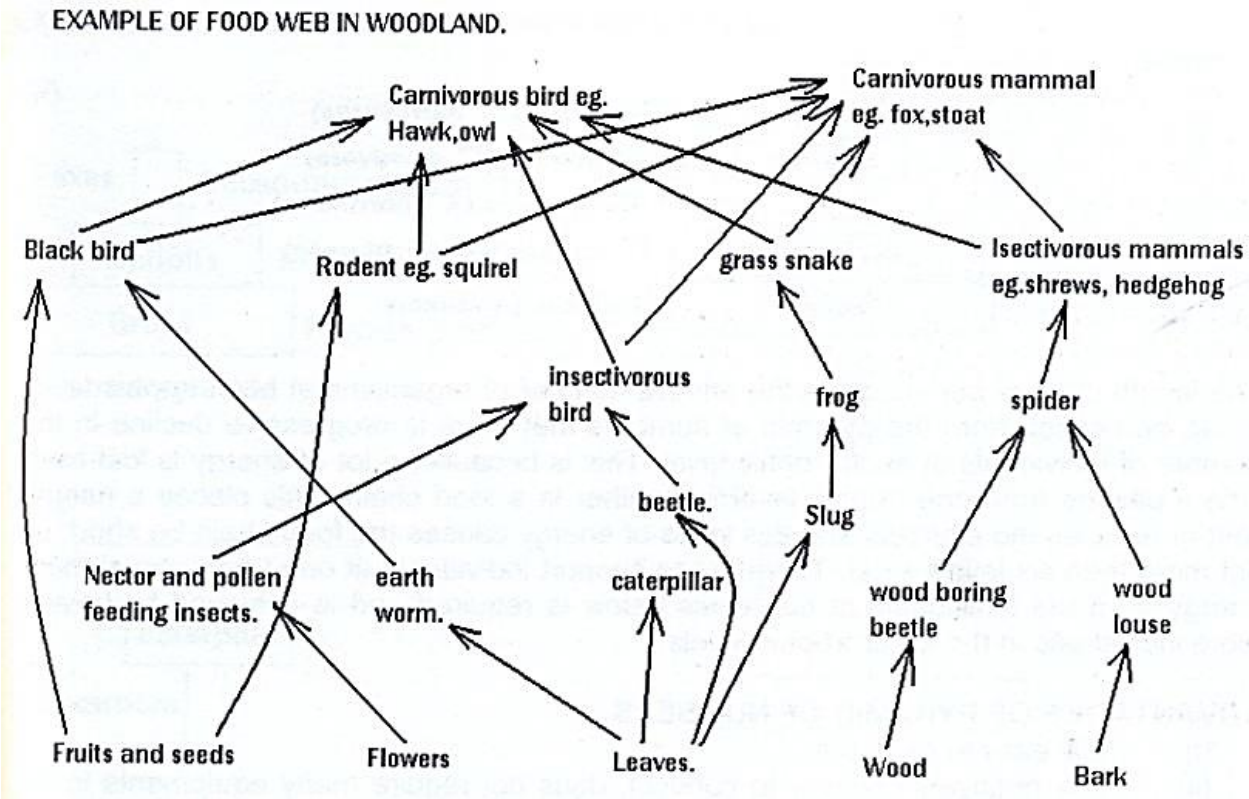
Earth worms burrow into the soil, burrowing promotes and improves aeration of the soil, oxygen is available for activities of aerobic bacteria which increases the rate of decomposition of organic matter, more nutrients are released into the soil. The nitrogenous wastes of the earth worms add more ammonia and nitrates in the soil. Dead individuals are decomposed to add humus into the soil. Earth worms ingest the soil particles and mix the plant materials within the soil. Earth worms contain mucus and bacterial polysaccharides which hold together the fine particles, improving the crumb structure of the soil. The crumbs are not easily dispersed by water and promote the granular texture of the soil.

FOOD WEB.

Is an interconnected food chains in which an animal or organism at one trophic level has several alternative animals that it can feed on at different trophic levels, and also has many other animals that can feed on it at different trophic levels.

EXAMPLE OF A FOOD WEB IN A TYPICAL FRSH WA TER POND.





ECOLOGICAL PYRAMIDS.

Feeding relationships and energy transfers through the biotic component can be quantified and shown diagrammatically as ecological pyramids. Ecological pyramids provides basis for comparing, different ecosystems, seasonal variation within an ecosystem, changes in an ecosystem. There three types of ecological pyramids, these include the following,

- Pyramid of numbers.
- Pyramid of Biomass.
- Pyramid of Energy.

Short comings of the Ecological pyramids include the following,

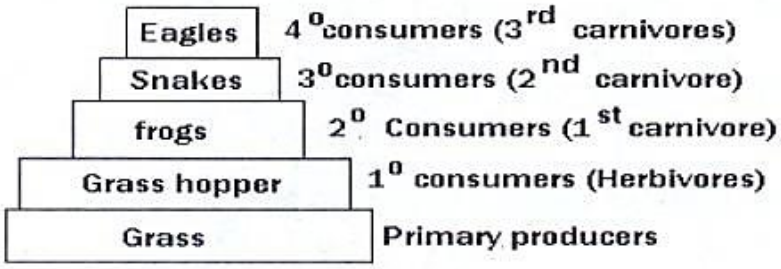
- It is quite not easy to identify the trophic levels of an organism as many organisms feed at several trophic levels.
- It omits the detritivores organic matter content, yet much of the energy fixed may be passed into the detritivores.

- It only considers energy stored by the green parts of the plant and consumed by the herbivores, yet some herbivores cannot digest chlorophyll, others eat only seeds or fruits or nectar.

TYPES OF ECOLOGICAL PYRAMIDS.

PYRAMID OF NUMBERS.

Is a bar diagram indicating the relative numbers of individuals at each trophic levels in a food chain.
Example.



The length of each bar indicates the relative number of organisms at each trophic level. It can be noticed from the pyramid of numbers that there is progressive decline in the number of individuals at each trophic level. This is because, a lot of energy is lost each time it passed from one trophic level to another in a food chain. This places a natural limit or reduces the biomass and this loses of energy causes the food chain be short, i.e not more than six levels exist. Therefore to support individuals at one trophic level more energy from the individuals at the levels below is required and is achieved by having more individuals at the lower trophic levels.

ADVANTAGES OF PYRAMID OF NUMBERS.

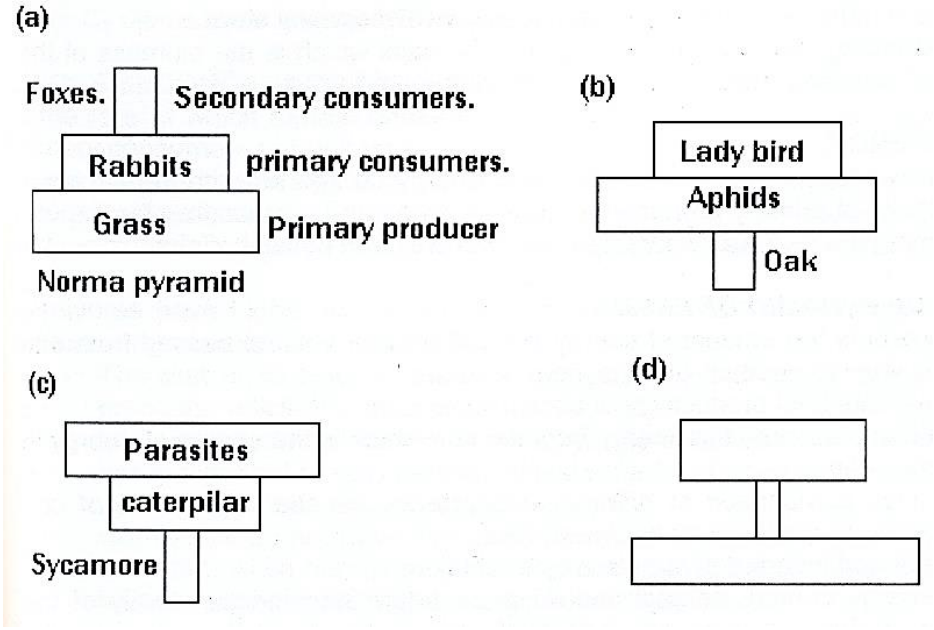
(i) It is easy to carry out.
(ii) It is relatively cheaper to conduct, does not require many equipments to do measurements.

DISADVANTAGES OF PYRAMID OF NUMBERS.

(i) All individuals are counted as the same, yet not all individuals have the same sizes. For example an oak tree is counted as one individual in the same way as an aphid.
(ii) No account is made for juveniles and other immature forms of species whose diet and energy requirements may differ from that of the adults.
(iii) The numbers of some individuals is so large that it is difficult to represent them accurately on the same scales other species in food chain with considerable numbers. For example, Millions of black flies may feed on a single rose-bush and this relationship cannot be effectively drawn to scale on a pyramid of numbers. Such conditions give rise to unusual pyramids of numbers.

(iv) Does not indicate the source of energy in an ecosystem.

EXAMPLES OF UN USUAL PYRAMIDS OF NUMBERS,



(a) In a normal pyramid of numbers for comparison.
(b) The producer is a single plant such as a single tree.
(c) Producer is a single plant, infested with parasites (primary consumers) and the later are parasitized by further parasites.
(d) A large number of producers are eaten by a single primary consumer which is infested with parasites {Secondary consumers)
Some of the disadvantages are overcome by use of a pyramid of Biomass.

•PYRAMID OF BIOMASS.

Is a bar diagram of proportionate length indicating dry mass of all organisms at each trophic level. Biomass is the weight of living material per unit volume or area.

ADVANTAGES OF PYRAMID OF BIOMASS.

(i) Biomass provides a relatively accurate measure of the amount of energy in each trophic level,
(ii) It gives the measure of total productivity in each trophic level.

DISADVANTAGES OF THE PYRAMID OF BIOMASS.

(i) It is impossible to measure exactly the biomass of all individuals in a population. A sample is usually taken and measured and this sample may not be a representative of all organisms at a particular trophic level.

(ii) The biomass of individuals varies from one season to another. For example Biomass of deciduous tree in summer may be different from those in winter, so, the sample only measures the amount material present at a particular time. This is called standing crop and gives no indication of total productivity.
(iii) It involves destroying or killing of the living organisms in order to obtain the dry weight.

(iv) No source of energy is indicated.
(v) It is more laborious and expensive to conduct,
(vi) It is very much time consuming because it involves many steps,
(vii) The standing biomass or standing crop biomass which is the biomass at the time of sampling does not indicate exactly the productivity.

PYRAMID OF ENERGY.

Is a bar diagram in proportion to indicate the total energy utilized at each trophic level. The total productivity of primary producers of a given area can be measured for a given period. But obtaining the necessary data can be a complex and difficult affairs.

ADVANTAGES OF PYRAMID OF ENERGY.

(i) It represents the amount of energy per unit area or volume passed from one trophic level to another. So, it is more accurate.
(ii) It represents total productivity at each trophic level.
(iii) It takes into account the energy from the sun which is the source of energy in an ecosystem.
(iv) It enables comparison of different ecosystems, so, the importance of one ecosystem to another can be determined.
(v) Unusual and inverted pyramids are not obtained.
(vi) The energy content of each individual is determined independently of the others; it shows that no two individual species can have the same energy content.

DISADVANTAGES.

(i) It is most difficult to obtain data for pyramid of energy since it requires a lot of technical knowhow.
(ii) It is expensive to carry out because it requires some sophisticated equipments to do measurements.

PRODUCTIVITY IN AN ECOSYSTEM.

Productivity refers to the rate at which energy and Biomas or organic matter is produced per unit time in a unit area by organisms in an ecosystem. Productivity are of two types,

- *Primary productivity.*
- *Secondary productivity.*

PRIMARY PRODUCTIVITY.

This is the rate at which certain amount of energy and Biomass is, produced and stored by primary producers per unit time in a unit area. It is further divided into,

• Gross ***primary productivity (GPP).***
This is the rate at which certain amount of energy and Biomass is produced and stored by primary producers per unit time in a unit area before any loss of energy due to respiration and photo respiration.

• Net ***primary productivity (NPP).***
This is the amount energy and biomass available per unit time in a unit area after lose of some energy from the Gross primary productivity due to respiration and photorespiration.
i.e
NPP = GPP - Respiration.

In C_3 plants, NPP = GPP – Respiration + Photorespiration.

Note: C_3 plants have a lower NPP than C_4 plants.

GROSS SECONDARY PRODUCTIVITY (GSP).

Is the rate at which certain amount of energy and Biomass is produced and stored by primary consumers per unit time in a unit area.
The amount of the energy and biomass that remains in primary consumer per unit time in a unit area after some energy have been lost from the GSP due to excretion, egestion and respiration is referred to as the ***Net Secondary Productivity (NSP).***

Carnivores have higher Net secondary productivity (NSP) than herbivores because of the following reasons,

- The diet of carnivores is rich in proteins which is easily digested and soluble products efficiently absorbed. In this case, very little energy is lost, while herbivores feed on diet rich in carbohydrate cellulose (plant material) which is not easily digested or only partially digested, a lot of energy is lost in the undigested parts and hence herbivores have lower NSP.

- Carnivores do not have symbiotic microbes to consume part of the energy from their diet, while herbivores have Cellulose secreting bacteria in their guts, these bacteria utilize some of the energy from the cellulose.

FACTORS THAT INFLUENCE PRODUCTIVITY OF AN ECOSYSTEM.

(i) Level of nutrients especially phosphate and nitrates. The higher the level the greater the productivity as they are used in protein synthesis hence more dry matter is formed.

(ii) Temperature. The higher the temperature the higher the productivity since temperature activate enzymes involved in photosynthesis.

(iii) Carbon dioxide concentration. The higher its concentration in air, the greater the productivity since carbon dioxide is a raw material for photosynthesis. The lower the concentration of carbon dioxide the, the lower the productivity.

(iv) Amount of light available. The higher the light intensity, the more energy fixed and the greater the productivity. Lower light intensity results into decreased productivity.

(v) Availability of water. Plenty of water increases rate of photosynthesis since water is a raw material for photosynthesis, hence more energy is fixed raising the productivity.

(vi) Length of growing season. The greater the length, the higher the productivity. The shorter the length, the lower the productivity.

(vii) Relative population size of primary producers. The greater size of green plants, the more energy fixed and the higher the productivity.

(ix) Nature and type of tree species. Certain tree species tend to be more productive than others, therefore the more abundant these tree species are, the greater the productivity. The fewer such tree species, the lower the productivity.

(x) Concentration of pollutants in air. The higher the concentration, the lower the amount of photosynthesis and less energy fixation, hence the lower productivity.

(xi) Chlorophyll concentration in case of aquatic ecosystem, upper zones of lake have higher chlorophyll content than deeper zones, hence the greater the concentration of chlorophyll, the higher the productivity.

(xii) Soil fertility, humus, mineral content. Productivity increases with increase in Soil fertility, humus, mineral content. They are utilized in protein synthesis and formation of new organic matter. Decrease in Soil fertility, humus, mineral content, decreases productivity.

(xiii) Abundance of decomposers which enable nutrient recycling making the nutrients available for synthesis of new organic matter. This will increase productivity. Few decomposers reduce productivity.

ECOLOGICAL TECHNIQUES OF STUDYING FEEDING RELATIONS OF ORGANISMS.

(i) Direct observations of what the organism eats.

This method has some disadvantages,

- It cannot be applied to aggressive animals.
- It cannot be applied to organisms living in concealed and hidden habitat.
- It cannot be applied on organisms which refuse to eat under observation. For example Rodents and some birds.

(ii) Faecal analysis.

This involves studying the content of faeces of a given animal.

This method has some disadvantages that include,

- Some food cannot be seen in the faeces because they are already digested and absorbed.
- It cannot be applied on animals which eat their faeces like Rabbits a practice known as ecopathy. The faeces are eaten because they still contain more nutrients following little digestion and absorption which occurred within the gut.

(iii) Examination of the stomach content.

This is to find out what they feed on and it requires identification skills after enzyme action and mastification.

(iv) Use of radio-active tracers.

It involves labeling available foods using radio-active substances and their trace their presence or absence in the animals gut. It can be used in all animals no matter their nature.

NOTE: To come up with more reliable information, more than one method is used.

CYCLING OF MATTER (BIOCHEMICAL CYCLES).

This is another feature or characteristic of an ecosystem. It is the means by which essential nutrients in nature like nitrogen, carbon, hydrogen and water are maintained constant. The Bio-chemical cycles existing in an ecosystem include,

Nitrogen cycle.

Carbon cycle. - Hydrological or water cycle.

NITROGEN CYCLE.

Nitrogen comprises about 78% of all atmospheric converted into nitrates by the following processes, gases. Atmospheric nitrogen is

• ***Lightening.***

Lightening combines nitrogen and oxygen to form nitrates. Nitrates formed dissolve in rain water and fall down and enter the soil. The nitrates are absorbed by the plant roots and converted into nitrogen compounds in plants such as amino acids and proteins.

• ***Fixation of nitrogen/Nitrogen fixation.***

The aerobic nitrogen fixing bacteria such as *Rhizobium* and *Azotobacter* live in the root nodules of leguminous plants like peas, beans and clover. These aerobic nitrogen fixing bacteria in the root nodules fix or convert atmospheric nitrogen into nitrates which are then built up into amino acids and proteins in the plants. Therefore ***nitrogen fixation*** is the process by which atmospheric nitrogen is converted into nitrogen compounds such as amino acids and nitrates.

The plant materials are consumed by the herbivores and other animals. In this way the nitrogen compounds become available in the herbivores. The herbivores are equally eaten by other animals called the heterotrophic organisms.

When the plants and animals become old, they die and their remains mix with the soil. In the soil, saprophytic organisms like putrefying bacteria and fungi cause the breakdown of proteins in dead decaying organisms to form ammonium compounds. Other ammonium compounds can be derived from any of the following sources,

•Animals excrete urine containing high concentration of the nitrogenous waste urea. Putrefying bacteria convert nitrogen compounds in the urea to ammonia.

• Industrial Haber process produce ammonia that is released into the soil.

• Human activity which involves application of organic farm fertilizers like CAN, NPK releasing nitrogen compounds and urea into the soil. Putrefying activities cause release of ammonia.

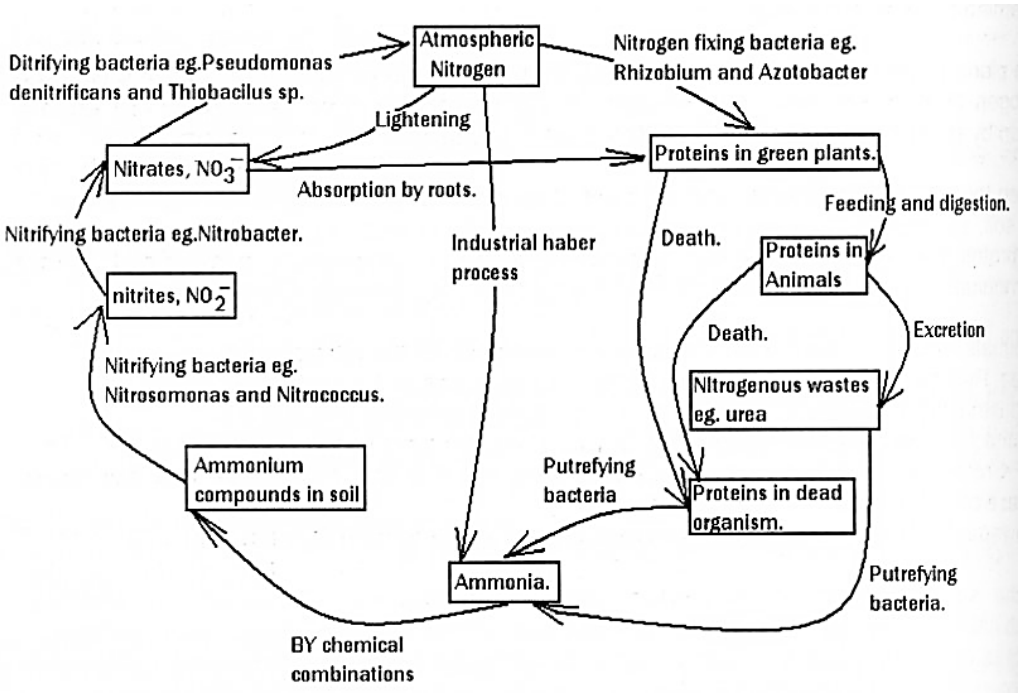
• Sewage discharge on the land. Sewage contains ammonium compounds

In the soil, ammonia is converted into the ammonium compounds by chemical combinations. The ammonium compounds are converted into nitrites and nitrates in a process called Nitrification. Nitrification is the process by which ammonium compounds are converted to nitrites and nitrates in the soil by the activities of nitrifying bacteria.

In this process, aerobic nitrifying bacteria like *Nitrosomonas* and *Nitrococcus* oxidize ammonium compounds to nitrites. Then the Nitrobacter bacteria further oxidizes nitrites into nitrates. Nitrates are absorbed by the plants.
Some of the nitrates in the soil can be converted back into atmospheric nitrogen in a process called ***Denitrification.***
Denitrification is the process by which nitrates in the soil are converted into gaseous nitrogen which is given off into the atmosphere. It is carried out by anaerobic bacteria like Pseudomonas dinitrificans and Thiobacilus dinitrificans. The necessary anaerobic conditions are in water logged soils, where the denitrificans thrive and by converting nitrates to atmospheric nitrogen, they reduce soil fertility. This is why farmers plough and dig up their land in order to improve drainage and aeration so as to avoid anaerobic conditions but instead promote aerobic conditions for the activities of the nitrifying bacteria.

Note that, nitrogen enters the food chain in the following ways,
• Lightening. Includes electrical and photochemical fixation of atmospheric nitrogen to form nitrates.
• Nitrification process.
• Nitrogen fixation.
• Use of organic fertilizers.
Denitrification releases nitrogen into the atmosphere.

THE NITROGEN CYCLE IN AN ECOSYSTEM.



SIGNIFICANCE OF NITROGEN IN ECOSYSTEM

(i) Used for synthesis of amino acids and proteins in plants.

(ii) The amino acids and proteins are used for making structural and fibrous proteins e.g. Muscles and cartilage in animals. The proteins are also used to form functional proteins like enzymes, antibodies and hormones.

(iii) Forms structure of vitamins needed for healthy body.

(iv) Used in synthesis of nucleotides which are subunits for nucleic acids, DNA and RNA.

(v) Utilized in synthesis of chlorophyll which traps sun energy for photosynthesis.

(vi) Components of plant hormones auxin, responsible for cell division, elongation resulting into growth. Also used in synthesis of insulin in animals, required for regulation of sugar levels in blood.

Deficiency of Nitrogen in plants causes,

Stunted growth.
Chlorosis (yellowing of leaves).

While in animals, it's deficiency is due to deficiency of proteins in the diet and causes, Kwashiokors.

Stunted growth.

General body weakneses.

And oedema.

CARBON CYCLE.

The composition of carbondioxide in the atmosphere is about 0.03%. Despite this small proportion, carbondioxide is the major pool of carbon for plants and animals in an ecosystem.

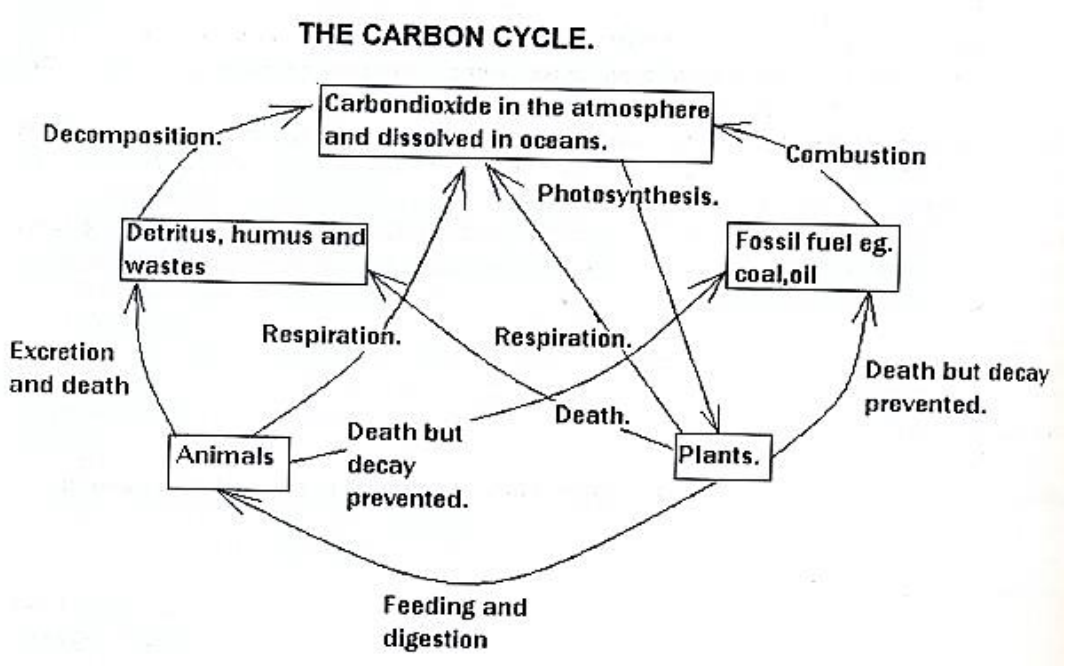
Carbondioxide is removed from the atmosphere by the process of photosynthesis by photosynthetic organisms. In this case, green plants absorb carbondioxide from the atmosphere, phytoplanktons absorb dissolved carbondioxide from the water. The carbondioxide is utilized for the manufacture of carbohydrates, proteins and fats in a process of photosynthesis. The plants are eaten by herbivores which digest and assimilate the foods originally synthesized by the plants. The herbivores are in turn eaten by the carnivores which also acquire the assimilated carbon.

