1. BASIC TERMS AND CONCEPTS OF ECOLOGY

1.1 Introductory Remarks

The word **ecology** is coined from the Greek words 'oikos' which means home, and 'logos' which means study of, or science of. Based on these Greek roots, the word ecology can be interpreted to mean the study of organisms in their home. A lot of definitions based on the interpretation above, have been proposed by different ecologists. A useful definition of ecology is "The study of organisms in relation to their environment."

Ecology is a branch of biology in which attempts are made to study the places where organisms live, their distribution and abundance in these places, their interactions with each other and with the non-living components of these places. Ecology was in the past studied as plant ecology and animal ecology. However, the approach in modern times is to study it as an integrated biological discipline.

Ecology as a biological discipline, has a number of unique features. It not only overlaps many other branches of biology, but also involves the application of many other physical and natural sciences. Its experiences are also acquired both inside the laboratory and in the field. Some of the main branches of ecology include the following:

Autecology

Autecology is concerned with the study of individual plants or animals in relation to their environments. It is also known as **Species Ecology.**

Synecology

Synecology is concerned with the study of different groups of organisms in relation to their environments. In synecology, the studies may be on groups of individuals all of which are of the same type. This aspect of synecology is often described as **population ecology.** The studies may be on different groups of organisms belonging to different species. Such studies are often carried out in **community ecology.**

Other branches of ecology are **production ecology, biogeography** and **human ecology. Production ecology** deals with the study of energy and material relations of organisms in their environments. **Biogeography** is interested in

distribution of organisms all over the world, and the factors determining this. **Human ecology** deals with the study of human populations in their environments.

1.2 Environment

Environment is the term for the surroundings of an organism in the place where it lives. The term environment embraces everything external to the organism, which influence its life in the place where it lives. The environment of an organism includes the organisms of the same types as that organism, other plants, animals, microorganisms, and even man, with which the organism is living and which influence its life. The environment also includes non-living things such as climate, soil and rock, and other non-living things present within the surroundings of the organism, and which influence its life.

1.3 Habitat

Habitat is a place or locality where an organism or a group of organisms live. The habitat is also regarded as the physical portion of the environment where an organism or a group of organisms live. Habitats are classified into different types, using different basis.

Two broad categories of habitats are recognized on the basis of their dimensions. The large habitats are known as **macrohabitats**. Examples of these include the coastal and inland water bodies, the tropical forests, the savannas and the deserts. The small-sized habitats are known as **microhabitats**. These microhabitats, exists within the macrohabitats, and are also characterized by minute-sized components. Examples of these are rock pools, hollows and cracks on tree barks, the forest floor litter and the tree crowns. The climates of microhabitats are usually referred to as **microclimates**.

Based on the nature of the main type or bulk of the fluid medium in the habitats, the habits irrespective of their dimensions, are also classified broadly into two categories of **aquatic** and **terrestrial habitats**. The aquatic habitats are characterized by the presence of water as the main type of fluid medium. Other differences however exist between the aquatic and terrestrial habitats.

Among these other differences are those listed below:

i. Aquatic habitats have less air in them than the terrestrial habitats;

ii. Aquatic habitats also have less light intensity in than the terrestrial habitats;

iii. The oxygen content of aquatic habitats is also fa than what we have in terrestrial habitats.

Aquatic habitats are divided into 3 main groups on the of their salinity. These 3 groups are:

a. **marine habitats,** which are extremely saline in nature;

b. **freshwater habitats,** which lack salt in any appreci amount, hence they are always flat in taste;

c. **brackishwater habitats,** which are more or intermediate in their salt content between the marine habi and the freshwater habitats.

The **Terrestrial habitats** on the other hand, are the l **habitats.** They are usually classified into a number of ty based on the type of vegetation they carry. The main type terrestrial habitats in Nigeria include:

(a) Mangrove Swamp (b) Freshwater Swamp
(c) Tropical Lowland Rainforest (d) Tropical Lowland Sem Deciduous forest
(e) Southern Guinea Savanna (f) Northern Guinea Savann
(g) Sudan Savanna and (h) Sahel Savanna.