Carbondioxide is subsequently returned into the atmosphere through the following processes,

•Aerobic respiration by many living organisms produce carbondioxide.

• Death of plants and animals and rapid decomposition or decay of their remains by the activities of the saprophytes or putrefying bacteria, this releases carbondioxide.

•When large quantities of dead plants and animals accumulate in anaerobic conditions and prevented from decaying, they form coal, oil and other fossil fuels. Combustion of these fossil fuels produce large amounts of carbondioxide into the atmosphere. The processes that absorb carbondioxide from the atmosphere and those returning it into the atmosphere function in such a way that the concentration of the carbondioxide is maintained fairly constant in the ecosystem/atmosphere.

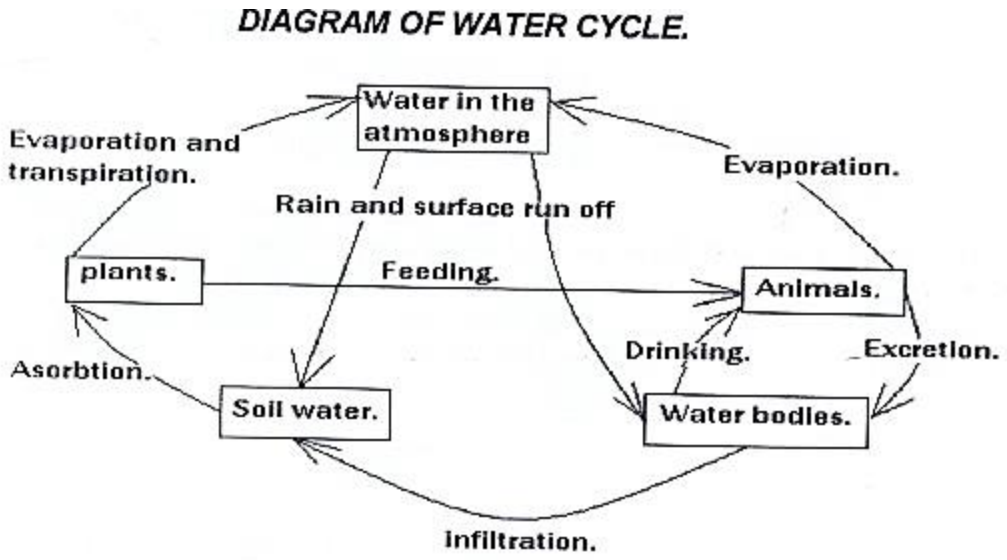


HYDROLOGICAL CYCLE (WATER CYCLE).

Water in the atmosphere exists as water vapour which form part of the cloud, subsequent condensation results into rain fall. Rain water is carried into water bodies and some rain water infiltrates the soil. Some water from various water bodies like rivers, lakes, seas also infiltrate into the soil to collect as soil water. Excretion of urine and faeces to a small extent add to the water bodies.

Plants absorb soil water by the root hairs. Animals drink water drawn from the water bodies. Animals can also obtain water when they feed on plant parts such as fruits, stem, roots which store high amounts of water.

Water is returned into the atmosphere when water evaporates from the surfaces of the skin of the animals, surfaces of the leaves, stem of plants through transpiration, and evaporation from water bodies.



HUMAN ACTIVITIES THAT AFFECT WATER CYCLE.

Dam construction which slows down the speed of water movements.

Swamp and land reclamation which drains water bodies and reduces the amount of water in the open water systems.

De-forestation which reduces the rate at which underground water is reabsorbed by the plants since the trees are cleared which absorb the underground water.

Over utilization of the underground water by excessive construction of boreholes and use of underground water pumping machines.

HUMAN ACTIVITIES THAT AFFECT NUTRIENT CYCLING AND ENERGY FLOW IN AN ECOSYSTEM.

(i) ***Deforestation.***

This is cutting down or felling down of trees. It reduces amount of sunlight absorbed due to decrease in number of producers. Soil erosion occurs, resulting into lose of more nutrients since soil layer is removed in the process.

(ii) ***Air pollution.***

This results from addition in excess of greenhouse gasses into the atmosphere, such gases include, carbondioxide, chlorofluorocarbon (CFC), and sulphur dioxide gas. Greenhouse gases results into depletion of ozone layer. While the rain water can dissolve sulphur dioxide gas to form acid rains.

Ozone depletion results into global warming may cause death of many consumers. Global warming and acid rains cause destruction of producers, decreasing the number

of producers, productivity is lowered which also lowers energy along the trophic levels.

(iii) ***Use of green houses and lighting of red and blue.*** Red and blue Wave lengths increase photosynthesis and number of producers, increasing light energy trapped.

(iv) ***Mulching*** reduces weed growth, thereby decreasing light energy absorbed by plants.

(v) ***Harvesting of crops.*** It involves removal of crops which reduces food energy available for herbivores. The herbivores (primary consumers) are eaten by humans.

(vi) ***Hunting.*** This removes energy available for carnivores and other organisms in food web.

(vii) ***Burning dead organisms*** including humans. Forest fires started by humans reduces energy available for decomposers and detritivores.

(viii) ***Use of pesticides and herbicides.*** This affect decomposers making recycling of materials slower.

COMMUNITY ECOLOGY.

Is a group of organisms of different species or species populations living together in a particular area, interacting with one another. Community represents biotic (living) part of an ecosystem, it is a dynamic which consists of the following units, energy flow, cycling of matter, it also involves interactions between the community members, these include, competitions, predator-prey relations, mutualism, communities may also under changes in a process of ecological succession.

ECOLOGICAL SUCCESSION / COMMUNITY CHANGES.

Succession is the sequence of change from the initial colonization of a new area to establishing a relatively stable community.

The main features of ecological succession include, they are of two forms, occur gradually and in stages called seres or serai stages, there is pioneer community gradually replaced by other communities until a relatively stable community which is in equilibrium with its environment called climax community is reached

Ecosystems are dynamic. They are constantly changing in response to both physical factors such as climate and biological factors resulting from the activities of organisms within the communities. Communities change gradually from one type to another.

A succession principle is applied to land restoration. Rapid colonization by vegetation of waste mine lands, reclaimed lands, construction sites, etc is important means of stabilizing them.

TYPES OF ECOLOGICAL SUCCESSION.

There are two types of succession. These are. *Primary succession. Secondary succession.*

PRIMARY SUCCESSION IN TERRESTRIAL ECOSYSTEM.

Is the sequence of change from the initial colonization of a new area which has never been inhabited before like bare rocks, sand or cooled lava flow, etc to establishing a relatively stable community (climax community). Primary succession occurs in three stages, pioneer stage, spruce stage and climax community. The process proceeds quite slowly. It begins when the propagation structures like seeds, buds, rhizomes, stolons and bulbs are not readily available.

• ***Pioneer stage.***

During this stage, bare rock breaks down physically and chemically during the process of weathering. The acidic rains in tropics dissolve more minerals which cause further disintegration of the rocks. The existing conditions do not favour growth of most plant species but lichen which is an association between algae and fungi are the first to inhabit the rock. They are referred to as the pioneer organisms. Algae are a drought resistant and photosynthetic, providing food for the fungi. Some invertebrates exist and feed on the algae. Then the hyphae of the fungus penetrate tinny cracks, absorbing minerals and widening the cracks further, the hyphae also provide support. Some lichen die, decay and add onto the organic matter.

After the activity of the lichen has enlarged the cracks in the rocks and filled them with decomposing dead lichens, the conditions within the rock become favourable for the growth drought resistant and sun tolerant mosses as well as insects that feed on them. Mosses form a dense mat like network which traps tiny particles of rocks, some organic debris and water, some thin soil layer begin to form and lichens gradually replaced by the mosses and liverworts.

• Spruce stage.

Death and decay of the mess plants adds nutrients to the rock particles. Thickness of soil increase and this favours the growth of herbs like the ferns, grasses and other angiosperms. Animals like amphibians, reptiles and birds also come in. Some herbs die off and add on the organic matter. The soil layer become thick enough.

• *Climax stage.*

Soon large woody shrubs begin to grow in the newly formed soil. The mosses and the lichens may be shaded or covered by decaying leaves and other vegetation. Eventually as a thicker layer of soil develops, trees are able to take root in deeper rock

crevices and the shrubs disappear. Larger animals may also come in. After a very long period of time, a mature forest community grows. This is the *climax community.*

Climax community is defined as the relatively stable community which is in equilibrium with its environment. A single type of climax community is known as *climatic climax* A community where human interventions have led to a relatively stable community very different from the original climax is termed as a *plagioclimax.* The succession is said to have been deflected. A climax community can have one *dominant* or *several co-dominant* species. Dominance in this case, refers to the species with the greatest collective biomass or productivity. Species with larger size can be referred to as being dominant.

DIAGRAM OF SUMMERY OF PRIMARY SUCCESSION.

Bare rock.⟶Lichens⟶Herbs⟶Shrubs ⟶Young Wood ⟶Climax community

(Algae and fungi) Land (Large trees)

PRIMARY SUCCESSION IN AQUATIC ECOSYSTEM.

In ponds and lakes, organic matter builds up from dead remains of plants and animals and sediments brought by the water run offs from the land. This causes the water in these water bodies to become shallower and richer in nutrients, allowing rooted plants to grow and crowd along the shores of the ponds, rivers and lakes.

The growth of these plants extends further into the pond, river and lake. More sediment is trapped in the process and the water become even shallower. The ponds, rivers and lakes develop into mashes, then into swamps which support growth of many herbs and shrubs. Given good climatic and ecological conditions, after a long time a wood land develops and eventually large trees forming climax community.

SECONDARY SUCCESSION.

Is the sequence of change from the initial colonization of an area which has previously been inhabited by a particular community like cleared forest, abandoned field, burnt area to establishing a relatively stable community (climax community).

In secondary succession, the pioneer organisms are fast growing annual plants like Bidens *pilosa, commelina species,* they grow in an area which was previously inhabited by well-established communities. The animals which become available at this stage include insects, detritivores such as earth worms and their predators. When some of the organisms die, they decompose and add organic matter into the soil.

After a few years, herbs such as *Lantana camara* begin to establish themselves in the area. After many years, the shrubs like Acacia and other small trees come in place, these shrubs gradually replace the herb community in the area. At this stage birds come in place. Due to favourable climatic conditions, accumulation of sufficient nutrients in the soil, a climax community comprising of large trees and larger animals develop. The animal communities keep changing with changing plant communities.

DRIVING FORCES OF SUCCESSION (INITIATIVES OF THE SUCCESSION PROCESS).

(i) Nudation.

This is exposure of a given locality to succession stages. For example clearing a given plant community to have an open land.

(ii) Arrival of propergules.

In this case, the propagation structures such as seeds, stolons, rhizomes and corms etc are dispersed to the locality or the already existing propergules begin to establish.

(iii) Germination (Easis).

The established propergules together with the newly introduced ones germinate.

(iv) Competition.

The germinated propergules begin to exhibit both interspecific and intraspecific competitions.

(v) **Reaction.**

A better adapted and well established individuals out compete those which are less adapted to the environment.

(vi) **Establishment**

A better competitor establish a climax community.

CHANGES THAT TAKE PLACE IN A COMMUNITY DURING THE SUCCESSION PROCESS.

(i) Species composition changes and its more rapid in the pioneer or early stages.

(ii) Biomass and non-living organic matter increases,

(iii) There is increased specialization in the trophic levels which become longer with upto five levels. Food webs become established from food chains.

(iv) Primary productivity in the community reduce because of increased specialization.

(v) Total number of species represented in a community becomes fairly stable,

(vi) Species diversity becomes high,

(vii) The structure of the community change from simple to complex with many microhabitats and stratification.

(viii) Niche specialization become narrow from being broad.

(ix) The size of organisms become large.

r-SPECIES AND k- SPECIES.

The first species to colonise an area are known as r-species (opportunists) and the last species to colonise the land are known as the k-species (equilibrium species).

Examples of r-species. Annual plants like the herbs, bacteria, paramecium, aphids, beetles etc.

Examples of the k-species; Perennial plants, large birds, tropical butterflies, humans etc.

DIFFERENCES BETWEEN r-SPECIES AND k-SPECIES.

r-SPECIES.	***k- SPECIES***
(i) Reproduce rapidly.	(i) Reproduce slowly.
(ii) Reproductive rate not sensitive to population density to population density (i.e they do not stop producing when the number is large).	(ii) Reproductive rate is sensitive to population density (they stop producing when the number is large)
(iii) Show significant population fluctuations.	(iii) Population size is close to equilibrium.
(iv) Are not very persistent in the environment.	(iv) Are very persistent in the Environment.
(v) Are small in size,	(v) Larger in size.
(vi) Disperse widely.	(vi) Do not disperse widely in an area.
(vii) Occupy short lived habitats eg. Bacteria on rotting.	(vii) Occupy long lived habitats eg. Trees in a forest.
(viii) Have shorter life cycle.	(viii) Have a longer life span.
(ix) Are poor competitors.	(ix) Are good competitors.
(x) Do not become dominant in an area.	(x) They become dominant in an area.

POPULATION ECOLOGY

Population is a group of organisms of the same species occupying a particular place at a given period of time, a population is usually isolated to some extent from other similar groups by geographical barriers. And ***a population size*** is the number of individual organisms of the same species living in an area at a given period of time.

Population density. Is the number of individuals per unit area.

PROPERTIES/CHARACTERITICS OF ANY GIVEN POPULATION. (i) Density.

Is the number of individuals per unit area of the living space.

(ii) Mortality rate.

Is the number of individuals which die within a population in a given area at a given period of time.

(Hi) Birth rate/natality rate.

Is the number of individuals born reproduced within a population in a given area

(iv) Fecundity.

Is the reproductive capacity of individual female species.

In mammals the birth rate is used to measure the fecundity. And therefore the size of a population is regulated by,

Balance between its fecundity and its mortality.

Migration rate, these include, Immigration, this is where individuals join or enter into a population from neighbouring areas and Emigration, this is where individuals depart or leave a population.

(v) Age distribution or age structure.

It refers to the proportional distribution of individuals of various ages in a given area. It gives information about the future trends of a population growth. More young individuals than the old ones indicate a growing population, while less young individuals than the old ones indicate declining population.

(vi) ***Biotic potential.***

Is the maximum rate at which members of the species can reproduce with unlimited resources and under an ideal environmental condition.

(Vii) Growth form.

It refers to the variation of a population size with time.

(viii) Carrying capacity.

Is the maximum number of individuals that can be supported or sustained by available natural resources in an environment.

(ix) Dispersion (Distribution).

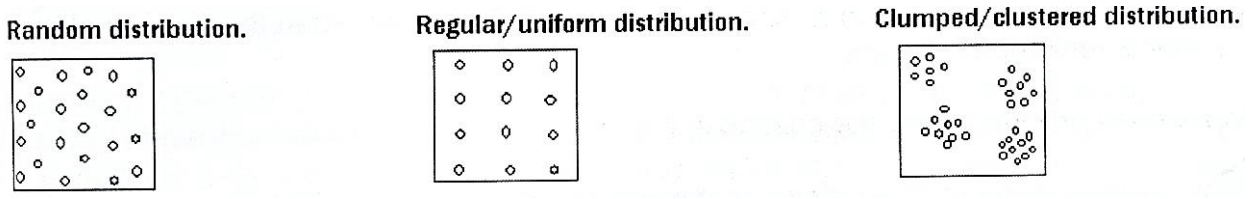
It is the spatial distribution of individuals within a given area. Dispersion is divided into three types, dispersion or distribution is divided into,

Random distribution.

Uniform or Regular distribution.

Clamped or clustered distribution.

TYPES OF DISTRIBUTION/DISPERSION.



Random and Regular or uniform distributions are quite rare in a population for the reasons that, environment is not usually uniform in terms of availability of resources, there is not intense competition.

In the other hand, clumped or clustered distribution is quite common because of the following,

Resources are clustered in nature or rarely uniform.

Social interactions are common resulting in social groups.

Some reproductive patterns favour clumping for example vegetative propagation in plants, the young animals remain with their parents for long among animals.

ADVANTAGES OF RANDOM AND UNIFORM DISTRIBUTION.

(i) Competition for natural resources like food, mates, space among the organisms is reduced.

Prevents spread of diseases since the organisms are not overcrowded. Leads to maximum utilization of resources in the habitat since wide range of habitats are occupied.

DISADVANTAGES OF RANDOM AND UNIFORM DISTRIBUTION.

(i) The organisms may lack group protection against their predators.

(ii) The organisms somehow far apart, reducing chances of locating mates.

(iii) Plants are not properly protected from strong winds.

ADVANTAGES OF CLUMPED DISTRIBUTION.

(i) Both the adult and young organisms are offered better defence and protections against predators.

(ii) Plants are quite close and can resist strong winds,

(iii) There are better chances of locating mates.

DISADVANTAGES.

(i) Increases competition for resources,

(ii) Increase spread of diseases.

(iii) There is little utilization of natural resources since small range of habitat is occupied.

POPULATION GROWTH AND CHANGES IN POPULATION.

Population growth is the measure of change in a population. The change can either be positive when the number of organisms increase and negative change when the number of organisms decrease. There is no change in population growth when the number of the organisms remained constant.

Population growth rate is the change in the number of individuals per unit time.

Many environmental factors determine the size of a population by affecting,

• Birth rate

Number of births or number of adults in a population.

• Death rate.

Number of deaths in a population.

• Immigration.

The amount or number of individuals moving or entering into the population.

• Emmigration.

The amount or number of individuals moving out or leaving a population.

In favourable conditions the population grows if,

Number of births + number of immigrants is greater than number of deaths + number of emigrants.

In unfavourable conditions, the population will decrease if,

Number of births + number of immigrants is less than number of deaths + number of emigrants.

IMPORTANCE OF POPULATION GROWTH AND POPULATION SIZE OF DIFFERENT ORGANISMS IN ECOSYSTEM.

(i) To construct food webs, food chains, pyramid of numbers, pyramid of

Biomass and energy,

(ii) To be able to understand the existing food relationships within the habitats.

The predator and prey organisms are easily identified,

(iii) To realize population changes overtime or seasons, so as to understand the way populations are affected by various environmental factors,

(iv) It determines the population of the pests, to help in designation of control methods and rapid prevention of its spread.

(v) To determine the carrying capacity of a habitat of different populations so as to maintain ecologically balanced habitats,

(vi) For management of national parks, game parks, game reserves and forest reserves to enable plans for cropping programmes.

(vii) To be able to value wild life reserves (national parks) and design or alter boundaries of various conservation areas.

FACTORS THAT AFFECT OR INFLUENCE SIZE OF POPULATIONS IN AN ECOSYSTEM.

These factors are divided into two broad categories, the density dependent and density independent factors.

DENSITY DEPENDENT FACTORS THA T INFLUENCE SIZE OF POPULA TION.
Density dependent factors are those factors whose effectiveness in controlling the size of population depends on the number of individuals or organisms per unit area. These factors are usually biotic and they include the following,

(i) ***Availability of food/water/nutrients.***

Plenty of food favours reproduction and increase in population size and lack of food and water leads to reproductive failures and death. This causes declines in the size of the population.

(Hi) ***Diseases and pests.***

Where there is a large number of individuals crowded together diseases spread rapidly and cause deaths, reducing the population and where there is overcrowding of individuals, diseases are rare and population grows.

(v) ***Accumulation of toxic wastes.***

Toxic wastes can cause death of some organisms and reduce their population size. Non-toxic environment provides favourable condition for growth of organism and the size of population increase.

(vi) ***Predation.***

Predators feed on other organisms called the preys. Where the number of predators are few or individuals have the ability to avoid predators, the population size increase. While a decline in the size of population is caused by large population size of predators or individuals lack ability to avoid predators.

(vii) ***Availability of space/shelter.***

This includes breeding sites. It determines protection of organisms from hostile environmental conditions, determining their survival. Plenty of suitable space increases population size. While, lack of suitable space or in adequate space decreases population size.

(viii) ***Reproductive or Biotic potential.***

High biotic potential increases size population of organisms, while low Biotic potential decreases the population size of organisms in an ecosystem. Large size of reproducing individuals in a population will increase size of population; few reproducing individuals in a population will maintain low population size.

(ix) ***Stress factors /psychological factors.***

These include stress factors arising from overcrowding. It leads to abnormal behaviours that may lead to reproductive failures, low food intake, decreasing population size. Absence of stress conditions increase size of population.

(x) ***Territorial behaviour/territoriality.*** It occurs among wide range of animals such as certain fish, reptiles, birds, mammals and social insects where a male or both male and female animals demarcate an area which they defend against members of the same species. Territoriality limit size of a population within the territory more than outside it.

DENSITY INDEPENDENT FACTORS THAT INFLUENCE SIZE OF **POPULATION.**

Density independent factors are those factors whose effectiveness in controlling size of population does not depend on the number of individuals or organisms per unit area. These factors are usually abiotic and they include,

(i) Availability of light.

Sufficient light intensity provides light energy for photosynthesis and favours the growth of plant population. This causes increase in the population size of the plants (primary producers). The animals feed on these plants, they reproduce rapidly and their population size too increases. In- adequacy of light or its absence limit plant population.

(ii) Availability of oxygen.

Oxygen is utilized by aerobic organisms for respiration, its presence in sufficient amounts favours growth of aerobic organisms, hence growth of population size of these aerobic organisms and its absence or insufficient amounts limits size of populations, especially in aquatic organisms.

(iii) Climatic conditions such as, temperature, relative humidity, salinity, wind when favourable increase growth of plants and survival of animals, hence leads to increase in size of population size and when these climatic conditions are not favourable lowers survival of organisms, hence decrease population size.

(iv) Catastrophies such as fire, storms, and floods may lead to sudden mass deaths of organisms, reducing size of population. In absence of such Catastrophies population size remain increasing.

(v) ***Edaphic factors,*** these are soil factors such as soil temperature, pH, air, water content, mineral and organic matter when favourable favour plants growth and activities of micro-organisms, increasing the size of population and when un favourable decrease the size of population.

(vii) Pollution, high levels of any kind of pollution will limit the population size of organisms compared to low level or no pollution of the ecosystem.

(viii) Topography. It influences local climate and "soil factors. The main topographic factor is altitude. Higher altitudes are associated with lower average temperatures, higher precipitation, increased wind speed, lower atmospheric pressures, more intense radiations, these lower growth rate and support smaller size of population than lower altitudes.

Mountains are climatic barriers to dispersal and migration, limiting increase in population size.

Population grows and declines in characteristic ways. The size of population increase is determined generally by the reproductive potential (Biotic potential and environmental resistance.

Maximum Biotic potential (Reproductive potential) of an organism is the rate of reproduction given unlimited environmental resources.

Environmental resistance is both biotic and abiotic factors that together prevent the maximum reproductive potential to be achieved and as such limit growth of a population. They include external factors such as shortage of food, water or oxygen, lack of light, presence of predators and parasites, lack of shelter (space), excessive heat, intraspecific competition and behavioural adaptations.

The balance between biotic potential and environmental resistance determines the ***carrying capacity for*** particular population.

CARRYING CAPACITY

Carrying capacity is the maximum number of individuals that can be supported or sustained using the available natural resource in an environment.

FACTORS THAT DETERMINE CARRYING CAPACITY OF THE ENVIRONMENT.

Food shortage. Increased predation. Overcrowding. Competition.

CONDITIONS THAT MAY CAUSE CARRYING CAPACITY TO BE EXCEEDED.

Removal, death or absence of predators in an area.

Abundant food supply.

Favourable climatic or weather conditions.

Adequate space/shelter/breeding sites.

High Biotic potential.

Low mortality rate.

ENVIRONMENTAL INDICATORS FOR A POPULATION THAT HAS EXCEEDED ITS CARRYING CAPACITY.

Destruction of vegetation, rapid environmental degradation.

Extinction of some species of organisms.

Accumulation of wastes.

Increased rate of emigration. Rate of emigration exceeds immigration.

Death rate exceeds birth rate.

POPULATION GROWTH CURVES.

These are graphs which show the trends of population growth over a period of time. There are two types of growth curves,

J-shaped growth curve.

S-shaped or Sigmoid growth curve.

J-SHAPED GROWTH CURVE.

It describes a situation where organisms better adapt in the initial lag phase, then the population size increase rapidly during the exponential phase that it exceeds the carrying capacity then population growth suddenly stops and declines, population crash occurs. The populations that show this type of growth curve is referred as boom and bust populations. Its growth is regulated by density independent factors. Overpopulation can damage the environment leading to a new lower carrying capacity. After the crash the population fluctuates around the new carrying capacity. The abrupt stop (population crash) may be caused by,

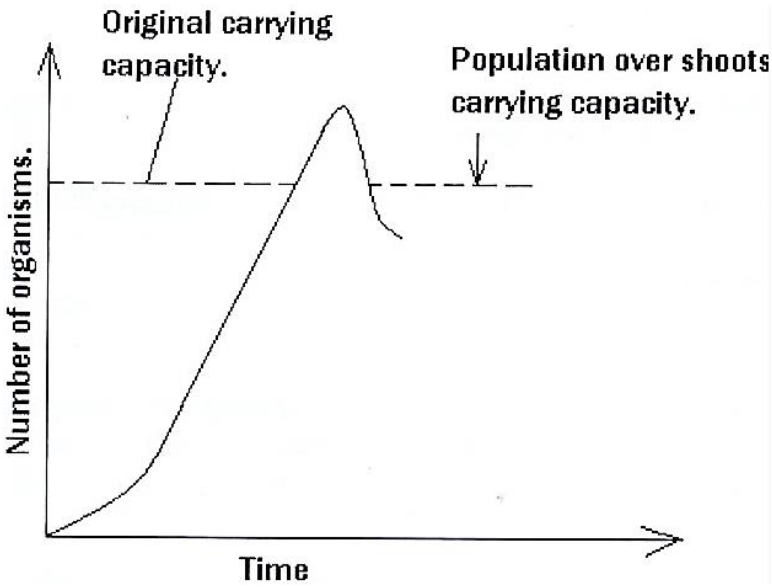
Application of pesticides or insecticides to control an insect pest.

Harsh environmental conditions.

End of breeding season.

End of particular stage in the life cycle of some organisms.

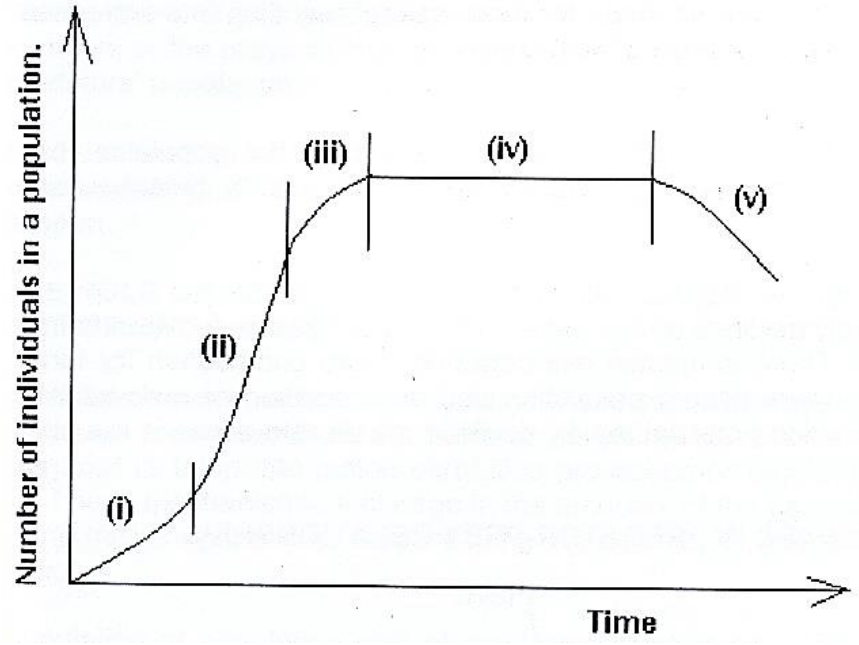
J-SHAPED GROWTH CURVE.



THE SIGMOID GROWTH CURVE.

The type of population that exhibits the sigmoid growth curve has population growth controlled by the density dependent factors. It is associated with a population living in an area with limited resources.

S-SHAPED SIGMOID GROWTH CURVE.



(i) Lag phase.

(ii) Exponential phase,

(iii) Decelerating phase,

(iv) Stable phase,

(v) Decline phase.

DESCRIPTION OF THE SHAPE OF THE GRAPH.

Initially the number of individuals in a population increase gradually and then the increase become drastic/rapid, but as it is approaching the carrying capacity, the number of the individuals in the population begin to increase slowly until it reached maximum, after which it remained constant for while and gradually decrease.

EXPLANATION OF THE GRAPH.

(i) ***Lag phase,***

Population increase slowly because there are fewer reproducing individuals and they are widely dispersed. In some cases, the organisms are not fully adapted to the environmental conditions, only the few individuals start to reproduce.

(ii) ***Exponential phase.***

Population increase or grow drastically/rapidly/steeply/fast. This is because there are more individuals reproducing, there is no environmental resistance, food and space are sufficient, there is no competition for the available natural resources such as food, shelter, water, oxygen, light and biotic potential is higher and hence the natality, or birth rate exceeds mortality rate. In some cases, the organisms have adapted to the environmental conditions which is more favourable to the organism.

(iii) ***Decelerating phase.***

The population increase slowly/gradually until it reaches maximum. This is because the environmental resistance sets in like shortage for food, space, resulting into increased competition, death rate increases exceeding the birth rate.

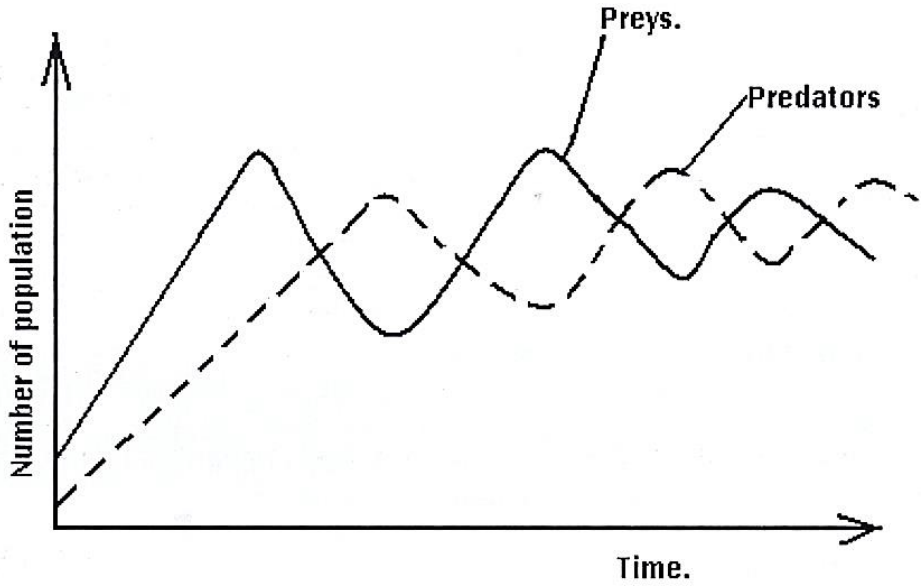
(iv) Stable phase/ constant phase.

The population of the individuals remains constant. In this case the population has reached its carrying capacity. The birth rate and the death rate exactly balance each other resulting in equilibrium.

(v) Declining phase.

The population rapidly/steeply declines or decreases. This is because the environmental resistance at its maximum. There is intense overcrowding, more competition for food, space, oxygen, etc. occurs, there occurs production and accumulation of toxic wastes from the organisms, reproduction potential rapidly declines, death rate exceeds the birth rate.

THE CYCLIC GROWTH CURVES IN PREDATOR-PREY RELATIONSHIPS



EXPLANATION OF THE PREY-PREDATOR CURVES.

DESCRIPTION.

Initially the population of the preys increases more rapidly than that of the predators until the population of the preys reach maximum, then the population of the preys decline rapidly as the population of the predators increase rapidly until the population of the predators reach maximum or peak, there after the populations of the preys and the predators rises rapidly and falls rapidly (fluctuates).

REASONS FOR THE CHANGES IN THE PREYS AND THE PREDATOR POPULATIONS

Predators feed on the preys and therefore the predators reduce the numbers of the prey. When the population of the preys is higher, predators are provided with enough food and there is no competition. This increases their reproductive potential and the number of predators rapidly increases until it reaches it's peak. At this stage more preys are fed on and the number of the preys decline rapidly, then the predators begin to compete with each other for the scarce food available which are the few preys. Some predators die of starvation. The predator population therefore declines. The reduction in the numbers of the predators results in fewer preys being eaten and so allows the numbers of the preys to increase again, this increases in turn leads to an increase in the predators' population.

Predator and prey populations are therefore regulated by **a *negative feedback mechanism*** that keeps the populations balanced at levels that the environment can support.

THE ROLE OF NEGATIVE FEED BACK MECANISM IN CONTROL OF POPULATION SIZE OF ORGANISMS.

Feedback mechanisms. Are systems that detect a change in the level or amounts of a particular parameter from the norm or normal levels, then the system is stimulated or triggered to bring into action corrective processes or regulatory processes. In negative feedback mechanisms, a change in the amounts of the parameter about the norm or set point, triggers processes that will bring the amounts or the levels of the parameter back to norm.

Regulation of population size of most organisms in an ecosystem is by negative feedback mechanism, which maintains size of population at the carrying capacity (the Norm) with minimum oscillations or deviations. When the population size increases far beyond or above the carrying capacity, environmental resistance or environmental stress factors set in, like competition for scarce natural resources such as food, space, mates. Other stress factors such as accumulation of own toxic wastes, starvations also occur, resulting into death of some organisms. The population size declines back to normal. And when the population size decreases below the normal, the environmental stress factors are removed, encouraging population growth and the size of the population increases back to norm.

However, human population cannot be regulated by negative feedback mechanisms. This is due the following reasons,

Modern methods of food production have led to production of plenty of food hence deaths due to hunger have been minimized.

Manufacture of drugs has minimized deaths due to diseases and other pathogenic infections.

Improved standards of living such as good hygiene, people tend to live longer.

Use of contraceptives or birth control methods has controlled abnormal rise in human population.

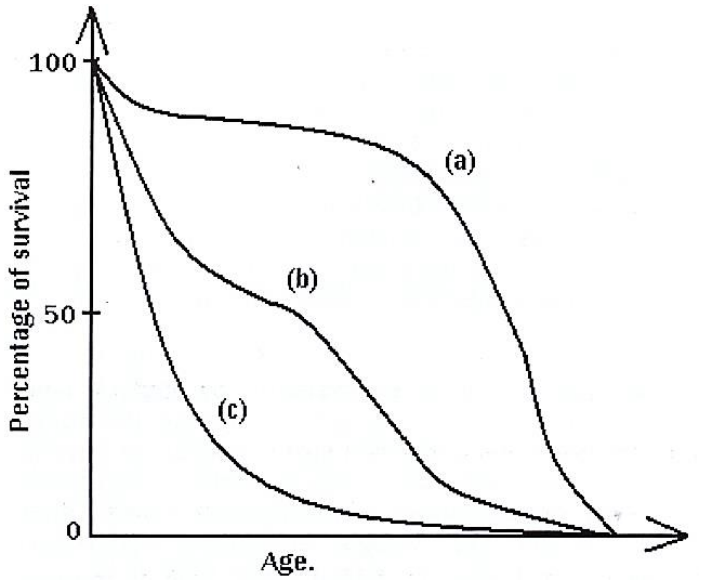
SURVIVORSHIP CURVES.

It indicates the relationship of the new born individuals and the decrease in numbers of survivors with time. When number of survivors is plotted against time, a survivorship curve is obtained. On the vertical axis, actual numbers of survivors may be plotted or percentage survival.

The percentage of individuals which die before reaching reproductive age (pre-reproductive mortality) is one of the major factors affecting population size. Different organisms have characteristic survivorship curves, some examples are shown in the graph below.

Percentage survival = $\frac{Numbers\ of\ survivors}{Number\ in\ original\ population} x\ 100$

A GRAPH SHOWING SURVIVORSHIP CURVES.



EXPLANATION OF THE CURVES. ***Curve (a).***

Shows ideal curve for a population in which senescence is the major factor affecting mortality. An example is a human population in modern industrialized country in which the standards of medicine and nutrition are maintained and so most people live to old age. But the life expectancy cannot be prolonged beyond 75 years of age. The initial gradual decrease of the curve is due to the infant mortality. The drastic decrease of the curve can be due to the following,

Accidental deaths i.e deaths through car accidents, etc.

Senescence (ageing). Is the general decline in the normal physiological functions of the body systems (declining vigor) with increasing age beyond maturity, resulting eventually into death of the organisms.

The immediate cause of the senescence are, reduced resistance to external factors such as diseases, others causes include, mistakes in protein synthesis, degeneration of cells, in-efficient homeostasis, auto immunity. Auto-immunity is where old people produce anti-bodies against their own antigens.

In curve (a) the population would combine its high survival rate with low reproductive rate to maintain a stable population.

Curve *(b).*

Is for a population with a high mortality rate early in life like for humans in a country in which starvation and diseases are prevalent.

In this case, the population would need a higher reproductive rate to maintain a stable population since high percentage of individuals would die before reproductive age is reached.

Curve (c)

It indicates a smooth curve that would be obtained if there was a constant mortality throughout life. In this case, chance is the major factor influencing mortality and organisms die before senescence with high juvenile mortality, examples is in the hydra where there is no special risks attached to being young, most non-vertebrates and plants.

NOTE: Minor variations in survivorship curves may occur within species due to sexual differences, for example in humans female life expectancy is slightly greater than for males.

FACTORS TO BE CONSIDERED BEFORE DETERMINING POPULATION SIZE OF ORGANISMS.

(i) Size of the area,

(ii) Nature of vegetation,

(iii) Topography or terrain,

(iv) Size of organisms to be counted.

(v) Behaviour of the organism or its social structure and activities,

(vi) Nature of the habitat whether terrestrial or aquatic, concealed or non-concealed habitat,

(vii) Resources available for example, apparatus, money etc.

METHODS/TECHNIQUES FOR ESTIMATING THE SIZE OF POPULATION IN AN ECOSYSTEM.

The methods used to estimate the size of a population is divided into two categories, Total count methods. Sampling methods.

TOTAL COUNT METHODS.

This method involves physical count of all the organisms in an area under study. In this method, the whole area is searched, all organisms are counted and it should give absolute number of organisms in the whole area. These methods include the following,

Direct observation.

Aerial photography.

Removal methods.

DIRECT OBSERVATION.

This involves direct counting of all the animals in the whole area of study. The total number of the animals observed and counted is recorded. It is applied to sessile, slow moving animals and also applied to many larger mobile organisms that do not live in concealed areas such as deer, lions, wood pigeons and bats as they leave their roost. Direct observation methods is further divided into,

• Drive and Count methods.

Here the animals are driven by number of people to a particular spot and they are counted. It applies to large animals which live in non-concealed areas and less hostile. ADWWTAGES.

(i) It reduces the chances of counting the same animals more than once.

(ii) It is a fairly quick and easy method for animals which live in herds.

DISADVANTAGES.

(i) It involves disturbance of the animals which may make them aggressive.

(ii) It can be applied on aggressive animals.

(iii) It is difficult to apply on animals which live in herds,

• Strip census.

In this method, animals are counted along paths while walking or in vehicles. Population density is determined as number of individuals per unit area of the strips. It is applied to large animals which live in non-concealed areas.

ADVANTAGES.

(i) It is fairly quick.

(ii) It is comparatively cheaper than aerial photography.

DISADVANTAGES.

(i) The animals may be scared by the passing vehicles or even by the presence of the human beings and scared away, such animals may not be counted at all.

(ii) Some animals avoid paths and therefore may not be counted.

(iii) Very many counts must be conducted in order to get reliable information.

(iv) Some of the animals are too mobile and are likely to be counted twice.

• ***Direct counting using a low flying air crafts.***

This method involves physical counting of all the animals within the study area. It is applied to large animals living in non-concealed habitats for example, Lions, Buffaloes, Rhinos, giraffes and elephants.

In this method, the study area within the park is surveyed using a low flying light air crafts, then a low flying light air craft is flown along a transect and animals along the transect are counted. The air craft then flies back along another adjacent transect and counting continues until the whole area sampled is covered. Several such counting are carried out and an average is determined, the product of the average count and the total square per unit area of the study area gives the estimated size of population of the organisms.

ADVANTAGES.

(i) Is a very quick method of estimating population.
(ii) It can be done concurrently with other studies for example studying feeding habits.
(iii) It can be applied in some aggressive animals like lions since it has minimum risks of the researcher being attacked.
(iv) It is less tiresome and not laborious.
(v) It reduces the chances of counting the same animals more than once since it very organized.

DISADVANTAGES

(i) It is very expensive since it involves expensive equipments like air-crafts.
(ii) The air craft may scare.

(iii) It is difficult to apply on animals that live in concealed habitats.

(iv) It can be applied to very small animals since they may not be seen from a distance,

(v) It's operation can be affected by bad weather or poor climatic conditions for example when the weather is misty or foggy.

AERIAL PHOTOGRAPHY.

This method is also applied to larger animals which live in non-concealed habitats,

Procedure.

Survey the area of the park with low flying light air craft, photograph the animals in places within the study area where they are present in groups or herds, count their number from the developed photographs, repeat the process of photography and counting animals from the developed photographs at regular intervals of time over a given period of time,

the average number of animals counted from photographs is obtained, then the product of the average count and the total area gives the number of the individuals per unit area.

Note: The advantages and the disadvantages of this method is the same as those for direct counting.

ADVANTAGES.

(i) Is a very quick method of estimating population.

(ii) It can be done concurrently with other studies for example studying feeding habits.

(iii) It can be applied in some aggressive animals like lions since it has minimum risks of the researcher being attacked,

(iv) It is less tiresome and not laborious,

(v) It reduces the chances of counting the same animals more than once since it very organized.

DISADVANTAGES.

(i) It is very expensive since it involves expensive equipments like air-crafts,

(ii) The air craft may scare away the animals which may go into hiding and end up not being counted.

(iii) It is difficult to apply on animals that live in concealed habitats,

(iv) It can be applied to very small animals since they may not be seen from a distance.

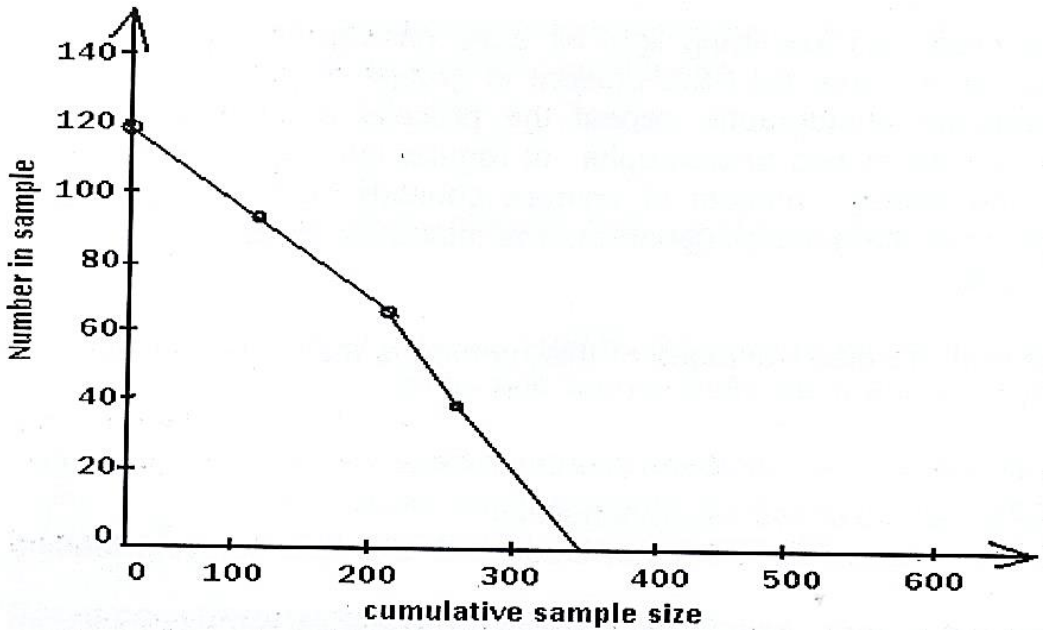
Its operation can be affected by bad weather or poor climatic conditions for example when the weather is misty or foggy.

REMOVAL METHOD.

It suitable to estimate numbers of small organisms, particularly insects within a known area of grass land or volume of water. Using a sweep net, the number of animals captured is recorded and the animals kept. This procedure is repeated three times and the gradually reducing numbers recorded. A graph is plotted of number of animals captured per sample against the previous cumulative number of animals captured. By extrapolating the line of the graph to the point at which no further animals would be captured i.e number in the sample = 0, the example of how the population will be estimated is shown below,

Sample	Number in sample	Cumulative sample size
1.	120	0
2.	93	120
3.	60	213
4.	35	273

A GRAPH SHOWING VARIATION OF NUMBER IN SAMPLES WITH CUMULATIVE SAMPLE SIZE



The estimated population size is equal to the cumulative sample size when the number in sample is zero (0), according to the graph = 350 individuals.

SAMPLING METHODS OF ESTIMATING SIZE OF A POPULATION.

Is the random determination of the number or distribution of organisms within a population. In this method, only part of the area is surveyed, only a few organisms within the study area are counted but bias should be avoided and every organism must have equal chances of being chosen in the sample, which must be large and the total number of organisms in the whole area is calculated or estimated from the sampled plots. These methods include,

Capture-mark release recapture method.

Quadrat method.

Use of line transect/Belt transect.

(i) CAPTURE - MARK RELEASE RECAPTURE METHOD.

This method is suitable to determining population of animals which are small, mobile, fast moving, live in concealed habitats and they can easily be tagged or marked, examples include, arthropods, fish, small mammals and birds.

In this method, a number of animals are captured using traps which are set up randomly within an area. The animals are marked for instance arthropods may be marked on their back with non-toxic dabs of paint, fish can have tags attached to their opercula, mammals may have tags clipped to their ears and birds can have their legs ringed. The number of the marked animals recorded is **labeled N** and then they are all released back into the population and given sufficient time to mix freely in the population. After a period of time, the raps are set up again randomly in the area and the animals are captured for the second time and the number of the animals captured for the second time is **labeled as M,** at the same time the number of the animals captured and marked (recaptured animals) is **labeled R.**

The size of the population size is estimated is determined using Lincoln index as,

Estimated population size =

$$\frac{\text{Total No. of Individuals in the First samples } (N) \times \text{Total number of individuals in the second sample } (M)}{\text{Number of marked individuals recaptured } (R)}$$

$$= \frac{\boldsymbol{N \times M}}{R}$$

ASSUMPTION OF THE CAPTURE MARK RELEASE RECAPTURE METHOD.

(i) Organisms mix randomly within the population.
(ii) Sufficient time must elapse between capture and recapture to allow random mixing. The less mobile the species of animals the longer the time lapse must be.
(iii) It is only applicable to populations whose movement is restricted geographically.
(iv) Organisms disperse evenly within the geographical area of the population.
(v) Changes in population size as a result of immigration, emigration, births and deaths are negligible.
(vi) Marking does not hinder the movements of the organisms or make them conspicuous to predators or death of the animals.
(vii) The population of the marked to unmarked individuals in the second sample is the same as the proportion of marked to unmarked individuals in the whole population.
(viii) Every marked animal has the same probability of surviving the sampling period.
(ix) Every animal captured, marked and released have the same or equal probability of being recaptured.

PRECAUTIONS TO BE TAKEN.

(i) The marks should not be harmful to the animals.

(ii) The marks or the tags used should not be conspicuous to the predators.

(iii) Sufficient time should elapse between the first and second capture.

(ii) QUADRAT METHOD.

A quatrat is a metal or wooden frame with one metre sides. It encloses an area of $1m^2$, however, larger quatrats marked on ground by either ropes or suitable materials may also be used. It is a random sampling method. This method is suitable to estimate population size of plant species and sessile organisms or very slow moving organisms. In this method, survey the area under study and establish its size in square metres, then a quadrate of known square meters i.e $1m^2$ is thrown at random on an area marked randomly and the number of enclosed organisms are counted, such of these of throws are carried out several times. An average of these counts is taken and the population size is estimated by determining the product of the average count taken and total square meter of the area under study.

Size of population = *Average number of animals in $1m^2$ Quatrat **X** Total square metre of area under study*

EXAMPLE:

If 5 quatrats of 1 m^2 show number of certain plant species as 1^{st} qutrat = 3, 2^{nd} quatrat = 7 3^{rd} = 2. 4^{th} = 4, 5^{th} = 4 respectively, if the total area under study = $500m^2$.

The size of population can be estimated as follows,

5 quatrats = 20 plant species.

1 quadrate of $1m^2$ = $\frac{20}{4}$ = 4 plant species.

Therefore $1m^2$ quatrats = 4 plant species.

$500m^2$ = 4x500 = 2000 plant species.

The quadrate method provides means of studying three aspects of species,

(i) Species density.

This is the number of individuals of a given species in a given area. It is obtained fay counting the number of organisms in randomly thrown quadrats.

(ii) Species frequency.

This is a measure of the probability or chance of finding a given species within any one throw of a quadrat in a given area. This is obtained by recording the presence or absence of the species in a randomly thrown quadrat.

(iii) Species cover.

This is the measure of the proportion of the ground occupied by the species. It gives the estimate of the percentage of the area covered by the species. It is obtained by observing the species covering the ground at a number of random points.

ADVANTAGES OF USING QUADRAT METHODS.

(i) It is cheap method to carry out since it does not require many expensive types of equipment to use.

(ii) The aspect of species density makes this method accurate enabling different areas and different species to be compared,

(iii) Species density provides an absolute measure of abundance of species in an area.

(iv) The aspect of Species frequency is easy and quick to conduct,

(v) It can be applied in large ecosystem such as wood land.

DISADVANTAGES.

It is time consuming like in determination of species density.

In determining species frequency, the quadrat size, plant size and spatial distribution affect the results.

It is slow and tedious like in determining species cover.

It can only be efficiently applied in estimating population size of plants species.

(iii) LINE TRANSECT/BELT TRANSECT.

This consists of record of plants occurring along a line taken by stretching a string in a study area. Survey the area under study to establish its size in square metres. Then a tape or string is stretched along the transect line and only plants touching or beneath the tape or string are counted or the plant species touching or beneath the tape or string are recorded. This method is useful to study changes in plant species in an area (Qualitative data) however, to establish size of population of plant species using this method (Quantitative data), several counts are made, and an average of such counts is taken, the population size is a product of average count and total size of the area under study in square metres.

Belt transect

Is where parallel strings called twines are tied across a habitat by help of pegs. The areas between the strings are belts which can be divided into small squares. Organisms within the belts are recorded. This method can be applied for both plants and animals in larger area of study.

In belt transect method, both a quadrat and a line transect can be used. The type of a transect to use depends on the following factors,

Qualitative or quantitative nature of the investigation.

Degree of accuracy required.

Nature of organisms present.

Size of the area to be investigated.

Time available.

Over a short distance a line transects is used and over a longer distance the species present every metre or any other suitable distance is recorded. Height variations recorded along line or belt transects produce a profile of transect known as profile transect.

NOTE: State advantages and disadvantages of using line transects.

METHODS USED TO COLLECT ORGANISMS.

There are several methods which include, trapping, trapping is a method of collecting moving organisms using a trap.

(i) Pit fall trap.

It is inform of a hole dug in a path where the animals pass and when they reach it they fall into it.

(ii) Sticky trap.

is made of wooden sheet onto which a sticky substance is applied when an animal comes into a contact with the sticky substance, it gets trapped and cannot move away.

(iii) Light trap.

It is made up of a mercury vapour light trap that attracts flying organisms which hit baffles and fall down into the base and become trapped in cardboard egg boxes or crumbled up paper. It traps night flying insects like the moths.

(iv) Footer.

This is where a collecting tube is directed to slow moving insects or other arthropods like, aphids, small insects and spiders. Air from the bottle is sucked from the sucking end. This results in reduction of pressure within the bottle, this draws the insect into the bottle. A mosquito netting is placed at one end to prevent the insects from being sucked out of the bottle.

(v) Using strainer or sieve.

This is for collecting soil arthropods. Sample of soil is collected and placed on a strainer. It is then heated from above using moderate heat source. As the soil dries from the trap, the trapped organisms move to the lower layer and finally fall into collecting container below the strainer

(vi) Tullgren funnel.

This method is useful to trap many soil and leaf litter-dwelling organisms that move from source of heat and towards moisture conditions. A soil sample or litter sample is placed in the sieve about 25cm below a bulb in a metal reflector. Every two hours the bulb is moved closer and nearer to the soil sample. The apparatus is left for a total of 24 hours.

All small arthropods move down wards and drop through the metal gauze into the alcohol.

(vii) Sweep net and plankton net.

A sweep net is a nylon attached to a steel handle and swept through grass, bushes, ponds or streams. It used for collection of insects and crustaceans.

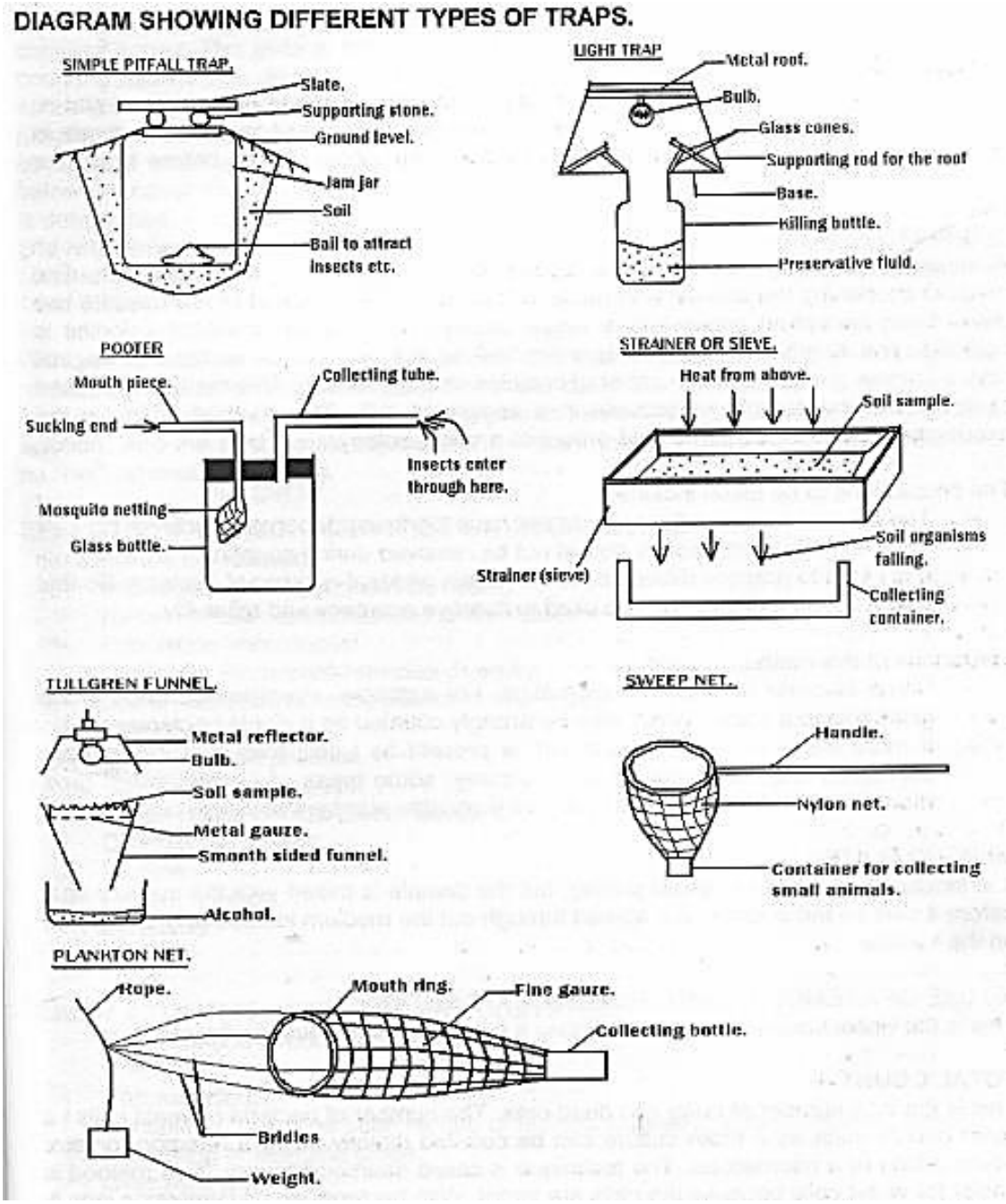
Plankton net is a bolting silk net attached to a metal hoop and rope harness and towed through the water. A small jar is attached to the rear of the net to collect specimens. It is used to collect planktons (zooplankton and phytoplanktons) in water.

(viii) Hand-sorting.

Samples of soil or vegetation. For example grass, leaf litter, pond and seaweed, are placed at one end of a tray and small amounts of materials are systematically examined between the fingers, specimens are removed to a collecting jar and sorted material passed to the other end of the tray. The sample is then examined as it is moved back to the original end of the tray. This method is applied for collection of mites, insect larvae and pupal stages.

(ix) Extractions.

Small quantities of 5% formaldehyde are added to $50cm^3$ of water and the solution is sprayed to square metres of lawn or grassland. Earth worms are driven out of their burrows and collected and immediately washed in water to remove the formaldehyde.



METHODS FOR ESTIMATING POPULATION GROWTH OF MICRO-ORGANISMS.

When estimating the population growth of micro-organisms such as, bacteria, fungi, and yeasts, it can be done by directly counting the number of cells or by indirectly measuring some indications of the number of cells such as the cloudiness of the solution, or production of the gas. There are two types of cell counts and these are,

Viable counts.

Total counts.

VIABLE COUNTS.

Is the total number of living cells only. Viable counts can be made using spread plates, pour plates and haemocytometry. For example the effectiveness of pasteurization milk in killing certain bacteria could be measured by making viable counts before and after pasteurization.

(i) SPREAD PLATES.

A known small volume of sample is added to the nutrient agar in a Petri-dish. The medium containing the sample with bacteria is incubated for a period of few days i.e two days. Each bacterium grows into a single colony. The number of visible colonies is counted. The number of bacteria is estimated as the number of bacteria in original added sample is equal to the number of colonies after incubation. This method is applied to determine the number of bacteria in a sample of milk. This method relies on the assumption that each bacterium will grow into a single colony.

The precautions to be taken include,

The original sample added should not have too few or too many bacteria. The lids of the Petri-dishes should not be removed during counting. It is usual to prepare dilution series to obtain an ideal number of bacteria. So that only a suitable dilution can be used to improve accuracy and reliability.

Limitations of this method include

Some bacteria form chains or groups. For example, streptococci. Each group gives rise to a colony which may be wrongly counted as a single bacterium. If more than one type of bacterium is present as I soil, milk or water sample, conditions will not favour all types equally, some types of bacterium will grow more rapidly than others. This will give a variable numbers of visible colonies

(ii) POUR PLATES.

It is similar in principle to spread plating, but the sample is mixed with the nutrient agar before it sets so the colonies are spread throughout the medium instead of growing only on the surface.

(iii) USE OF HAEMOCYTOMETER/HAEMOCYTOMETRY.

This is the viable counts of yeast cells using a haemocytometer and methylene blue.

TOTAL COUNT.

This is the total number of living and dead cells. The number of bacteria or yeast cells I a liquid culture such as a broth culture can be counted directly using a haemocytometer which

a king of a microscope. The technique is called haemocytometry. This method is easier for yeast cells because the cells are larger. With bacteria, an oil immersion lens is required.

HAEMOCYTOMETRY METHOD FOR ESTIMATING POPULATION SIZE/ GROWTH **OF MICRO-ORGANISMS.**

A haemocytometer slide is obtained. Counting grid is put into the surface of the slide. A cover slip is placed and to ensure close enough contact between slide and cover-slip, the cover slip is pressed down firmly either side of the counting chamber, the cover slip is moved slightly until coloured lines appear on either sides of the cover slip. The liquid sample in the pipette is applied on one side of the slip and drawn under the cover-slip by capillary action. The slide is left for 2 to 30 minutes to allow the cells to settle, making counting easier. The microscope is focused on the grid and the number of cells in the entire grid or represented sample is counted. Where cells lie in the boundary, they are judged as in the square to avoid counting half cells. The grid or the counting chamber consists of small squares. Each small square is a known area and the depth of liquid below the cover slip is constant (usually 0.02mm or 0.1mm). The volume of each square is determined. The total area for the grid is $1mm^2$. If the gap between cover slip and the grid is 0.02mm, the total volume above the grid is therefore $1 \times 0.02 = 0.02mm^3$ then the number of cells in a given volume is counted, (note $1000mm^3 = 1cm3$ and $1000cm^3 = 1\ dm^3$ (1 litre)

With yeast, methylene blue stains is added, this stains dead cells blue and living cells remain colourless or very pale blue. For yeast cells, the best method is to count the increase in number of yeast cells on a daily basis i.e number of yeast cells/cm^3 of culture solution. And the final results represented as graph of daily increase in yeast cells (log no./cm^3) against time (days).

EFFECTS OF HUMAN ACTIVITIES ON ECOSYSTEM.

These include the following,

Interruption of biogeochemical cycles.

Natural resources imbalances and exhaustion.

Population imbalances.

Decline in Biodiversity/species diversity.

Soil erosion/soil exhaustion/loss in soil fertility.

Extinction.

Environmental pollution.

Drought/Desertification.

Green house effects/Global warming.

Disease out breaks.

Famine.

Loss of habitats.

Speciation.

HUMAN ACTIVITIES AFFECTING AN ECOSYSTEM.

Pesticide use to control pests.

Pollution.

Deforestation.

Agricultural practices such as use of fertilizers, mulching, crop rotation, weeding, harvesting of standing crops.

Over fishing.

Urban development. These include activities such as construction of dams, bridges, houses, roads, recreation centers and reclamation of swamps and wet lands for urban development.

Hunting and poaching.

Use of fire to burn forests and grasslands.

Mining activities.

Nuclear plants.

Industrialization.

BIODIVERSITY/SPECIES DIVERSITY.

Biodiversity is defined as the variety of species on earth or the richness of the natural world. It includes ecosystem complexity, genetic variation, biochemical diversity and species richness.

Species richness specifically refers to the number of species present in a habitat. The most commonly used measure of biodiversity is a species diversity index. It is calculated using the number of species present and the abundance of each species called the Simpson species diversity index.

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

Where,

D is the diversity index.

N is the total number of individuals of all species found.

n is the total number of individuals belonging to a particular species.

Σ is the sum of, for all the individual species present in a habitat.

The species index can be related to the abiotic harshness of an environment for example during different stages of ecological succession or the level of pollution in an ecosystem. Generally, the species diversity is greater in habitats in which abiotic conditions are less demanding or in which pollution levels are lower.

LIMITATIONS OF THE SIMPSON SPECIES INDEX.

• It does not take into account the differences in sizes of the individuals.

• It is difficult to apply in determining the species index for plants because it is not always easy to decide what constitutes a plant.

• Some species index are based on biomass and do not depend on identifying individual species.

• The Simpson species diversity index is sometimes used as an indicator of ecological stability, the assumption being that the greater the diversity, the greater the stability. But stability of an ecosystem is defined in many other ways such as,

Resistance. The ability of an ecosystem to resist a change following a disturbance.

Resilience. The ability of the ecosystem to return to its original state after being changed.

Local stability. The tendency of a community to return to its original state after small disturbance.

Global stability. The tendency of a community to return to its original state after a large disturbance.

Each of these types of stability is sometimes but not always related to species diversity.

In ecological terms, a more complex community leads to a more stable ecosystem. Complex ecosystems with high species diversity were assumed to be more stable.

PEST CONTROL AND PESTICIDES.

A pest is any organism that people find undesirable. It may cause harm economically or affect someone's health. A agricultural pests cause economic damage to crops and farm animals. Most pests cause significant damage when their populations reach ***economic injury level*** which is the pest population level which cause significant economic level. And

therefore a pest control measures must be started at a lower pest population level called ***economic damage threshold.*** This is the pest population level at which treatment is needed to prevent population of pests reaching the economic injury level.

METHODS OF PEST CONTROL.

Pests can be controlled by any one of the following methods, Cultural control methods. Chemical control. Biological control. Integrated pest management/Combination of the control methods.

(1) CULTURAL CONTROL METHODS.

Cultural methods such as weeding, tillage and crop rotation are among the most common methods of pest control. Weeding and tillage remove weeds and overturn the soil that may expose insect pests to predatory birds. Crop rotation often prevents the buildup of pests that occur in monoculture. Other cultural methods of pest control include the following,

• Removing the remains of crops and badly damaged plants which might harbour pasts.

'Creating physical barriers for example apple trees are protected from their potential pests by putting sticky bands on their trunks.

• Covering the soil with organic material (mulching) which prevents light from reaching weeds.

• Growing crops or harvesting crops at a particular time in the life cycle of the pest when the pests can do least damage. For example in maize.

• Intercropping, Planting two different crops in the same field, for example undersowing cereal crops with rye grass provides suitable conditions for ladybirds which control aphids on the cereals.

(2) CHEMICAL CONTROL.

This method involves the application of toxic chemicals that control pest population called pesticides.

Pesticides are defined as chemical substances used by humans to control pests. Different types of pesticides are classified according to the pest organisms that they treat. These include,

• *Herbicides.* These are pesticides that kill plant species.

• *Insecticides.* Are pesticides that kill insects.

• *Fungicides.* Are pesticides that kill fungi.

• *Contact pesticides* kill pests without being eaten for example penetrating cuticles of insects.

• *Systematic pesticides* are taken into a plant and translocated within the plant and enter the pest when it eats the plant or its sap.

• *Broad-spectrum pesticides,* designed to control a wide range of pests, may also kill harmless or beneficial ones such as the predators of the pest.

Most pesticides are poisons and aim to kill the target pest species. But others can cause sterility (chemosterilants) or inhibit growth.

ECOLOGICAL CHARACTERISTICS OF PESTICIDES.

The important ecological characteristics of pesticides are toxicity, persistence and specificity.

• Toxicity.

Toxicity is defined by the lethal dose 50 (LD_{50}). This is the single dose which kills half an experimental population. When organisms are subjected in addition to environmental stresses a higher proportion die.

• *Persistence.*

This is the length of time that pesticide remains in the environment and within organisms without being broken down. An example of a persistent insecticide is DDT. Persistence is undesirable quality of a pesticide particularly on food crops. However, in the control of animal parasites and soil-borne diseases, persistence makes the pesticides effective and efficient, but persistence for too long is very damaging to organisms.

• ***Specificity.***

This is the range of organisms the pesticide can affect. DDT is an example of a broad spectrum pesticide, it seriously affects many different kinds of animals. Narrow-spectrum pesticides only affect a restricted range of organisms.

Use of broad-spectrum pesticides can lead to **pest *resurgence.*** This is when numbers of the pests after treatment increase to more than before the treatment. This is because the pesticide kills both the pest and predator of the pest.

PROPERTIES FOR IDEAL/GOOD PESTICIDES.

(i) Specificity. It must be specific so that it has minimal effects on the species other than the pests. The pesticide should have a narrow range of organisms it affects otherwise, if it has a broad spectrum, it may kill the pest and its natural predators leading to resurgence when a few pests survive.

(ii) Toxicity should be adequate to kill most of the targeted pests within a short period of time without damaging crops. The lethal dose should be sufficient enough to kill the pests.

(iii) It should be cheap to produce and manufacture.

(iv) Non-persistence. Relatively non-persistent in the eco-system, the pesticide should not remain in the environment including within organisms without being broken down as long term persistence may lead to accumulation along the food chain, thereby affecting the untargeted organisms.

(v) It should be bio-degradable. It can gradually be broken down to simpler and less harmless substances once it has accomplished the purpose for which it was applied.

(vi) Non-volatile so that it cannot be carried in the atmosphere by wind.

CONCENTRATION EFFECTS OF PESTICIDES IN FOOD CHAINS.

This is the progressive accumulation of certain toxic chemicals such as herbicides and pesticides in the body organisms at a particular trophic levels and is availed in even much higher concentrations to the organisms in the next trophic levels. Examples of the toxic pesticides that can accumulate in food chain include, DDT (Dichloro Diphenyl Thchloroethane), Dieldrin and aldrin.

In 1960s DDT was detected in the livers of penguins in the Antarctic, a habitat very remote from the areas where DDT might have not been used. Pesticide poisoning has devastating effects on carnivores occupying higher trophic levels. This is because of its concentration effects in food chains. Disadvantages of DDT pesticide in food chains in an ecosystem include,

High mortality rate (death) among vertebrates especially birds.

Leads to extinction of some species of organisms especially birds from an ecosystem due rampant deaths.

It reduces resistance to diseases in some organisms.

Reduction in fertility (low fertility) among organisms especially carnivorous vertebrates.

Leads to reduction in calcium metabolism in birds, resulting to production of thinner egg shells which easily break.

It kills species of some insects, pests and other organisms.

ADVANTAGES OF DDT PESTICIDE.

Easily affordable and relatively cheap to produce.

It effectively kills mosquitoes and their larvae and therefore very efficient in control of malaria, which is the biggest killer disease in sub-Saharan Africa.

It is quite persistent and have a long lasting effects and more efficient in eliminating pests, important in controlling animal parasites and soil- borne diseases.

In more recent years, some powerful but non-persistent pesticides have been developed to replace DDT, i.e Organophosphate.

CONCENTRATION EFFECTS OF DDT PESTICIDE IN FOOD CHAINS IN ECOSYSTEM.

DDT pesticide is subject to progressive increase in concentration as it passes along the food chain. This is because DDT is persistent chemical, not easily broken down and it is store rather than metabolized or excreted in living organisms and it remains active for many years i.e 10-15 years.

DDT is mainly stored in fatty tissues; this is because DDT pesticides are more soluble in fats than in water. During times of food shortage, fat is mobilized and used so that the DDT pesticide accumulated over a long period of time is released into the blood stream in relatively high concentrations.

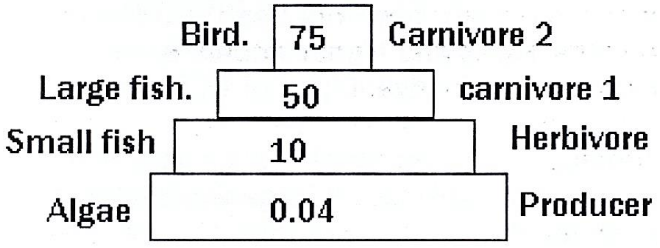
DDT can widely be spread in an ecosystem. This is because of two factors.

It can be carried at very low concentrations in water. If it is washed off agriculture land and carried into the rivers, some of it reaches the sea and becomes concentrated in marine food chains i.e fish and other aquatic organisms will have DDT stored in their body tissues.

DDT pesticide can be carried in the atmosphere because it is volatile and is spread as dust, which is carried by wind over a long distances.

EXAMPLE SHOWING CONCENTRATION EFFECTS OF DDT PESTICIDE

The figure below shows the amount of DDT at different levels in a food chain. Study it carefully and answer the questions that follow.



(a) If the concentration of DDT in the water surrounding the algae was 0.02ppm. Determine the final concentration factor for DDT in passing from water into,

(i) Primary producers, (ii) Small fish, (iii) Large fish, (iv) the top carnivores

SOLUTION.

(i) $\frac{0.04}{}$ = 2 times, (ii) $\frac{10}{0.02}$ = 500 times

(iii) $\frac{50}{0.02}$ = 2500 times

(iv) $\frac{75}{0.02}$ = 3750 times.

(3) BIOLOGICAL PEST CONTROL.

Biological control is the control of the population of pests and weeds by using other living organisms that are natural enemies or predators or parasites to the target pests. The control organisms are used to keep the pest or weed population below the economic injury level.

Population of pests can also be controlled by some biological products such as pheromones and genetically engineered insecticides. Synthetic pheromones have been used to lure pests into traps laced with an insecticide.

EXAMPLES OF BIOLOGICAL PESTICIDES.

• Cane toads introduced into Australia to control beetle infestations of sugar cane.

• In green houses, parasitic wasps are introduced to control whitefly and lady birds to control aphids.

• In natural environments, caterpillars of the moth control the population of prickly pear population successfully and bacillus bacteria *(Bacillus thuringiensis)* applied as sprays to cabbage plants infected with caterpillars. The bacteria infects and kills the caterpillars without harming other insects.

• Myxomatosis is a viral disease introduced deliberately in Australia to control rabbit populations. However, this virus infected other non-targeted domestic rabbits and lost its effectiveness as the pests evolve resistance.

• Irradiation is another method of biological control. It involves breeding the pest species, separating the males and sterilizing them by exposure to x-rays. Sterile males are released into the population to mate with females which produce infertile eggs.

ADVANTAGES OF BIOLOGICAL PEST CONTROL.

Control agents are specific to their target organisms. So, they cannot destroy other useful organisms in the environment.

No danger of polluting or harming the environment.

Control agents may become useful food materials for other organisms.

It does not lead into extinction of the target organisms.

Have few incidences of pest resurgence.

They are very effective and efficient; they can control population of pests within the shortest time possible.

PRECAUTIONS TAKEN IN USING BIOLOGICAL CONTROL METHODS.

(i) Careful matching of climatic conditions to ensure that they favour the natural enemy of the pests especially when the population of the pest is at peak.

(ii) Monitoring of interactions with native species to ensure that the natural enemy of the pest is not preyed on by other unsuspected organisms, prey organisms which may be preferred instead of the targeted pest can be identified.

(iii) The predator must be released at a time when the pest population has reached large numbers to provide sufficient food for the natural enemies otherwise, it may get wiped out prematurely resulting into pest resurgence.

(4) INTEGRATED PEST CONTROL/MANAGEMENT.

Is pest population management which combines and integrates biological and chemical controls in a sensitive way, to maintain the pest population at a level below the economic injury level or even prevent their development. This method must ensure minimum harm and disruption to a crop, natural ecosystem and the natural enemies of the pest species.

While applying this method, favourable environmental conditions and biology of the pest be considered. Pest population densities be monitored and pesticides used only when the pest reaches the economic damage threshold.

DEFORESTATION.

This is the permanent removal of trees and undergrowth. Many forests have been destroyed by burning and felling of trees. Many forests have been converted to agricultural lands, grass lands and shrubs.

REASONS FOR DEFORESTATION.

(i) To open land for agricultural practices.

(ii) Supplying firewood as fuel and making charcoal.

(iii) To make room for houses, industrial buildings, roads and dams.

(iv) To obtain trees for manufacture of pulp and paper.

(v) Cutting trees for timber used in the construction industry and getting poles for construction of houses.

(vi) Destruction of some trees by atmospheric pollution such acid rains,

(vii) Replacement of native trees with fast growing species such as conifers, eucalyptus and rubber trees.

Large scale deforestation has significant effects on global biodiversity, nutrient recycling, soil erosion and desertification.

EFFECTS OF DEFORESTATION ON BIODIVERSITY

Deforestation has most significant effect in tropical rainforest. Tropical rain forests are the habitats to about 50% of the world species. Felling of trees or their destruction, will result into large scale habitat destruction for many species that will eventually die and then be driven into extinction. Many of the known tropical rain forest species have great human value. For example the rosy periwinkle, has provided the alkaloid anti-cancer drug vincristine used to treat some form of leukaemia, other forest plant products have been used as anticoagulants, tranquillizers and antibiotics. Some of the species are becoming extinct, yet they add value for survival for many other organisms.

Complete replacement of native trees with introduced species also leads to a reduction of biodiversity.

EFFECTS OF DEFORESTATION ON NUTRIENT RECYCLING.

Increased level of atmospheric carbon dioxide occurs, which may cause the greenhouse effects or global warming. The increase in the levels of atmospheric carbon dioxide is due to,

• Removal of young photosynthesizing plants. Young plants take in more carbon dioxide for photosynthesis than they release in respiration. Removing these plants would add to the levels atmospheric carbon dioxide.

• Burning forests releases huge amounts of carbon dioxide directly and very quickly into the atmosphere. But cutting down forests with mature trees will only add very little to levels of the global atmospheric carbon dioxide, this is because the amount of carbon dioxide taken up by photosynthesis in established forests of mainly mature trees is the same as that released in respiration by producers, consumers and decomposers.

• Deforestation leads to removal of tree canopy, the forest floor is exposed to sunlight and warmer temperatures. In forests or woodlands with significant litter and soil humus contents, this exposure will favour accelerated rates of decomposition and carbon dioxide is released to add into the atmospheric carbon dioxide level.

Deforestation by burning trees in tropical rain forests significantly reduces the nitrogen held in the biotic ecosystem. Even when the wood ash is added to the soil, deforestation removes the tree canopy and the tree roots that hold soil particles, allowing rain drops beating down into the soil, causing nutrients to be lost through leaching (nutrients dissolve in surface water and run off to a stream or river rather than being held in the soil).

DESERTIFICATION AND DEFORESTATION.

Severe degradation of semi-arid land into desert in many parts of Africa resulted from both climatic changes and deforestation. Deforestation is believed to have speeded the process of desertification by disrupting the water cycle and soil structure. Reduction in tree cover means reduced transpiration, fewer clouds and less rain fall in the area. Removing tree also

increases the risks of flooding following heavy rains. If the agricultural land becomes heavily populated, it is likely to be over cultivated or overgrazed and the soil will be less fertile and more easily eroded during periods of drought.

The buildup of soluble salts near the surface of soils called salination may also occur usually as a result of upward capillary movements from salty ground water. The salt may reach a concentration that is toxic to most plants, sterilizing the land.

SOIL EROSION AND DESERTIFICATION.

Desert may form naturally especially when rains persistently fail in semi-arid areas but their creation can be accelerated by human activity in a process called ***desertification.*** This is a term which refers to a degradation of dry land areas so that formerly productive land becomes useless. It usually results from,

Overgrazing by livestock,

Over cultivation,

Deforestation

Poor irrigation practices.

Grass lands that are overgrazed by livestock frequently lose the plant cover that holds the top soil. In addition the plants are eaten to their roots and die, with the results that water running freely across the land surface causes sheet erosion, carrying off the top soil. Channeled rain water causes gully erosion, cutting deep into the land surface. Much of grass land become wasted this way and eventually become desert.

Hilly areas with steep slopes which are regularly cultivated and also have high rain fall are susceptible to soil erosion.

In irrigated areas, waterlogging and salination are the main problems. Waterlogging occurs when the water table lies close to the soil surface. Many plant species are intolerant to the conditions of waterlogging and salination, they die, removing the plant cover, causing soil erosion. The consequence of the intensive soil erosion is desertification.

DISADVANTAGES OF DEFORESTATION.

(i) There is a loss of traditionally harvested products such as timber, poles, fire wood, honey, fruit, game animals and herbs that are one time supply local people with their needs.

(ii) More rapid run-off of rain water results in soil erosion, resulting into loss of soil structure and soil fertility, crop production and yields is lowered. This may cause famine and great economic losses.

(iii) Leads to floods in low lying plain lands.

(iv) Increases global carbon dioxide which causes global warming.

(v) Rain fall regimes are interrupted, leads to reduction in the amount and frequency of rain fall and supply of water from spring waters is lost, resulting into change in climatic conditions, water shortage, drought and desertification.

(vi) Leads to loss of genetic variety and reduction in biodiversity.

(vii) Habitat loss of many organisms, leads to extinction of some plant and animal species since forest has the most species-rich and diverse wild life.

(viii) Leads to loss of some important medicinal plants. For example, tropical rain forest tree species have great human value, rosy periwinkle used for anti-cancer drug, others tropical rain forest trees are used as antibiotics and anti-malarial drugs.

AGRICULTURE.

Is the production of crops and animals. It is a human activity that affects greatly the lives of organism in an ecosystem.

EFFECTS OF AGRICULTURE ON ECOSYSTEM, (a) Positive effects.

- Increase productivity in an ecosystem. This is achieved through, appropriate use of fertilizers, crop rotation, mulching to improve plant growth and crop yields.

- Increase population density of many organisms in an ecosystem since agriculture increases food production.

- Improve soil conditions for the survival of soil micro-organisms.

Proper tillage improves soil structure, texture and aeration for survival of soil micro-organisms. Terracing method of farming also prevent soil erosion and maintaining mineral nutrients in the soil.

- Mixed farming where both plants and animals are reared leads to nutrient recycling.

(a) Negative effects.

- Leads to pollution of the environment.

Over use of artificial fertilizers can cause leakage of soluble nutrients into the water bodies resulting into Eutrophication and hence fresh water pollution, it can also change soil pH and structure that kills some soil micro-organisms.

Use of pesticides. Is the main cause of land pollution. Pesticide is persistent in an ecosystem, kills other organisms at higher trophic levels.

- Leads to habitat destruction.

Use of fire, deforestation to open land for agricultural purposes destroy habitat for organisms and may cause extinction of species of some organisms.

• Deforestation, weeding, harvesting of standing crops reduce primary productivity of ecosystem.

• Use of fire to open land for agriculture leads to many negative effects which include destruction and death of slow moving animals and destruction of many plant species.

Agriculture production is favoured by development of new varieties of crops and animals more intense methods of farming.

INTENSIVE FARMING METHODS/INTENSIVE AGRICULTURAL PRACTICES.

(i) Selective breeding and genetic engineering.

Artificial selection of crops and farm animals. Genetic engineering of crops and farm animals achieve to improve on flavour, delay ripening in fruits, improve upon animal products like meat, wool, and increase resistance towards pests, diseases and drought.

(ii) Intensive farming.

It involves,

Mechanization of agriculture from preparation of the soil, sowing of seeds to harvesting and storage.

Increased use of pesticides to control pests. Use in-organic and organic fertilizers.

(iii) Greenhouse growing and factory farming.

These are methods of farming where organisms are grown indoors in a confined space under controlled environmental conditions. This include,

• Growing plants in glass houses referred to as green houses. Green houses consists of panes of glasses, letting light in but retaining some of the heat before it escapes into space, hence the term "greenhouse effect". Green house growing allows conditions such as light intensity, temperature, carbon dioxide concentrations and mineral levels to be controlled artificially.

• Factory farming ensures that food ingested by animals goes towards production like in growth, milk production and rapid reproduction. This is achieved through,

Provision of highly digestible products and that can easily be assimilated and converted to animal products.

Minimizing unwanted energy expenditure by minimizing movement of animals.

Providing optimum conditions like warmth.

Addition of artificial growth stimulants to the food.

Using young animals since older ones are less efficient at converting food into growth.

ADVANTAGES OF FACTORY FARMING.

Supply cheap food in large quantities to the population.

The conditions are not cruel or stressful.

Requires little space.

DISADVANTAGES.

It is cruel and causes stress to animals by keeping them in confined spaces.

Antibiotics, pesticides and growth promoting substances may harm humans' health and environment.

Excessive use of antibiotics can result into the anti-biotic resistance.

Intensive cultivation involves heavy use of fossil fuels.

(iv) The removal of hedge rows,

This is an Arable farming, where large fields are used for mixed farming. It involves removal of hedge rows.

Hedge rows may be removed for the following reasons.

They reduce space for planting crops.

Use of large machinery is difficult.

Roots of large hedge rows compete with crop roots for moisture and nutrients.

Hedges can harbour weeds, diseases and pests.

Expensive to maintain.

Many environmentalists oppose removal of hedge rows for the following reasons,

Adds beauty to the land scape in the country side.

Increase diversity of wild life by providing food and nesting sites for birds and provide corridors along which animals can move.

Act as refuges for predators which limit the growth of pests naturally.

Hedges act as wind breaks, reducing wind erosion of the soils.

ENVIRONMENTAL POLLUTION.

Pollution is defined as the release into the environment of substances or energy in such quantities and for such a duration that they cause harm to the people or other organism or their environment.-

A pollutant is a natural or artificial substance which enters the ecosystem in excess amounts that it becomes harmful to the ecosystem.

A pollutant may be physical for example noise,

COMMON POLLUTANTS.

These include the following,

• Physical pollutants such as noise/sound, heat, radioactive substances from nuclear power stations,

• Chemical pollutants such as, industrial waste products like nitrogen oxide, hydro-carbons, mercury or any other heavy metals.

• Biological pollutants such as the sewage.

• Gaseous emissions like carbon monoxide, carbon dioxide, sulphur dioxide.

• Oil leakages.

• Agricultural drugs like pesticides and herbicides.

• Smog or fog.

TYPES OF POLLUTION.

• Air pollution.

• Water pollution.

• Sound pollution.

• Radio-active pollution.

• Terrestrial pollution.

AIR POLLUTION.

All air pollutants are gases added to the mixture of air which supports life. All air pollutants is a result of burning fossil fuels either in the homes, in industries or internal combustion engine. Examples of the air pollutants are,

• Smoke.

• Sulphur dioxide,

• Lead.

• Nitrogen oxide.

• Carbon monoxide.

• Carbon dioxide.

SMOKE.

Smoke is tiny particles of soot (carbon) suspended in the air which are produced as a result of burning fossil fuels such as coal and oil. It has a number of harmful effects which include,

(i) When breathed in, it blackens the alveoli causing damage to their epithelial lining. It also increases the risks of bronchitis,

(ii) It reduces light intensity at the ground level. This lowers overall rate of photosynthesis and hence productivity,

(iii) Deposits of soot and ash coats plant leaves, blocking the stomata thus reducing rate of photosynthesis in green plants.

(iv) Smoke, soot and ash dirtens or blackens clothes, ears and building, these are costly to clean.

CARBONMONOXIDE (CO)

Carbon monoxide is released from the car exhausts. When Carbon monoxide is inhaled, it combines irreversibly with haemoglobin to form carboxyl-haemoglobin reducing the capacity of red blood cells to transport oxygen.

SULPHUR DIOXIDE (SO_2).

Burning of fossil fuels at home or from industries, emit some amount of sulphur dioxide. It may combine with water and ammonia and form harmful compounds, especially when released in higher concentrations. Harmful effects of sulphur dioxide include,

(i) It causes irritations of the respiratory systems and damages the lining of the alveoli of the lungs.

(ii) It can damage the eyes by causing irritations of the conjuctiva of the eye.

(iii) It kills the lichens on the surfaces of trees and on rocks. This reduces photosynthetic activities of the blue-green algae, reducing primary productivity of the ecosystem. Absence of lichens may expose certain insects like the peppered moths to their predators.

(iv) Sulphur dioxide dissolve in rain water and falls down as acid rain that enters lakes and oceans, causing death of aquatic plants. Acid rains also cause great destruction and damages of forests. For example coniferous trees.

In other hand, sulphurdioxide has some advantages, for example when sulphur dioxide combines with other chemicals like ammonia and water, it forms compounds that are deposited into the soil, increasing soil fertility or adding phosphates/phosphorus in areas where sulphates are deficient.

The compounds containing sulphur when fall or deposited into some plants, they work as fungicides. For example black spot on roses are treated when acid rain falls on them.

The concentration of the sulphur dioxide in the environment can be used to provide the measure of the level of environmental pollution by industrial wastes.

NITROGEN OXIDE (NO).

They are produced b burning of fuel in car engines and emitted as exhaust. They are poisonous and also results into the formation of photo-chemical smog. The action of sun light on this chemical converts Nitrogen oxide to perox-acyl nitrate (PAN). This* compound formed is dangerous, causing damage to vegetation and eye and lung irritations in man.

LEAD (Pb).

Lead can be emitted into the air through car exhausts. Tetra-ethyl lead (TEL) is added to petrol as an anti-knock agent to help it burn more evenly in car engines. If breathed into the lungs and then into the general body, it will have the following effects,

(i) Digestive problems, For example Intestinal colic,

(ii) Impairing the functioning of the kidney,

(iii) Nervous problems including convulsions,

(iv) Brain damage and mental retardation in children.

Lead can also be used to make water pipes but lead is not easily absorbed in the so, less dangerous.

To solve the problem of environmental pollution by lead, the use of unleaded fuel should be encouraged.

CARBONDIOXIDE (CO_2)

Carbon dioxide is formed through respiration by aerobic organisms, volcanic activities, decomposition of organic matter and burning of the fossil fuels. It is used by plants for photosynthesis to ensure that it does not accumulate. Deforestation and increased burning of fossil fuels has resulted into in excess release of carbon dioxide into the atmosphere. This has caused unnecessary rise and increase in concentration of atmospheric carbon dioxide, causing occurrence of the three world problems, ozone ***depletion, greenhouse effect*** and ***Global warming.***

CARBONDIOXIDE AND GREEN HOUSE EFFECT.

Solar energy reaches the Earth in form of short wave radiations. When these radiations strike a surface, much of its energy is converted into heat or long wave radiations. Carbon dioxide is present in the lower atmosphere (troposphere) in very small amounts. Carbon dioxide is transparent to incoming short wave radiation from the sun. So, carbon dioxide, water vapour and other gases present in the atmosphere allow the shortwave radiations from the sun to pass through them to reach the surface of the earth. When that radiation strikes a surface, much of its energy is converted into heat, and reflected as long wave radiations. Carbon dioxide, water vapour and the other gases form layer called heat blanket in the atmosphere that prevents escape of the heat or long wave radiations reflected from the earth, but instead absorb or retain the long wave-radiation or reflect it back towards the surface of the earth. In this case these gases, including carbon dioxide act like panes of glass in a greenhouse, letting light in but retaining some of the heat before it escapes into space, hence the term "greenhouse effect".

The retention of heat by the greenhouse effect is a natural process, essential for the evolution of life on earth. It maintains optimum average temperatures of the earth, otherwise, without it freezing temperatures would exist in the earth. And many species of organisms would die until be driven into extinction. However, the greenhouse effect appears to be increased by the emission of certain industrial gases collectively called greenhouse gases, the most important of which are carbon dioxide, chlorofluorocarbons, methane and ozone.

• Carbon ***dioxide.***

It is produced naturally from respiration, decomposition and volcanic activities. Burning of fossil fuels is another source of carbon dioxide. It contributes the largest percentage of the green house, about 50%.

• ***Chlorofluorocarbons (CFCs)***

Are organic molecules that are not natural and are manufactured artificially for use as refrigerator coolant in air conditioning units, as aerosol propellants, and in the manufacture of foam plastics. They have advantages of being cheap, non-flammable and non-toxic chemicals and are relatively stable. When released into the atmosphere, tends to last for long time (upto 60 years). Its effect is many times greater than that of carbon dioxide.

CFCS dissociate when exposed to ultraviolet light, releasing highly reactive free chlorine atoms, by series of chemical reactions the chlorine released reduce the ozone concentration.

• ***Methane.***

It is produced by anaerobic bacteria living in the guts of certain insects such as termites and in the stomachs of the ruminants such as cattle, sheep, and camel. So, the human activity such as cattle ranching has increased the release of methane.

- **Ozone.**

Ozone is a triatomic form of oxygen. It occurs naturally in the atmosphere where it is formed by the action of solar energy {ultra-violet radiation) on oxygen gas. Ozone forms a layer called ozone layer at high altitudes 20 - 50 Km above the earth surface. Ozone is a greenhouse gas but at high altitudes it absorbs harmful ultra-violet radiations and prevents it reaching the earth. At low altitudes, its concentrations are low but boosted by the action of sunlight on nitrogen oxides. Ozone forms part of the photochemical smog seen in large cities during bad weather. As a low altitude pollutant, ozone is harmful. It causes irritations of the eyes and respiratory tissues and it can damage plants. A higher concentration of ozone is toxic.

Ozone depletion can occur. This is constant damage and destruction of the ozone layer by the greenhouse gases, especially the chlorofluorocarbons to the point that holes are created into it. This will allow harmful ultra-violet radiations to directly reach the earth. Ultra-violet radiation causes skin cancer to humans.

CARBONDIOXIDE AND GLOBAL WARMING.

Increase in carbondioxide or greenhouse gases in the atmosphere absorbs and retains heat or reflects the long wave-radiation back into the earth. This causes unnecessary rise or increase in the global temperatures above the usual, a phenomenon called global warming. This could cause change in the climate. The effect of global is detected in rising sea levels, an increase in the melting of ice caps at arctic and Antarctic regions, changes in the vegetation and unusual weather patterns.

EFFECTS OF THE GLOBAL WARMING.

• *It* leads to melting of the ice caps in the polar regions of the earth. This result into increased volume of water bodies, causing floods that displace a number of plants and animal communities living at the shores of the rivers, lakes and oceans.

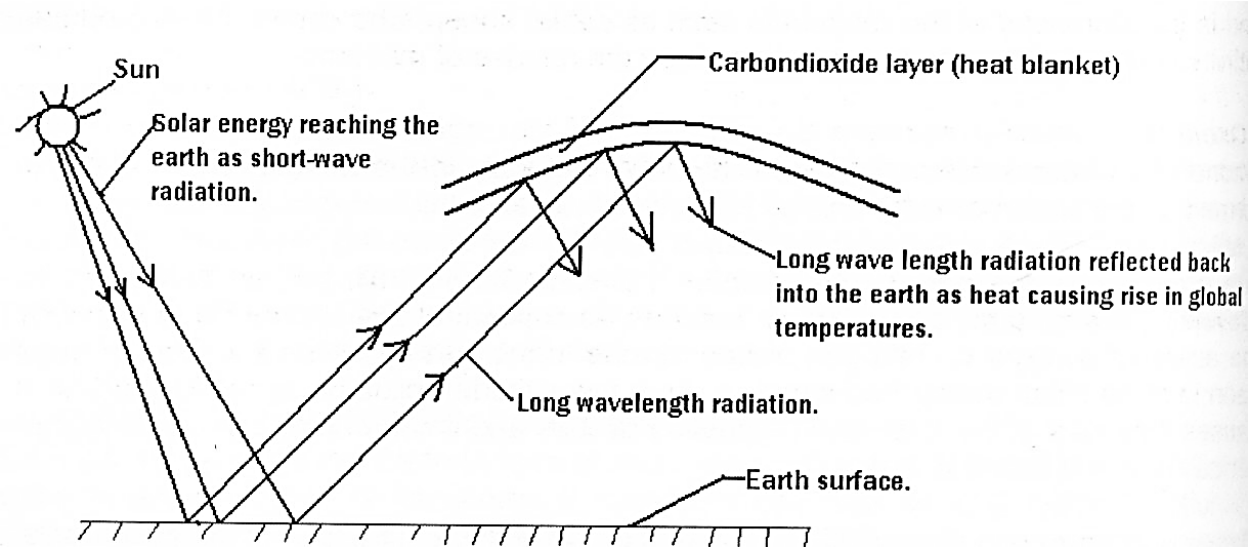
• The increased atmospheric temperatures increase evaporation of water from the surfaces of the water bodies causing rampant heavy convectional rain fall seasons known as Elninoes.

Elnino rain causes destruction of crops and leads to famine, outbreak of water borne diseases like cholera, causing mass death of people.

• It leads to extinction of species of organisms which cannot adapt to extremely high temperatures. This causes changes in the Bio-diversity of plants and animals.

• High temperatures increase primary productivities. Demand for essential nutrients increase, resulting in competition among plant species for such nutrients.

DIAGRAM SHOWING PROCESS OF GLOBAL WARMING IN AN ECOSYSTEM.



WATER POLLUTION.

Water Pollution is defined as the release into the water bodies or aquatic environment substances or energy in such quantities and for such a duration that they cause harm to the people using the water or to the aquatic organisms living in the aquatic environment.

Man has several uses of water in an ecosystem, some of these uses include, For drinking.

For bathing, washing clothes, utensils, cars etc. For removing sewage. To irrigate crops. Used as a coolant in industries.

Habitat and breeding sites for fish and other aquatic organisms that provide source of food.

Used to generate electric hydro-power For recreational uses, sailing, fishing and diving.

COMMON CAUSES OF WATER POLLUTION.

These include the following,

• Discharge untreated sewage into the aquatic ecosystem.

• Eutrophication due to agricultural wastes from factory farms and organic industrial wastes from food and drink industry.

• Eutrophication due to nitrate and phosphorus fertilizers that enter nutrient cycle.

• Oil spills mainly from accidental spillage and cleaning tanker storage tanks.

• Hot water from power stations resulting into the thermal pollution.

• Heavy metals such as mercury, cadmium from industrial effluent.

• Persistent pesticides such as DDT.

• Radioactive materials from nuclear power stations.

• Mining wastes such as china clay waste.

• Medical waste such as hypodermic needle, blooded bandages, etc.

BIOLOGICAL OXYGEN DEMAND/DEPT (BOD).

Adding organic materials to water stimulates the growth of micro-organisms which feed on the organic materials. As the density of the micro-organisms increases, their demand for oxygen also rises. This demand is called the ***Biological Oxygen Demand (BOD).*** **BOD** is defined as *the minimum amount of oxygen in certain volume of water required by the aerobic bacteria to decompose organic matter.* ***Or*** *is the mass in mg of oxygen used in* $1dm^3$ *of water stored in darkness at 20°C for 5 days.* Water that is very heavily polluted with raw sewage may become deoxygenated, this can lead to the death of aerobic organism such as fish.

SEWAGE DISCHARGE AND ITS EFFECTS ON THE AQUATIC ECOSYSTEM.

Sewage is liquid waste, industrial waste from abattoirs, factories, hospitals or domestic waste including human faeces, urine and detergents. Sewage is carried through pipes called sewers. So, sewage is any waste materials from home and industries that pass down the sewers.

EFFECTS ON THE ECOSYSTEM DUE TO DISCHARGE OF UNTREATED SEWAGE.

• Biological Oxygen Demand (BOD).

Oxygen deficiency occurs downstream the water bodies, the water may also become anaerobic for much of its length, resulting into aerobic aquatic animals and zooplanktons to suffocate to death.

• Eutrophication of the water bodies.

Enrichment of the water bodies by the nitrate and phosphate ions causes rapid growth of the algae (algal bloom). This prevents penetration of the sun light into deeper layers, aquatic phytoplanktons cannot photosynthesize, and they die. Death and rapid decomposition of these aquatic plants by the aerobic bacteria causes BOD/oxygen deficiency.

• Sewage may contain potentially dangerous pathogenic organisms such as those causing cholera and typhoid. So, may lead to outbreak of diseases,

• The organic matter in the sewage makes water to have unpleasant smell, turbid and therefore unsafe for domestic use like drinking, washing etc. Prevents penetration of the light intensity, stopping photosynthesis by the aquatic plants.

• Buildup of ammonia and hydrogen sulphide from anaerobic decomposition occurs. These chemicals are toxic and result in death of many aquatic organisms and almost lifeless river.

The above situation can be improved by the introduction of the sewage treatment works. It removes organic material and potentially dangerous pathogenic organisms such as those causing cholera and typhoid. The stages in sewage treatment include,

(i) ***Screening.***

Large pieces of debris are filtered off. Then sewage allowed to enter a machine called commuter which reduces all large particle sewage into smaller ones.

(ii) ***Detritus removal.***

The sewage enters a tank or a channel in which the rate of flow is reduced to allow heavy inorganic material such as the grit to deposit out. The lighter organic matter is carried in the water flow. The materials that settle out is called detritus and can be dumped out without further treatment.

(iii) Primary sedimentation.

The sewage flows into large tanks. The flow across this tank is very slow and takes several days. Fine sand, silt and any organic material settle out and become deposited at the bottom of the tanks. Ferric acid is added to increase sedimentation, a process called flocculation. The materials that settle out is called sludge and periodically pumped from the bottom into sludge digestion tanks. Methane gas is produced during sludge digestion which can be used for generating power. The sludge can also be dried in large tanks, the resultant semi-solid material can be dumped or sold as fertilizers.

The liquid sewage that remains is called the effluent. The effluent then enters activated sludge tank or passes through percolating filters.

(iv) Activated sludge method.

The effluent is inoculated with aerobic micro-organisms which break down dissolved organic material. It then flows into long channels through which air is blown in a fine stream of bubbles from the bottom. This provides oxygen for aerobic micro-organisms for decomposition of the organic matter.

Or

The alternative to the activated sludge method is to spray the effluent onto beds of sand, clinker and stones in which live a large variety of aerobic organisms like the bacteria producing urease, Nitrosomonas and Nitrococcus.

(v) Final (humus) sedimentation.

The effluent is then passed into further sedimentation tanks to allow these microorganisms to settle out. The sediments known as humus is passed into the sludge treatment tanks.

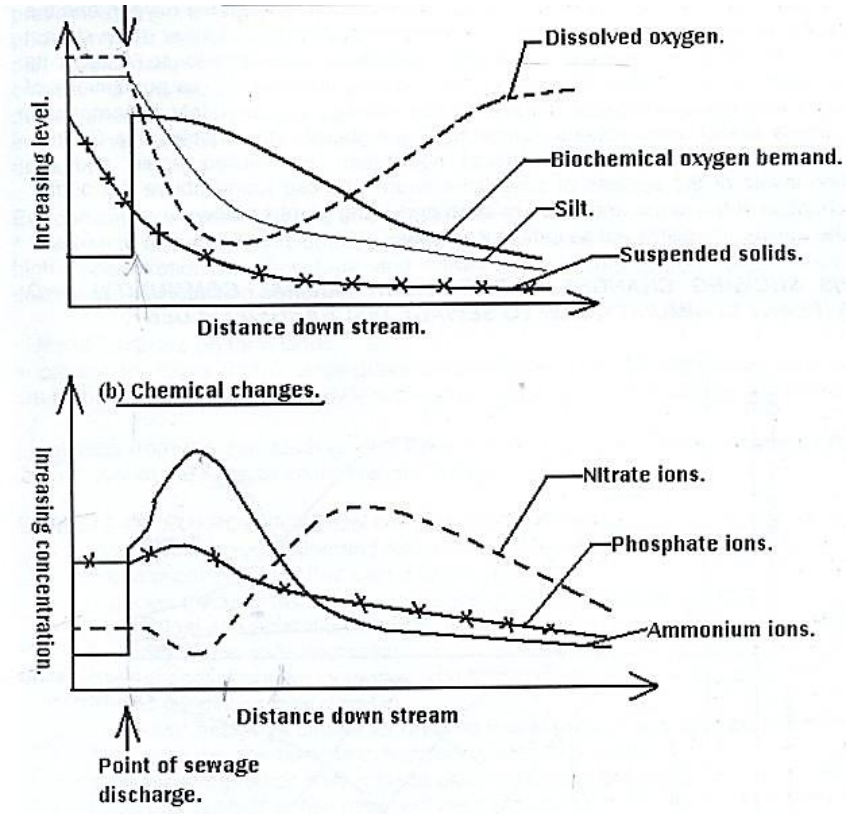
(vi) Effluent then passed through fine filters to remove any suspended particles in the effluent before safely discharged into the rivers or lakes.

PHYSICAL AND CHEMICAL CHANGES IN A RIVER DUE TO DISCHARGE OF UNTREATED SEWAGE IN AQUATIC ECOSYSTEM.

Sewage contains mainly water and organic materials, other in-organic substances such as nitrogen compounds like urea and uric acids, ammonium ions, nitrate and phosphate ions may be present in low concentrations.

Organic matter acts as food source for saprophytic aerobic bacteria. The bacteria carry out decomposition of the organic material, using oxygen dissolved in the water in a process called putrefaction, causing a BOD. Initially the decomposition activity utilizes little oxygen, but as the distance downstream increases, the decomposition processes increases. In this case, the aerobic bacteria successfully decompose the existing organic matter, urea into ammonium ions and there concentration increase rapidly. The ammonium ions are converted to nitrates. The concentration of the ammonium ions decrease while those of the nitrates increase rapidly. Some ammonium and nitrate ions are absorbed by the aquatic plants, reducing their concentrations. The rapid decomposition by aerobic bacteria uses up dissolved oxygen, reducing the concentration of the dissolved oxygen to minimum levels, this creates a Biochemical oxygen Demand (BOD) that will cause the death of most aerobic species, including fish leaving only anaerobic ones. When all organic matter has been broken down further downstream, little or no decomposition activities occur and less dissolved oxygen is used up and its levels rises rapidly again. The increased photosynthetic activities by the phytoplanktons, turbulent, fast moving streams, new dissolved oxygen from the atmosphere may all increase the levels of dissolved oxygen further downstream.

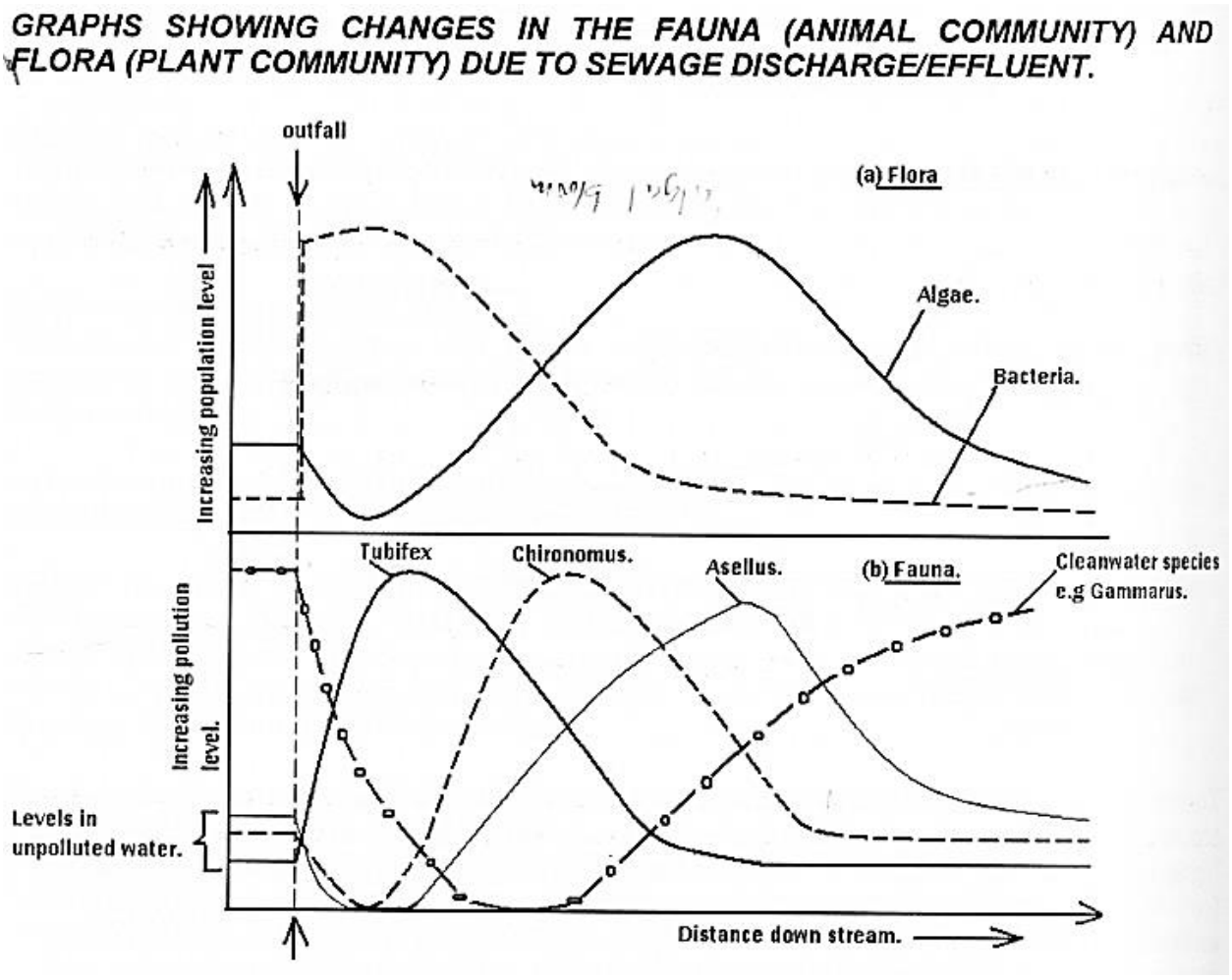
Sewage outfall, (a) Physical changes



The changes in the physical and chemical conditions in the rivers are accompanied by changes in the flora and fauna of the water body. When the level of organic material is high, saprophytic bacteria survive e.g. the sewage fungus which increases because they feed on sewage. Algal populations lower initially due to the sewage reducing the amounts of light that penetrate the water body. Further downstream, the algal levels rise above normal because the bacteria break down sewage releasing many minerals including nitrates. As the minerals are used up, the algal levels return to normal.

The population levels of animal species vary according to the level of oxygen in the water. Most tolerant species of organisms to low oxygen levels are the worms of the genus *Tubifex* whose haemoglobin has a particularly high affinity for oxygen which it obtains even at very low concentration. These worms survive in regions close the point of sewage discharge. *Tubifex* population grows high in this region due to lack of competition from other species and absence of predators since they are unable to survive in this region with low oxygen. Further downstream, there exists other species such as the larvae of the midge *Chironomus* which are also able to tolerate low oxygen levels. They begin to compete with *Tubifex* for small amount of available oxygen and the population of the worm *Tubifex* reduces. A continuing rise in oxygen further downstream from the outfall results in the appearance of the species like the water louse, *Asellus.* Its presence adds on the intraspecific competition, causing reduction in the populations of the Tubifex and the *Chironomus.* Finally, as the sewage is completely decomposed, oxygen levels in the water returns normal high and clean water species like Chrimp, *Gammarus* appear again. The ecological equilibrium is restored

again and the population levels of the species of organisms return to those found above the outfall. These changes in the fauna and flora are illustrated in the graphs below. Note: The above organisms act as indicator species.



EUTROPHICATION.

Is defined as the nutrient enrichment of the water bodies such as rivers, lakes with nitrates and phosphate salts.

Eutrophication is a natural process during which the concentrations of nitrate and phosphate salts build up in lakes and rivers.

The immediate effect of Eutrophication is the dramatic fast growth of algae called algal blooms. Algal blooms produce toxins that cause mass death of fish species and also prevent light penetration to any depth. The alga, phytoplanktons and other aquatic photosynthetic plants in deeper regions of the lake are unable to photosynthesize and die. Rapid decomposition of these dead organisms by aerobic saprophytic bacteria creates a considerable biochemical oxygen debt/demand (BOD) resulting in deoxygenation of lower

regions of the water, as a consequence most aerobic organisms in this region die. A useful chemical indicator of Eutrophication is Biochemical oxygen demand.

Eutrophication is caused by any one of the following,

• Discharge of treated and untreated sewage into lakes and rivers. Sewage contains high concentration of phosphate and nitrate ions, resulting from decomposition of detergents and washing powders.

• Use of fertilizers on farm lands.

In-organic fertilizers contain large quantities of nitrates. Nitrates and phosphates, nitrates are highly soluble and are readily leached and quickly runs off into lakes and rivers.

• Leaching from the surrounding land but it is a slow process and sometimes offset by the removal of the salts as water drains from lakes and rivers.

EFFECTS OF EUTROPHICATION ON THE ECOSYSTEM.

Biochemical oxygen demand causes death of aerobic organisms.

Algae produce toxins that cause fish to die.

Species diversity decreases and the dominant biota change.

Plant, algal and animal biomass increase.

Turbidity of the water increases.

Rate of sedimentation increases, shortening the life span of the lake.

Anoxic conditions may develop.

The water becomes unsafe for drinking due to unpleasant taste and odour.

The water may be harmful to humans and other animals.

Increased vegetation may impede water flow and navigation. Important species of fish may become instinct.

Lakes and rivers with low salt concentrations are termed as ***Oligotrophic lakes.*** While those with waters with high concentration of the nitrate and phosphate salts are termed as ***Eutrophic lakes.***

DIFFERENCES BETWEEN OLIGOTROPHIC AND EUTROPHIC LAKES.

OLIGOTROPHIC LAKE

EUTROPHIC LAKE

(i) Deeper in depth.

(ii) Relatively higher oxygen concentration in lower regions.

(iii) High species diversity with low productivity.

(iv) Green algae dominant.

(v) Algal bloom are absent or rare due to low salt content of the water.

(vi) Concentration of nitrate and phosphate salts are low.

(vii) Animal production is low.

(i) Shallower in depth.

(ii) Relatively lower oxygen concentration in lower regions.

(iii) Low species diversity with high productivity.

(iv) Blue-green bacteria dominant.

(v) Algal blooms very frequent due to high salt content.

(vi) Concentration of nitrate and phosphate salts are high.

(vii) Animal production is high.

PHYSICAL INDICATORS OF EUTROPHIED WATER BODY.

Turbidity increases due to increase in the amount of suspended solids. The water darkens.

Over growth of algae on water surface referred to as algal bloom.

Low concentration of dissolved oxygen due to increased microbial activity.

Reduced gross productivity of the water.

Shallowing of water.

Death of aquatic organisms, this reduces the biodiversity.

In Lake Ecosystem, the problem of Eutrophic oxygen depletion may be worsened by seasonal **water thermal stratification.** This is where water forms layers with different temperatures. This occurs for two reasons,

(i) The sun heats the surface water, it becomes warm and less dense so it

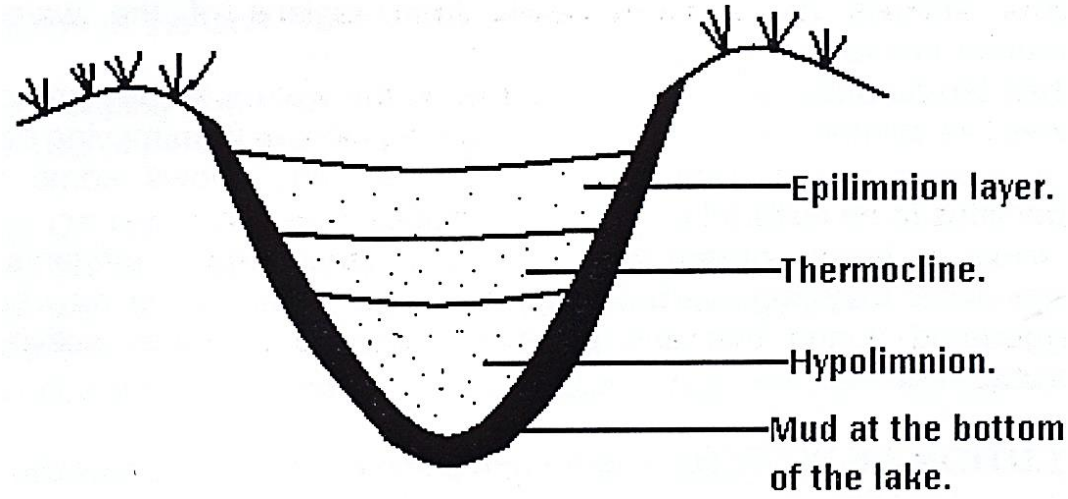
remains in the top layer of the lake called the ***epilimnion.***

(ii) Rivers and streams are shallower compared to lakes and seas and when sun heats their waters, the river and the stream waters become warm through out their depth. And when the warm waters from the rivers and streams are fed into lakes, the warm waters mix only with the surface waters of the lake, and since the waters entering the lakes are light and less dense,

they remain on top while raising the temperatures of the waters at the surface forming a layer of warm water at the surface of the lake called epilimnion. The deeper layers remain cool called hypolimnion.

The thermal stratification of mid-latitude lake in summer is in such a way that, a warm oxygen rich circulating layer of water called **epilimnion** at the top is separated from cold oxygen poor layer called hypolimnion waters at the bottom by a broad zone of rapid temperature change layer called the **thermocline** existing in the middle.

DIAGRAM SHOWING THERMAL STRATIFICATION IN SUMMER.



Thermal stratification affect supply of oxygen to the deep waters. Oxygen supplies in the lake waters come from three main sources and these are,

Photosynthesis which requires light and is therefore most rapid in the surface waters.

Atmospheric air that mixes with the surface waters and oxygen diffuses and dissolve in the water.

Dissolved oxygen in stream and river waters draining into the lake.

The above sources of oxygen enrich mainly surface waters. Oxygen in deeper water depends on effective diffusion from upper layer and extreme turbulence linked with storm events. This occurs quite well in winter season. In summer thermal stratification occurs, preventing dissolved oxygen reaching the deeper layers (hypolimnion). The deeper layers will depend on the oxygen that had dissolved in the previous season.

In a healthy lake ecosystem, most primary producers are eaten, few die and form food for detritivores and decomposers. However increased phytoplankton production may occur at the surface layer of the water due to warmth and increased nutrient status of this epilimnion or due to Eutrophication, excess primary producers not eaten by herbivores will fall into the hypolimnion, when they die there decomposition will create an additional oxygen demand and when oxygen supply is sufficient like in seasons where oxygen from the surface diffuse

to the deeper layers, no major problem will arise but if there is no sufficient oxygen diffusing from top to the deeper layers like in summer, sudden fish kill occurs in late summer when biochemical oxygen demand is maximum (oxygen supply approach exhaustion).

THERMAL POLLUTION OF WATER.

It arises from the use of water as a coolant in industrial processes like in electricity generation plants. Excess heat is discharged into a nearby waterway causing thermal pollution, warm water has less dissolved oxygen than cool water. Thermal pollution can therefore have the following effects on the aquatic ecosystem

Kill fish by depriving them of oxygen since increase in water temperatures lowers the amount of oxygen that will dissolve in water.

It may also cause indirect death of fish and other aquatic animals by encouraging the increased growth of parasites.

Increased warmth raises the metabolic rate of organisms in the water and therefore increases their oxygen demands.

Some animals may migrate away from regions of the water with high

Temperatures to where water temperatures are cool.

When temperature differences are large in the waters, it may prevent migratory

Fishes like salmon from returning to spawning sites or from moving downstream.

It increases growth rate of some shellfish and allows some warm water organisms to be cultured in temperate regions.

In rivers or lakes polluted with sewage or other organic effluents, addition of warm water may improve the conditions. The coolant water may become more oxygenated during use and promote increased microbial activity within the polluted water.

OIL POLLUTION OF WATER.

The main sources of fresh water or marine oil pollution are, Damage to oil tankers due to accidents. Seepage from offshore installations. Illegal washing at lakes, rivers or seas of storage tanks of oil tankers.

The effects of oil pollution are,

The oil coats the feathers of sea birds preventing them from flying, their insulatory ability are reduced causing their death by hypothermia. -. Oil coats seaweed, preventing photosynthesis.

Oil covers the gills of shellfish interfering with feeding and respiration.

METHODS FOR TREATING AND PREVENTING OIL POLLUTION.

Burning heavy oil residues.

Collection of oil and pumping back into special collection ships.

Spraying onto oil slicks naturally occurring bacteria such as Pseudomonas that

can digest oil.

Routine check ups of supertankers to avoid such hazardous accidents in

ecologically sensitive areas.

Introduction of double tanker hulls and new ballast systems.

Use of floating booms to prevent slicks from reaching sensitive lines.

WATER POLLUTION BY TOXIC CHEMICALS.

These include heavy metals such as copper, zinc, lead, mercury and cyanide that may enter the water bodies. Fish and algae are killed by low concentrations of copper. Mercury denatures most enzymes and may cause many organs to stop functioning, such organs include, kidney, liver and brain. These may lead to loss of sensation, paralysis and eventually death.

The sources of such heavy metals include,

Natural weathering of rocks, mercury enters oceans in this way. Discharge of toxic industrial wastes into water bodies.

Microbial/bacterial activities may convert less toxic chemicals to toxic ones in the water. For example conversion of less toxic mercury into the toxic dimethyl mercury by anaerobic bacteria.

TERRESTRIAL POLLUTION.

This is the pollution of the land. It is divided into two,

(i) The dumping of wastes and deposits, (ii) The use of pesticides,

THE DUMPING OF WASTES AND DEPOSITS.

Waste materials are dumped into pits or heaps. This may result into,

- **Large volumes of solid waste materials** accumulating on land from many commercial activities.

- **Spoil heaps** consist of waste material from various mining activities like gravel digging.

- **Slag heaps** are wastes from ore-digging and metal refining activities especially mining of coal.

• **Domestic waste or rubbish.** This contains a high proportion of ash, organic matter, solid non-combustible materials, combustible materials like papers, plastic materials. Domestic rubbish are damped in old quarries, pits and on low lying land.

EFFECTS OF TERRESTRIAL POLLUTION ON ECOSYSTEM.

(i) Heaps of domestic wastes can cause air pollution as unpleasant odour/smell is produced.

Leads to destruction of habitats for living organisms.

Some domestic wastes include accumulation of sewage that may end up in water bodies causing Eutrophication. Some toxic chemicals from the heaps and pits of the waste materials may run off into the water bodies after rain, causing death of aquatic organisms or causing Eutrophication. Decay of rubbish in absence of air produces methane which is a green house gas. This will lead to global warming.

Toxic substances in the slag heaps may cause death of some organisms. They prevent growth of vegetation, this increases the incidences of soil erosion, and removal of vegetation also lowers primary productivity. Leads to development of new species of plants tolerant to heavy metals and growing on mine heaps.

Combustible material in the domestic rubbish may cause uncontrolled fire outbreak.

When properly covered in soil, can form organic manure for agricultural practices, increasing plant growth and overall yields. May lead to out break of diseases.

METHODS TO CONTROL DUMPING OF WASTES/DOMESTIC WASTES.

(i) Digging deep and large pits to burry the waste materials.

(ii) Recycling of the materials in domestic wastes.

(iii) Use of organic waste to generate power. For example Biogas production.

(iv) The use of organic waste to produce fertilizers.

(v) Burning rubbish or treating with chemicals to reduce bulk.

USE OF PESTICIDES.

Pesticides are poisonous chemicals which kill pests. Pesticides have been used for some time.

TYPES OF PESTICIDES.

(i) Fungicides. For example Bordeuax (copper sulphates + lime), calomel, are used to control transmission of fungal diseases by dusting seeds with the chemical.

(ii) Herbicides, for example sodium chlorate, used to control weeds, 2,4 D or 2,4,5-T hormones are selective weed killers which kill broad leaved species.

(iii) Insecticides. For example malathion DDT,dieldrin, aldrin. They kill insect pests.

and parathion (orga no-phosphorus,

EFFECTS OF PESTICIDES ON THE ECOSYSTEM.

(i) They are used to kill unwanted organisms, weeds and pests in a given area so as to increase crop yields. They can also be used to control spread of diseases by killing vectors of diseases. For example DDT kill fleas and mosquitoes.

(ii) Pesticides are often not specific so they may kill even beneficial organisms thus destroying food webs. Organic pesticides like malathion and parathion may kill useful insects such as bees, some Herbicides like paraguate kill all vegetation.

(iii) Pesticides may get concentrated along food chains killing animals at higher trophic levels. Pesticides may affect products of animals. Pesticides have a marked effects on the birds which include,

• DDT alters behaviour of birds and they are prevented from building proper nests.

• Cause infertility in birds.

• Kill birds at higher trophic levels.

• Cause egg shells to become thin and easily break when the female one sit on them during the incubation period.

• Leads to decrease in population of birds.

They may be washed off or blown to other areas and may affect or harm the organisms inhabiting such areas.

Over use of pesticides may lead to resistance to-wsietantse in pest resulting in resistant strains. This may in turn leads to pest resurgence and speciation.

Wide use of pesticides is main cause of terrestrial pollution. This may cause death and extinction of some species of organisms.

Dioxin a very toxic herbicide to man, it is as a defoliant. Dioxin can cause mass death of humans, cancer, skin disorder, mental disorder in children and miscarriages.

RADIOACTIVE POLLUTION.

There are two main forms of radiation.

(i) Electromagnetic waves.

(ii) Sub-atomic particles,

Electromagnetic waves of short wave lengths have high energy content, they include X-rays and gama rays, both rays are harmful and hazardous.

Sub-atomic particles include a-particles and G-particles which are naturally radioactive. There are other man made sources of radiations. These include testing of nuclear weapons and wastes from the nuclear power industry.

EFFECTS OF RADIOACTIVE POLLUTION.

(i) Causes gene mutation due to breakage of hydrogen bonds in the DNA molecule.. Mutations in the gonads may lead to production of defective gametes and hence resulting into deformed offsprings.

(ii) Early somatic effects of radiations that include damage to the gut, damage blood cells, bone tissues, skin burns, loss of hair and infertility, all these effects are collectively referred as radiation sickness. While delayed effects include an increased risk of cancer and possible hereditary defects.

(iii) Radioactive materials can also become persistent and accumulate along the food chains, this also affects animals at higher trophic levels especially birds, the normal embryonic development is impaired

(iv) Causes genetic diseases like leukamia.

NOISE POLLUTION.

• Extreme noise causes hearing damage.

• Loud noises can cause anger, discomfort; the loud noise is irritating and stressful

• Loud and sudden noise causes adrenalin to be secreted into blood, causing rise in blood pressure.

INDICATOR SPECIES.

Is a species of organisms that needs a particular environmental condition or set of conditions in order to survive. Presence, absence or population sizes of such species of organisms provide information about the state of the environment. Indicator species are used in a wide range of ecological investigations which include,

Present and past Edaphic (soil) conditions.

Present and past climatic conditions.

Biological monitoring of water and air quality. This involves detection of level of fresh water pollution, BOD of water, Eutrophication and pollution due to sulphur dioxide.

Detection of concentration of Carbon monoxide in mines.

EXAMPLES OF APPLICATIONS OF INDICATOR SPECIES OR BIOLOGICAL MONITORING OF WATER, AIR AND SOIL QUALITY USING INDICATOR SPECIES.

(i) Many rivers show that there are characteristic communities of organisms associated with different levels of organic pollution in rivers, lakes and seas. Clean water organisms include stonefly nymphs (larvae), *chrimp, Gammarus,* may fly larvae and caddis fly larvae. They indicate unpolluted, well oxygenated water, As pollution increases and oxygen content falls, those organisms tolerant to this conditions appear, these include worms of the genus *Tubifex, Chironomus, Asellus,* rat tailed maggots. These organisms are indicator species of high levels of organic pollution, low dissolved oxygen content of the water called Biochemical oxygen Demand (BOD).

(ii) Lichens are commonly used to indicate levels of air pollution by sulphur dioxide. Most lichens are very sensitive to levels atmospheric sulphur dioxide. Air pollution levels by sulphur dioxide are indicated by Biotic Index based on lichen species diversity in which lichen species abundance/number of individual lichens, extent of area covered by the lichens and lichens growth forms are considered. On heavily polluted surfaces with sulphur dioxide, species of lichens are absent but only algae are present. Many species of lichen are only present on surfaces less polluted or not polluted at all by sulphur dioxide. Species of lichen such as *Leconora comizoides, L. dispora* and moss species *Ceretodon purpureus* and *Funaria hygrometrica* are most tolerant to high levels of sulphur dioxide pollution. While Lichen species like *Permelia scivatilis* and *P. fulginosa* inhabit areas with low levels of sulphur dioxide such as areas far distance away from industrial cities or towns.

(iii) Indicator species can also be used to asses levels of in-organic pollutants. For example chemicals contained within individual indicator species may be analysed to assess levels of in-organic pollutants such as pesticide organochloride.

(iv) Some years ago, coal miners used a canary in a cage to detect levels of air polluted by Carbonmonoxide and the canaries used as indicator species to determine whether the conditions in the mine were suitable for health of the miners. Canaries are very sensitive to small amounts of Carbonmonoxide and Carbonmonoxide poisoning. So, a canary falling off its perch was taken as an alarm signal to accumulating levels of Carbonmonoxide and the miners quickly get out of the mines.

(v) Eutrophication can be monitored biologically. Changes in phytoplankton species present may help to indicate Eutrophication for example Blue-green bacterial blooms are common in eutrophied water. Eutrophied water also show high abundance and low species diversity of phytoplankton.

ADVANTAGES OF BIOLOGICAL MONITORING OVER PHYSIOCHEMICAL MONITORING.

• Abundance of organisms depend on the sum of all factors affecting environmental quality, physicochemical factors are usually measured individually.

• The abundance of organisms reflects the effect of continuous exposure to all environmental factors, physicochemical measurements are usually taken at intervals and are often spot checks.

• A brief and damaging pollution incident would continue to affect the abundance of organisms for some time even after the event, physicochemical measurements could miss this when they are not continuous.

DISADVANTAGES.

• Biological indicators do not reliably identify the precise cause of a pollution incidence, physicochemical measurements can identify the precise cause allowing specific actions to betaken.

• The abundance of the indicator species may vary naturally, so absence of an organism may not reflect a particular environmental conditions, carefully conducted physicochemical measurements do not suffer from this problem.

NOTE:

In most situations, environmental quality is monitored both biologically and physicochemically.

Biotic indices are used for routine, continuous monitoring of the environment and when they indicate a problem, physicochemical tests are conducted to identify the precise cause.

NATURAL RESOURCES AND CONSERVATION OF THE NATURAL

RESOURCES.

Natural resources are useful materials to man provided naturally by the environment.

Examples of natural resources include, Forests, Water bodies, fishes, oil, minerals, mountains, soil, sun, air, wild life, coal, natural gas.

TYPES OF NATURAL RESOURCES.

These are,

Renewable natural resources. Non-renewable natural resources. Non-exhaustible resources.

RENEWABLE NATURAL RESOURCES.

These are resources when used or destroyed may be replaced if proper conservation measures are applied. So, they are replaceable and can be used continuously.

Examples of such resources include forests, soil, water, fishes, wild life etc.

NON-RENEWABLE NATURAL RESOURCES.

These are resources when once used or destroyed cannot be replaced. So, they are irreplaceable resources. Examples of natural resources include coal, oil, natural gas and minerals.

NON-EXHAUSTIBLE RESOURCES.

These are not exhaustible in life. They are always available in abundance. These include, water, air (wind) and sun.

CONSERVATION OF NATURAL RESOURCES.

Conservation is defined as the action taken to avoid species decline, extinction and any permanent detrimental change to the environment. It is about maintenance of the biosphere. Conservation aims to maintain the quality of natural environments and their biological resources.

REASONS FOR CONSERVATION OF NATURAL RESOURCES/WILD LIFE.

(i) Ethical reasons.

It is morally wrong to destroy ecosystem or to allow species to become extinct. So, it is right to conserve the diversity of life and the environment so as to pass it onto the future generations the way they were inherited.

(ii) Aesthetic Reasons.

Conserving the wild life for the pleasure it provides. This is to encourage eco-tourism, this is the tourism based on visiting natural environments, promoting art, design, literature and recreation.

(iii) Utilitarian Reasons.

This is where Biological resources are conserved for their usefulness or economic values. Wild life supplies human community with food, medicines and many industrial products.

Medicines obtained from wild plants include quinine and codeine, those obtained from animals include snake venom used as anticoagulants and anaesthetics.

They can also contribute for our needs in agriculture, forestry and fisheries. We make use of pollinating insects and use of predators in pest control.

Soil management and conservation is to achieve the following, to maintain or improve soil structure. To reduce soil erosion. To maintain or improve soil fertility. To control pests and diseases.

(iv) Ecological/scientific Reasons.

For the well-being of humans that depend on maintenance of a fully functional Biosphere. For instance maintaining stable biochemical cycles which can only be disrupted by extinction of some species, such disruption can affect negatively human lives. For example loss of vegetation cover can cause soil erosion, siltation of rivers and coasts and may even result in changes in rainfall and climate patterns.

SOIL USE AND CONSERVATION METHODS.

SOIL USE.

Used in agriculture for growing of plants and rearing of animals.

Habitat for soil micro-organisms for example earthworms, bacteria, etc.

For settlement.

For mining for example sand, clay and other minerals.

Source of nutrients for plants for example minerals like calcium, nitrogen, magnesium, iron, iodine etc.

SOIL MANAGEMENT TECHNIQUES AND CONSERVATION METHODS.

(i) Crop rotation.

Farming methods where different crop plants are grown in a field in regular rotation. This method prevent, buildup of pests and parasites to any crop species, minimizes the risk of depleting the soil of nutrients and water, where legumes are used in the rotation, nitrogen fixing bacteria in their root nodules add to soil erosion.

(ii) Tillage.

Is the mechanical turning of the soil by ploughing. It suppresses the growth of weeds and promotes a good drainage and soil structure.

(iii) Liming.

This is the addition of agricultural lime to the soil. Lime is a mixture of calcium hydroxide (slaked lime), calcium oxide {Quick lime) and Calcium carbonate (limestone). Liming increases soil pH, neutralizing acidic soils and promoting clumping of soil particles, thus improving soil structure.

Note: Liming adds carbondioxide into the atmosphere and may cause global warming.

(iv) Addition of organic matter.

This involves addition of substances such as manures, straw and sewage sludge. This promotes humus formation, improving soil structure, and promoting plant growth. Organic fertilizers are also usually more difficult to handle, use and apply onto the soil, they take

longer time to have an effect and their compositions are variable and therefore not easy to determine the right amounts or dose, this makes them unreliable.

(v) Addition of in-organic fertilizer/Artificial fertilizers.

It involves addition of granules, pellets or liquid containing one or more inorganic nutrients such as nitrogen, phosphorus and potassium. They have the following advantages,

Their actions are quick.

Easy to use and apply.

Are reliable, effective and efficient.

Promote fast plant growth when used appropriately.

Inorganic fertilizers also have disadvantages that include,

Heavy use may destroy soil structure, texture and increase soil acidity or pH. They can run off into rivers and lakes or leaching into aquatic environment may cause Eutrophication and algal blooms. This causes death of aquatic plants and their decay leads to oxygen deficiency in water. Heavy use destroys beneficial soil micro-organisms. They may also damage plants, burning or scorching them.

(vi) Practicing terracing, contour ploughing and mulching as good agricultural practices to prevent soil erosion.

(vii) Building dams across streams to reduce the speed of flowing water, preventing soil erosion.

(viii) Establishment of permanent grass lands and wood lands where growth of other useful crops are not possible.

WATER USE AND CONSERVATION.

Water bodies include lakes, rivers, streams, swamps, wells, seas and oceans.

USES OF WATER BODIES.

Habitat for fish and other aquatic plants (phytoplanktons) and aquatic animals

(Zooplanktons).

Sources of water for domestic and industrial use.

For recreation purposes for example swimming, sports and fishing.

Minning for example mining salt, soda ash and fish.

Climatic control like in convectional rainfall formation.

WATER CONSERVATION METHODS.

Restoration of streams and rivers.

Dumping of untreated sewage and industrial wastes into rivers, lakes be avoided to prevent water pollution.

Mulching and replacement of the vegetative blanket to retain soil moisture. Construction of dams which act as water stores or reservoirs. Correct ploughing and cultivation methods.

WILD LIFE USE AND CONSERVATION METHODS.

Wild life refers to wild animals and plants.

USES OF WILD ANIMALS (FAUNA)

For tourist attractions. Provides hides and skins.

Means of transport for example horses, elephants, camels, donkey etc. Source of food, they provide meat.

Source of income for example from game cropping and hunting. Some are pollinators like the bees, improving crop yields. Provide carbondioxide to green plants.

CONSERVA TION METHODS.

Legislation. Institute laws against encroachment and poaching and the laws must be state enforced.

Practicing ***game cropping.*** It is the scientific killing of game animals to keep the population at the carrying capacity level. Prevent deforestation. Restoration of natural habitats. - Increasing state national parks to protect many wild life from extinction.

USES OF WILD PLANTS (FAUNA).

Source of medicine for example quinine is got from specific wild plant materials.

Provides food inform of many fruits and roots of some plants. Nectar and pollen can be collected by insects and used for manufacture of honey.

Habitat for many insects.

Photosynthesis by these plants removes excess carbondioxide from the atmosphere, minimizing global warming.

Biological control agents. Some plant species control population of mosquitoes and tsetse flies.

CONSERVA TION METHODS.

Prevent over grazing.

Prevent land, water and air pollution.

Prevent deforestation.

Institute legislation that will regulate collection of wild plants and their products such as flowers.

Use of botanical gardens and seed banks to keep plants that are endangered.

Controlled fire out breaks.

FOREST USE AND CONSERVA TION METHODS.

USES OF FOREST.

Nutrient recycling.

Provision of fuel for example fire wood for domestic and industrial uses.

Catch large amounts of rainfall, are useful for rain formation.

Habitat for many animals and plants.

Increase soil fertility by adding organic matter into the soil.

Act as wind brakers.

Prevent soil erosion by reducing speed of low of water and wind.

Tropical forests provide humans with anti-cancer and anti-malarial drugs.

Trees in the forest are photosynthetic utilizing the excess carbondioxide in the atmosphere, so prevents occurrence of global warming.

Prevents sound pollution by absorption of loud and bad sounds.

Used for recreation purposes.

Mis-use of forests can occur due to, Un-controlled felling of trees.

Encroachment for agricultural purposes and settlement. Charcoal burning. Un-controlled fire.

CONSERVATION METHODS.

Re-afforestation, this is planting of trees where they have been before. Afforestation, is the planting of trees where they have never been before. Selective felling (cutting) of trees. By imposing regulations which discourage forest encroachment.

FISHERIES, USES AND CONSERVATION

Fish are renewable resource. These are resources which with proper management can be used again and again because they are constantly replaced.

Fish are found in rivers, lakes, seas and oceans. Fish are not evenly distributed in lakes, seas etc. Fish feed on phytoplanktons and therefore fish are most abundant where phytoplankton productivity is highest. Most oceans have a low concentration of nutrients at the surface, so phytoplanktons and fish population are low at the surface. There are two zones in the oceans where nutrient concentration and fish population is high,

(i) Where wind and currents cause water close to the sea bed to rise. The upwelling carries nutrients into waters high up where there is sufficient light to support photosynthesis. This region is known as up welling zone.

(ii) Shallow sea above continental shelves. In this area the concentration of nutrients are high, the water is shallow, the bottom sediments are disturbed by heavy storms to permit nutrients rise up, this zone is also fed by rivers carrying nutrient rich sediment that comes from natural erosion and human activities.

USES OF FISH.

Source of protein food to humans and other animals.

Provide carbondioxide to phytoplanktons.

Source of medicine for example cod-liver oil, hypochromis species of fish for treatment of measles in children.

Used for sports and recreation purposes.

Fish are renewable resource and therefore be replaced. However, over fishing can cause depletion of the species of fish.

EFFECTS OF OVER FISHING ON ECOSYSTEM.

- Reduces the population size of adult fish and limits their distribution.

The population structure of fish is changed, the population size of younger and smaller fish become greater than those of adults.

It disrupts food webs by causing increase in plankton population following removal of fish as their predators.

Population of other animals that feed on planktons may increase.

The population of fish predators may fall drastically.

It may result in extinction offish.

Conservation METHODS OF FISH.

(i) Fish must not be caught faster than the fish stocks can replenish themselves, a phenomenon referred to as sustainable yield.

The largest amount of a naturally renewable resource that can be regularly harvested without causing a decline in stock of that resource is called maximum sustainable yield. The maximum sustainable yield is maintained when,

• The growth rate of the resource is at its highest and when the harvest is at the correct level to keep the population at its optimal size.

(ii) Regulations must be made to prevent over fishing or to allow over fished stocks t recover. So, the following measures must be considered,

• *Quota system of fishing.*

This is where the amount of fish that each country is allowed to catch be specified.

• *Minimum mesh sizes.*

Ideally mesh size should be large enough to allow small, fast-growing, immature fish to pass through. These fish can then reach maturity, spawn and help replenish fish stocks.

• *Closed seasons.*

This is the season of the year where fishing is not allowed, usually during the breeding season of a particular fish species.

• *Exclusion zones.*

Designated areas in which fishing is banned completely.

(iii) Practicing fish farming. The deliberate cultivation of fish and shell fish so as to meet the high demands for fish.

(iv) To prevent discharge of untreated sewage and toxic industrial wastes into the rivers, lakes, seas to avoid occurrence of Eutrophication and algal blooms.

ASSOCIATIONS BETWEEN ORGANISMS.

Individuals do not live in isolation in a community, they continually interact with each other or form close associations. These associations are divided into two categories,

(I) Intraspecific *associations/interactions.*

This is an association or relationship that may occur between organisms or individuals of the same species. Most individuals of the same species have nothing or little to do with each during their lives. However certain animals live in groups or colonies showing social

organization. The two groups to have developed this to high degree are insects and mammals. And social organizations are important in the following ways,

Ensures protection and care for the young ones.

Group protection against predators.

Promotes breeding among individual species.

Search for food to feed the individual species.

Improve communication among individuals.

(ii) Interspecific associations/interactions.

This is an association (relationship) that may occur between organisms or individuals of different species.

The close association between different species of organisms in which the body of one organism generally provides the habitat for another is nowadays referred to as symbiosis. Organisms that do not have to adopt a certain mode of life are described as *facultative.* Whereas those compelled to follow a particular mode of life are described as *obligate.*

INTERSPECIFIC ASSOCIATION/INTERACTIONS.

These include,

(i) Commensalism.

In this association one organism, the commensal gains while the host neither loses nor gains.

(ii) Mutualism

In association either partners or organisms of different species benefit from the relationship.

(iii) Predation
In this interspecific interaction in which one organism the predator kilts another called the prey in order to obtain food.

(iv) Competition

This is an interspecific interaction where organisms of two or more different species try to obtain the same limited resources. The relationship is harmful to both species.

(v) Allelopathy

This is an interspecific interaction in which one organism produces a chemical substance which has a harmful effect on another organism of different species.

(v) Parasitism.

This is an association or relationship between two organisms of different species in

which one organism, the parasite fives temporarily or permanently in or on the other

called the host, deriving benefit from it and causing harm to it. In this case the parasite

gains but the host loses. Parasitism can be broadly studied such a study is referred to as

parasitology.

NOTE: The major interspecific associations include Mutualism, commensalisms and parasitism.

PARASITISM.

The association between parasites and hosts can be divided into spatial and temporal relationships.

Spatial relationship refers to the part of the body of the host that is exploited by the parasite. Parasites which live on the outer surface of a host are termed as **ectoparasites** for example ticks, fleas and leeches. These parasites do not always live a fully parasitic existence,

The parasites that live within or inside the host are the **en dopara sites.** For examples are plasmodium, tapeworm *Taenia* and liver fluke *Fasciola.* Endoparasites can live in, or just beneath, the skin, others in the gut, others in the tissue fluid between the cells called **intercellular parasites,** others penetrate individual cells and are termed as intracellular **parasites,** for example malarial parasite plasmodium.

Most parasites are endoparasites because the inside of the body provide an environment which is rich in nutrients and not subjected to extremes of environmental conditions.

Temporal relationship refers to the time the parasite spends in or on its host. Parasites that never live their hosts and live parasitically at ail times is termed as obligate **parasites.** For example tapeworms, phytophthora.

Parasites or organisms that live as parasites at one time but do not live parasitic life at another time, others may live saprotrophically at later time, such are referred to as **facultative parasites.** Facultative parasites may kill their hosts and then live saprotrophically. For example fungi *Candida* and Pythium. Other facultative parasites are ectoparasites that attach themselves to the host when they are feeding such as mosquitoes and Tsetse flies.

The main benefits gained by the parasite are shelter and food, But parasites can also harm the host. They feed on and damage the tissues of the host causing death or serious injuries, they may secrete toxic substances that may harm the hosts, they may simply feed on host's digested food as this cause least harm.

Plants are parasitized mainly by fungi and bacteria, plants are poor hosts for invertebrates because,

They remain in one position and so it is more difficult for the parasite to reach a new host.

Their cellulose cell walls are difficult for animals to digest.

They have few internal cavities suitable for parasites.

The most successful invertebrate parasites of plants are nematodes. In animals the habitats most used are,

The body surfaces and its infoldings such as the buccal cavity, lungs, external

gills and nostrils.

The alimentary canal and its associated organs such as the liver and bile duct.

Internal tissues such as blood and muscle.

TRANSMISSION OF PARASITES

Parasites can enter into a new host by the following ways and these include,

i. Parasites can lodge into tissues which are then eaten by the hosts. Forexample *Taenia.*
ii. They can penetrate the skin or body surface of a new host after leaving an intermediate host for example Schistosoma.
iii. Parasites can be injected by an intermediate host for example transmission of plasmodium by the mosquitoes.
iv. And when parasites are not on or in their hosts they can exist as, dormant stages, free living stages or in intermediate hosts.
v. Endoparasites can also escape from their hosts through any one of the following ways, Escape through the air from the lungs.
vi. Passed in the faeces from the intestines for example the ascaris. Passed in urine from blood to the wall of a bladder for example schistosoma. Parasites can be sucked from the blood of an intermediate organisms for example plasmodium.
vii. Discharge larvae of the parasite through skin of the host. Disintegration of the host tissues after death releasing the parasites,

MAIN FEATURES OF THE PARASITES.

(i) Possession of attachment devices such as hooks and suckers.

(ii) Reduced or no digestive systems.

(iii) Have intermediate hosts or vectors.

(iv) Production of many eggs.

(v) Existence of dormant or resistant stages.

(vi) Protective devices covering the body surfaces.

ADAPTATIONS OF PARASITES TO LIVE IN IT'S ENVIRONMENT FOR ITS MODE OF LIFE.

STRUCTURAL (MORPHOLOGICAL) ADAPTATIONS

(i) Possession of devices for attachment especially ectoparasites to permit the parasite cling on or in the host for example suckers and hooks. They are also responsible for attachment of scolex of the tapeworms.

(ii) Degeneration of certain unnecessary organ systems for example digestive system is reduced or absent, absence of well-developed locomotory system. This reduces the energy requirements of the parasite.

(iii) Change in body shape for example laterally compressed body to enable them move freely like fleas moving freely within the forest of the hair. Dorso-laterally compressed body to enable them squeeze in narrow cracks to get access to the host like in bed bugs. Flattened body of the tapeworm increases surface area for absorption of digested soluble foods of digestion.

(iv) Possession of penetrative devices for entering into the host and its cells for example the miracidium larva of the liver fluke possesses glands that enable the bore into the snail.

(v) Gut parasites have protective devices which prevent the body being harmed by the host's digestive processes. In the same way, the bacterial capsule gives protection against the host's phagocytes making them more difficult to ingest.

PHYSIOLOGICAL ADAPTATIONS OF PARASITES.

(i) Secretion of protective devices to prevent distraction by the host defence mechanisms for example replacement of surface epithelium by a resistant cuticle. This contains substances which are not hydrolysed by pepsin and frypsin for example round worms (Ascaris lumbricoides), Schistomes absorb giycolipids from the host tissue and thus prevent immunological attack.

(ii) Secretion of enzymes that can digest body tissues of the host to permit easy penetration. For example a number of parasitic fungi secrete cellulase at the tips the hyphae enabling penetration into the host's cells. Parasitic bacteria produce enzymes called aggressins which dissolve connective tissue and enable them penetrate the host tissues and digestive enzymes secreted by the glands of miracidia of Schistosoma species.

(iii) High affinity of haemoglobin in the parasite for oxygen where oxygen partial pressures are generally low.

(iv) Development of dormant or resistant phases to overcome in favourable periods away from the host for example eggs which are produced in the resistant cuticles to withstand adverse environments for example in *ascaris lumbricoides.*

(v) Secretion of large quantities of mucus and production of inhibitor substances which locally inactivate the host's digestive enzymes.

(vi) Production of chemicals which protect them against the host's defence mechanisms for example the blood fluke *Schistosoma* synthesizes substances which switch off the host's immune system, the parasite coats itself with molecules which the host recognizes as "self.

OTHER ADAPT A TIONS.

These are seemingly behavioral adaptations which are aimed at increasing chances of infections of the prospective hosts these include,

(i) Production of large numbers of eggs for example *Taenia solium.* In addition to many eggs they have more efficient means of fertilization by becoming haemophrodites and undergoing self-fertilization.

(ii) Use of a vector or intermediate host either as a means of entering the primary host or surviving when primary host is not available i.e the malarial parasite can not enter man unless injected by mosquitoes.

(iii) Localisation in areas where they can easily be extracted by the host for example parasites of the genital system for example *Candida albicanes.*

(iv) Close association between the female and male sexes for example Schistosoma mansoni and haematobium. This removes the need to look for the mate,

(v) Assumption of the body colour of the host for example bed bugs, fleas, lice and ticks. This gives them protective camouflage.

(vi) Some parasitic bacteria allow themselves to be ingested by the host's phagocytes which convey them to other parts of the body without killing them.

(vii) Some parasites are so closely linked with the host that their tissues are actually connected for example certain plant parasites plug into other plants and tap off nutrients from the host's vascular tissues. For example dodder *(Cuscuta)*

EFFECTS OF PARASITES ON HOSTS

Causes diseases to the host for example plasmodium parasites cause malaria to the host.

Deprives the host of its food/nutrients for example Tapeworm, taenia.

Cause damage to the cells for example giggers, parasitic Phytophthora infestans causing damping off in seedlings.

Suck blood from their hosts causing anemia.

Transmit diseases for example Trypanosoma cause of sleeping.

May cause intestinal obstructions (Blockage of intestines) for example the

Ascaris lumbricoides (Round worms).

Produce toxins which may interfere with normal functioning of body. For example Trypanosomes, flagellated protests.

The tiny larvae of Filarial worms *(Wuchereria bancrofti)* a nematode transmitted by mosquitoes, invade lymphatics where they mature into adult into adult worms. These increase in size and numbers to block the lymph vessels, this causes excessive growth of the tissues in the infected areas resulting into enormous enlargement of the body extremeties particularly legs, breasts, scrotum, this is a condition known as ***elephantiasis***

A parasitic crustacean that attacks the shore crab carcinus. When the crab moults following infection, it changes its sexual features, the males develops into females, while the females change towards juvenile type lacking gonads, this condition is referred to as **Parasitic castration.** In this case parasites seem to interfere with the host's hormonal balance.

ADVANTAGES OF PARASITIC MODE OF LIFE.

(i) There is constant food supply for parasites,

(ii) No need to store food.

(iii) Relatively constant environment, so are protected from climatic extremes especially endoparasites.

(iv) Parasites are protected from predation.

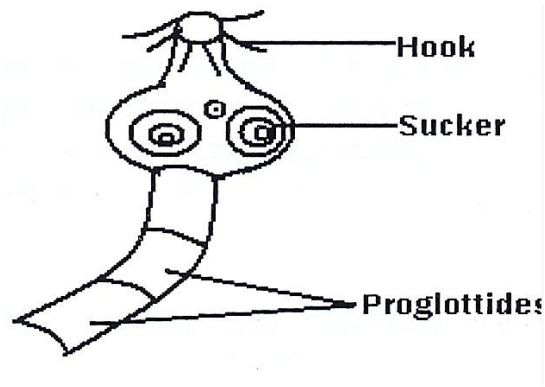
(v) Degeneration of many systems in parasites and simplified form means less energy required to maintain themselves and allow rapid development.

LIFE CYCLES AND ADAPTATIONS OF SOME ENDOPARASITES.

(a) TAPE WORM (TAENIA). CHARACTERISTICS.

Body is dorso-ventrally flattened. Body is segmented. Reproduce asexually. It is hermaphrodite.

EXTERNAL FEATURES OF TAPEWORM.



ADAPTATIONS OF TAPEWORM.

(i) Carries out anaerobic respiration hence can tolerate areas of low oxygen tension,

(ii) Has tiny head (scolex) bearing four suckers and two rows of hooks on the rostellum for firm attachment on the host,

(iii) Undergoes a period of dormancy in its life cycle as cysticercus to overcome adverse environmental conditions,

(iv) Body dorso-ventrally flattened and thin to increase surface area for absorption of food from the host and to be easily accommodated within the host,

(v) It is hermophriditic for fast and easy multiplication as it does not require a sex partners because it carries out self-fertilization.

(vi) Produces large number of eggs to spread fast since it has a short life span.

(vii) Makes use of intermediate host in its life cycle to serve as vectors to primary host,
(viii) Body covered with resistant cuticle for protection against the digestive enzymes of the host.

(ix) Has ability to regenerate itself to ensure continued survival,

(x) Usually not more than one parasite on a host to avoid intraspecific competition and avoid over harming the host to an extend of killing it.

LIFE CYCLE OF A TAPEWORM.

There are two stages in the life cycle of the tapeworm.

Larval stage develops in tissues of the pigs and the adult worm develops in the intestines of human beings.

Adult Taenia lays eggs which are ingested in faeces by the pigs or cattle. The eggs hatch into larvae (Oncosphere) which is carried in blood circulation to lodge into the tissues. The larvae develop into cyst. When poorly cooked meat or pork is eaten by humans, the cyst reaches the intestines and develops into adult tapeworm which when mature begins to lay eggs.

EFFECT OF THE PARASITE ON THE HOST.

Causes epileptic seizure due to toxic effects of the larvae (oncosphere) lodging in the brain and the heart.

PREVENTIVE MEASURES.

(i) Eat well cooked pork or beef.

(ii) Mass education or sensitization of the public.

(iii) Proper disposal of wastes.

(iv) Drinking safe water.

(v) Regular deworming.

(vi) Treatment of victims.

(vii) Preventing children from playing with dirt/soil.

Note: T. saginata does not have hooks, only uses suckers and does not affect the brain.

HOOK WORMS (ROUND WORMS).

There are two common species of hook worms.

(i) Ancylostoma duodenalis.
(ii) Necater Americans,
(iii) Ascaris lumbricoides.

ADAPTATION OF THE HOOKWORMS.

(i) Produce large number of eggs to increase chances of survival.

(ii) Respire anaerobically due to lack of oxygen in the gut of humans.

(iii) Resistant to digestion by body enzymes.

(iv) Presence of cuticle covering the body surface to avoid enzymatic action onto them.
(v) Have sharp teeth/mouth parts for cutting tissues and sucking blood from the host.

(vi) Feeds on already digested food from the host.

(vii) It shows degeneration of organs, reducing high energy demands.

(viii) Have strong teeth for grasping the walls of the small intestine,

(ix) They occur in large numbers to increase chances for survival.

LIFE CYCLE

The eggs are passed in faeces onto the soil. The eggs hatch into larvae and then undergo series of developmental stages. The larvae attach on the skin and penetrate through the skin into blood stream. It is carried into the lungs and then through trachea to reach the buccal cavity. In the buccal cavity the larvae which is mixed with mucus is swallowed to reach the intestines where it develops into an adult hookworm.

EFFECT OF THE PARASITE ON THE HOST.

(i) When the worms enter the skin, they cause itching or water sores and inflammation on the feet.

(ii) Burrowing in the lungs may cause infections in the lungs, which may result into pneumonia.

(iii) Causes nausea (feeling like vomitting).

(iv) Causes abdominal discomfort.

(v) Causes diarrhea.

In children, it causes,

Swollen abdomen.

Irregular heart beat (palsipitation)

Loss of weight.

PREVENTION.

Proper disposal of wastes.

Drinking clean and safe water.

Regular deworming.

Mass public Education and sensitization.

Preventing children to play with dirty so/I.

PLASMODIUM (MALARIAL PARASITE).

TRANSMISSION OF THE DISEASE.

Malaria is an infection/disease caused by the plasmodium parasite. It is the most important killer disease in tropical regions.

Malaria is transmitted by a vector (a disease transmitting organism). The vector of the malaria is the female anopheles mosquitoes. The female anopheles mosquitoes breed in stagnant waters, or waters which collect on leaves, ponds, broken tins and pots, etc.

THE LIFE CYCLE OF THE MALARIAL PARASITE (PLASMODIUM)

Pre- erythrocytic cycle is an asexual cycle that occurs in the human liver. Following a bite by an infected mosquito, the plasmodium parasites inform of slender sporozoites are introduced into blood stream of human. The sporozoites circulate in blood circulation; the sporozoites invade the liver cells and reproduces rapidly by schizogony to form the numerous merozoites. The enlarged liver bursts, releasing the merozoites in the blood. Some merozoites invades and enters into red blood cells while others reinvades the liver cells.

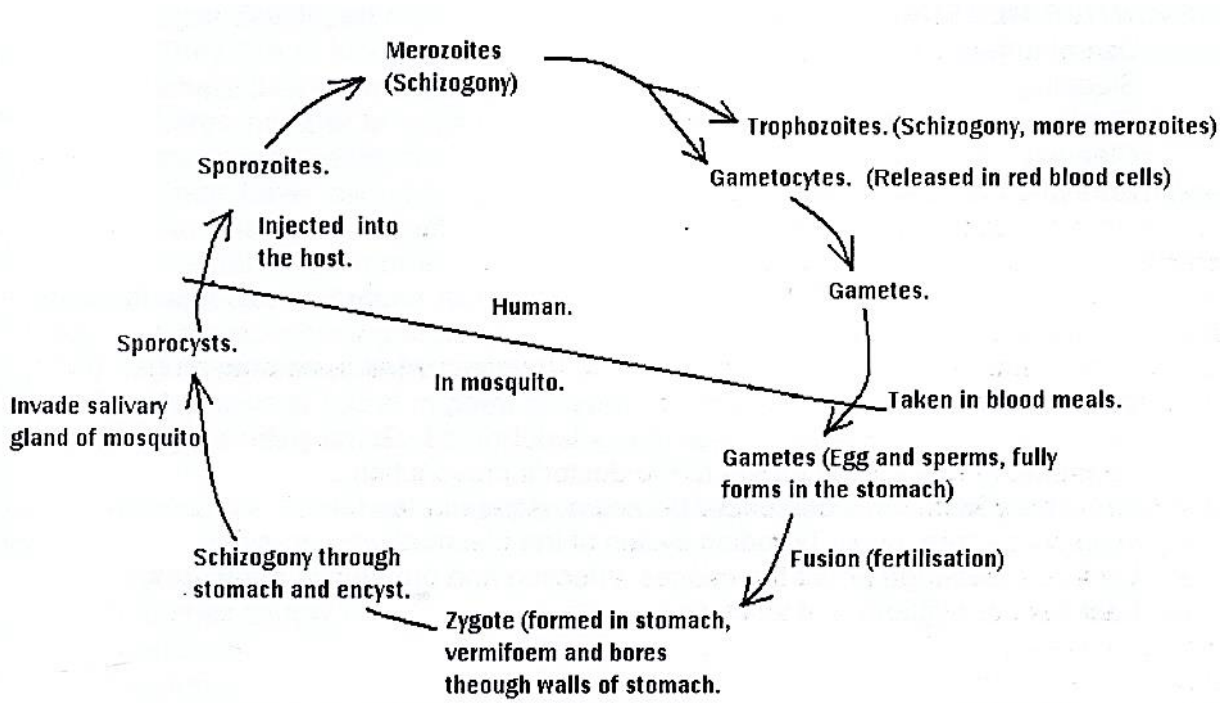
Erythrocytic cycle. Is an asexual cycle that occurs in the human blood stream. The merozoites invade the red blood cells. The red blood cells have receptors which attract them. In the red blood cells they feed on haemoglobin they grow and develop to form trophozoites which appear ringed, the trophozoites further grows and develops to form schizonts, the numerous schizonts cause the red blood cells to burst and release more merozoites, some merozoites invade more red blood cells while others are transformed into sexual forms (gametocytes) they are male gametes (spermatozoa and female gametes (egg cells). The release of more merozoites occurs at regular 48 or 72 hours intervals and is accompanied by attacks of high fever. The gametocytes will not develop further unless sucked up into stomach of mosquitoes of the genus Anopheles when they bite an infected person.

Sexual cycle occurs in mosquito (vector).

In the stomach of the mosquito, eggs and motile sperms are liberated and fertilization takes place to form a motile zygote (cyst). The zygotes spherical at first, acquires a vermiform shape which enables them to penetrate into the stomach wall of the mosquito and form on the outer surface wart like cysts. Some migrate upto the thoracic part of the mosquito. Within each cyst rapid asexual multiplication takes place forming thousands of slender sporozoites. The cysts rupture releasing several slender sporozoites that migrate to the mosquito's salivary glands. When such infected female anopheles mosquito bites an individual, they inject into the human bloodstream the sporozoites which then circulate in the bloodstream to invade the liver, thus completing the cycle.

Under heavy infections large numbers of red blood cells are destroyed. The major consequences of malaria is anaemia, a lot of byproducts are also released for example proteins, hormones and these leads to fever or chills felt by the individual.

LIFE CYCLE OF PLASMODIUM.



ADAPTATIONS OF THE PLASMODIUM (MALARIAL PARASITE) TO PARASITIC MODE OF LIFE.

(i) Has a short life cycle for rapid population increase.
(ii) Have both sexual and asexual reproductive stages in its life cycles, asexual reproduction ensures rapid increase in numbers.
(iii) Encysted zygotes survival in harsh environmental conditions.
(iv) Infects liver and red blood cells to obtain nutrients to increase their chances of survival.
(v) Exist in different generations to increase their chances for survival.
(vi) Tiny and slender to feed on small amounts of food and can survive in large numbers within a cell.
(vii) Vermiform shape of zygote to bore into the walls of the stomach.
(viii) Motile male gametes increasing the chances of fertilizing the eggs.
(ix) Motile zygotes that enable the offsprings to move to sites where they can obtain nutrients and survive.

(ix) Motile zygotes that enable the offsprings to move to sites where they can obtain nutrients and survive.

SYMPTOMS AND SIGNS OF THE MALARIA.

Head ache.
Pain in the joints.

Shivering.
Vomitting.
Loss of apetite.
High temperatures.
Feeling cold.
Dizzyness.
Stomach ache.
General body weakness.

PREVENTIVE MEASURES

Use of anti-malarial drugs.

Sleeping under treated mosquito nets.

Closing doors and windows before dusk.

Clearing the bush.

Spraying the nearby vegetation by DDT.

Draining stagnant waters.

Despite the preventive measures, malaria is still the most hazardous disease in Africa. This is of because the following reasons,

Lack of money in many rural areas to buy the effective anti-malarial drugs.

Wide use of ineffective and expired drugs.

Drug abuse and mis-use of the anti-malarial drugs. Some patients do not take treatment of malaria according to the doctor's prescription.

Many people do not sleep under treated mosquito nets.

Tropical climate favour breeding cycles of the plasmodium parasites.

Lack of knowledge about the causes, infection and preventive measures.

Lack proper hygiene and sanitation.

THE LIFE CYCLE OF LIVER FLUKE (Fasciola hepatica)

The adult flukes live in the bile passages of sheep where it reproduces sexually producing numerous encapsulated zygotes. These zygotes give rise to ciliated miracidium larva which swim through water onto the ground. The miracidium then penetrates the fleshy foot of the snail (Limaea truncatula) where it forms sporocysts. Inside the sporocyst special cells divide

to form rediae larvae which burrow into the liver of the snail feeding on the tissues. Inside each redia, special propagatory cells divide to give rise to either more redia or numerous cercariae larvae. The cercariae leave the snail and encyst on blades of grass. When sheep graze, it consumes it. The encysted cercariae bursts open to release a small immature fluke which migrates from the sheep's gut into the liver. In the liver it feeds and grows to maturity thus completing the cycle.

THE HUMAN BLOOD FLUKE (SCHISTOSOMA).

Three species of blood fluke are endoparasites of man, Sch/stosoma mansoni which is prevalent in South America, S. haemotobium which occurs in Africa, S. japonicum occurs in the Far East Asia.

THE LIFE CYCLE OF BLOOD FLUKE (SCHISTOSONIA).

Blood fluke is a close relative of the liver fluke, it lives in the blood vessels associated with the intestine and urinary systems. In the urinary or intestinal blood vessels, the flukes reproduce sexually since the male and female flukes live always in pairs. Large number of eggs is laid and released into the intestine or bladder by rupture of the blood vessels. These eggs are passed in faeces or urine. If the eggs get in contact with water, the eggs release ciliated miracidia which bores into the tissues of a certain fresh water snail, the intermediate host. Within the snail the miracidia form sporocysts which reproduce internally to form numerous cercariae similar to those produced by the liver fluke. Cercaria production may continue for several weeks with very many produced by a single sporocyst per day. The cercariae leave snail and swim through the water and when they find humans as the second host, they penetrate through the skin by use of special glands or they can be consumed in drinking water. Once in circulation the cercariae develop into adult flukes.

ADAPTATIONS OF SCHISTOSOMA.

Most developed resistance to anti-parasitic medicine.

They live in blood vessels associated with the intestines and urinary system where they reproduce sexually.

Large number of eggs is released into the intestine or bladder by ruptures of the blood vessels for rapid multiplication.

They have miracidia that can penetrate into snails as vectors to ensure survival and continuity in their life cycle.

Formation of sporocysts which form numerous cercariae which have a high reproductive rate.

Cercariae have glands for piercing the skin.

They have ventral structures and mouth, the mouth has feeding devices.

Are always found in pairs of male and females to effect sexual reproduction cycle and ensure a high reproductive rate.

Blood flukes cause **Schistosomiasis** known as Bilharzia. The symptoms of the infection include,'

Skin rush.

Bronchial cough.

Sickness.

Anaemia.

Abdominal pain and Diarrhoea.

Weakness and emaciation.

And if the condition is not treated, death of the victim occurs.

CAUSE/SPREAD OF THE DISEASE.

Caused by people drinking or bathing with contaminated water with cercariae/ drinking unsafe water/ Use of contaminated for irrigation purposes.

Swimming, washing or playing in river waters contaminated with cercariae.

Urinating or defaecating into streams, rivers or lakes.

Use of human faeces as fertilizers.

CONTROL MEASURES.

Administering certain drugs for treatment of Bilharzia at an early stage of infection.

Spraying vegetation near water bodies like rivers, lakes with molluscicides, chemicals that kill snails.

Practicing biological control methods by introducing ducks that feed on snails/

Snails can be trapped by placing canvas sheet across the river.

Human faeces fertilizers must first be thoroughly dried before use.

Farm laborers working in the rice fields must wear protective clothing or gears to prevent getting into contact with the cercariae in waters in the swamps.

Drinking water should be chlorinated to kill the cercariae.

Proper hygiene such as proper disposition of faeces into pit latrines.

Swimming or bathing in dirty river waters or in lakes should be avoided.

Education and sensitization of the masses about causes, dangers and control of bilharzia be encouraged.

TICKS (ECTOPARASITE)

A tick is an ectoparasite of mainly mammals.

ADAPTA TIONS OF TICKS TO PARASITIC MODE OF LIFE/NUTRITION.

(i) Hypostome has several rows of curved hook like teeth which enable tick to hold firmly onto the host/Strong hooked jaws for attachment on host.

(ii) Tough exoskeleton prevents physical injury.

(iii) Mouth parts are modified into strong piercing organs or hypostomes for piercing the host's skin.

(iv) Extensible abdomen can accommodate large quantity of blood.

(v) They are very sensitive to the presence of hosts.

(vi) Can survive for several days without feeding.

(vii) Have hard or tough article which is resistant to mechanical injury and dehydration.

(viii) They produce large number of eggs.

(ix) Have a dull colour for camouflage.

(x) Able to climb and perch on vegetation.

EFFECTS OF THE PARASITE TO ITS HOST.

(i) Physical discomfort and irritation.

(ii) Transmits disease to host such as east coast fever.

(iii) Causes blood loss from host.

(iv) Damage host skin by biting.

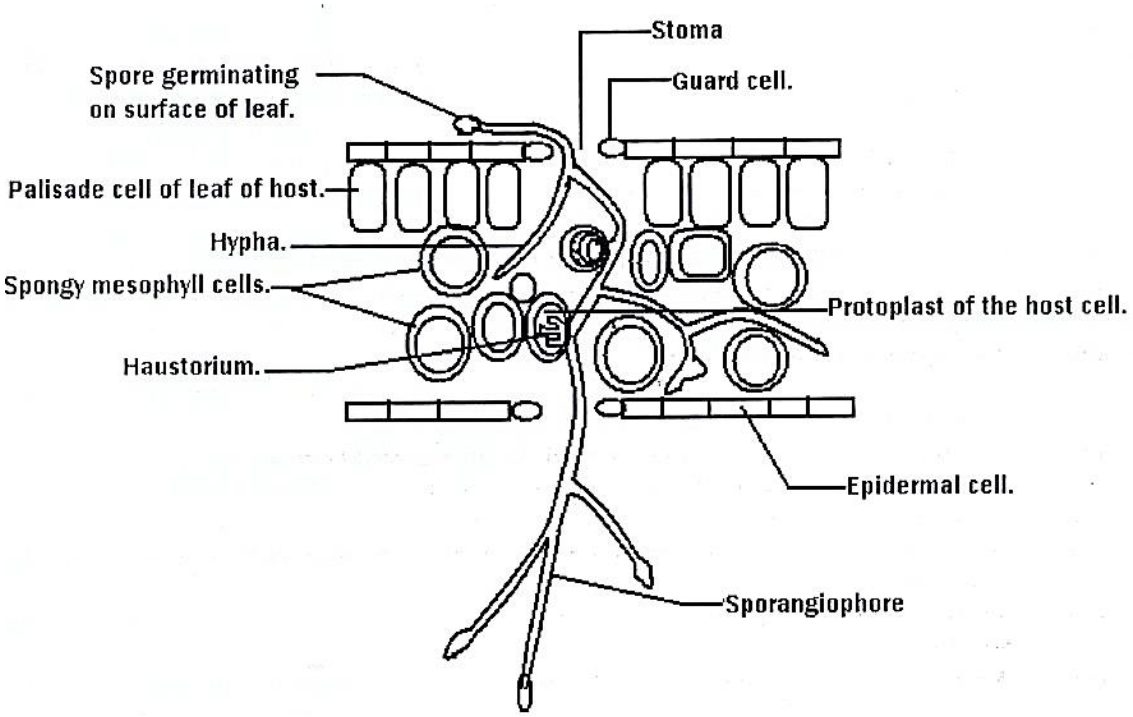
(v) Open wounds which become sites of secondary infection.

PHYTOPHTHORA INFESTANS (PARASITIC FUNGI)

Is a facultative parasitic fungus causing a potato blight disease.

STRUCTURE OF PHYTOPHTHORA INFESTANS.

The fungus consists of an intercellular network called mycelium. A mycelium of branched, aseptate slender filaments known as hyphae which grow and spreads through the intercellular spaces of the leaves of the plant, giving off short side branches (haustoria) into the cells.



ADAPTATIONS OF THE PHYTOPHTHORA INFESTANS (POTATO BLIGHT).

(i) Secretion of digestive enzymes that digests the host cells/carbohydrates to release nutrients for the parasitic fungi,

(ii) It has a flexible, slender and long hyphae to penetrate and reach most of the host cells,

(iii) They secrete cellulose enzyme at their tips to soften cellulose for their penetration into the host cell,

(iv) They produce small and light spores which can be easily dispersed by wind from one host to another.

(v) Development of the haustoria with large surface areas for absorption of soluble products of digestion (nutrients) and specialized penetrating structure,

(vi) Sporangia produce spores for fast growth and rapid multiplication of the parasite so as colonize host rapidly.

(vii) Zoospores/encysted spores withstand adverse environmental conditions like very cold conditions.

EFFECTS OF THE ORGANISMS ON THEIR HOSTS.

(i) Conges stomata and intercellular air spaces, this prevents entry of essential gases like carbondioxide for photosynthesis and oxygen for respiration. Rate of transpiration is lowered which interferes with transport of water and mineral salts within the plant.

(ii) Digest cells causing death of host tissues, producing brown spots that spread further. Heavy infections cause blackened, smelly mass and brown tissues.

CONTROL METHODS OF THE PHYTOPHTHORA INFESTANS,

(i) Infected tubers must not be planted and all tubers should be lifted out of the field,
(ii) New plant materials must not be planted in soil known to have carried the disease previously or practice crop rotation,
(iii) Diseased parts of the infected plant should be destroyed by burning or spraying with corrosive solution of sulphuric acid. And spraying should be timely,
(iv) Growing plants must be sprayed with fungicides like Bordeaux to destroy the disease or tubers. The tubers can also be sterilized externally by immersion in a dilute mercury (ii) chloride.
(v) Breeding for resistance to the potato blight should be conducted.

WITCH WEED (Striga asiatica).

Is a parasite of cereals and grasses.

ADAPTA TIONS FOR THE PARASITIC MODE OF LIFE

(i) Produce large numbers of tiny seeds for rapid multiplication.

(ii) Seeds can remain dormant in the soil for a long time to survive adverse environmental conditions,

(iii) Germination occurs in the variety of the host stimulated by exudates from the host, increasing chances for survival of the parasite,

(iv) Seedlings quickly get attached to the host plants, increasing its chances of survival,
(v) A vascular connection is established between Striga seedlings and the host plants to enable the parasitic plant to obtain water and nutrients,

(vi) They are green and photosynthetic.

EFFECTS ON THE HOST

(i) Causes host plant to show symptoms of nutrient deficiency or starvation,

(ii) Causes water stress and stunted growth,

(iii) They compete with the host plant for light,

(iv) They lead to poor crop yield.