In Nigeria, a savanna zone, known as Derived Savanna also recognized between the Tropical Lowland Semi Deciduo Forest and the Southern Guinea Savanna. This usually carrie mixed flora representative of those found in the forest and savanna regions.

A number of other types of habitats also exist. The include:

a. montane vegetation — mountain
b. arboreal habitat — tree trunk/branches
c. deserts — dry & hot non vegetated area.

The **montane vegetation** is a peculiar type of vegetatio usually confined to mountainous places and places existing o fairly high lands.

This peculiar type of terrestrial habitat, usually exhibits a phenomenon known as **Zonation.** Zonation is a feature in which different zones on the mountain or highland, carry different typ of plant communities, with the communities at the base bein more luxuriant than those towards the top of the mountain. In typical type of montane vegetation, the zone near the base of th mountain may carry forest or woodland vegetation, whereas th

ear the middle may carry a vegetation which is sparsely populated by woody species and grasses, whereas those close to the peak of the mountain, may carry a grassland vegetation. In very high mountains, the peak may even be covered with snow.

The **arboreal habitat** is also known as a **tree habitat.** It is a special type of habitat in which a tree carries a number of microhabitats on it. Such microhabitats are usually found in the tree crown, the cracks and hollows in which water is held and the surfaces of the tree in some tree habitats. More is said about the microhabitats in Chapter 10 of this Handbook.

The **arid lands** are typified by the deserts. They are special habitats in which water is not found occurring in abundance. Arid lands are discussed in greater details in Chapter 9 of this Handbook.

The term habitat gives a concrete impression of a place where an organism or a group of organisms live. The environment on the other hand, exists within the habitat of an organism. It is therefore composed of concrete things such as other organisms, and other tangible objects within the surroundings of the organisms, with some abstract things such as climate and the atmosphere.

1.4 Ecological Factors

Every habitat (or the environment of a habitat), has a number of features that are used in characterizing it and differentiating it from other habitats or environments. Notable among these features are certain components or factors, and the processes which these factors take part in. The factors of a habitat, or environment of a habitat, constitute the **habitat factors** or **environmental factors.** Because of the importance of the factors in the ecology of a habitat, or of an environment they are collectively known as **ecological factors.** These factors include the following: **biotic factors** (for factors of organisms); **climatic factors** (for those of climate), **edaphic factors** (for soil factors), and **topographic factors** for factors of the topography of a habitat.

The **biotic factors** are the factors of the biota or living organisms of a habitat. The organisms include the plants which are known as the **flora,** and the animals which are known as the **fauna.** The microsopic plants constitute the **microflora,** while the microscopic animals constitute the **microfauna.**

All other factors which are all factors of the non living components of the environment, are collectively known as the

abiotic factors or the **physical factors** of the environment. These factors include those of the climate, those of the soil, those of the topography and those of the parent rock types and the gases found in the environment or habitat.

The **factors of the climate** of a place, are known as the **climatic factors.** These are made up of the **temperature, rainfall, light, humidity, pressure, wind** and **evaporation** of a place. The climatic factors, are discussed in details in Chapter 2 of this Handbook along with their importance and techniques for measuring them.

The **factors of the soil** of a place, are known as the **edaphic factors.** They are made up of the physical, chemical and biological characteristics of the soil of a place. These too are discussed in details in Chapter 3 of this Handbook.

The **factors of the topography** of a place, are known as the topographical factors. They are made up of the overall physical features of the surface of the land of a place, they include features such as the relief of the land of a place, the degree of exposure of the land, its elevation above sea level, its slope, and its drainage features.

The factors of the parent rock types of a place, are known as the geological factors. These factors are made up of the types of rocks in place and their influence on the other ecological factors of climate, soil, topography and the biota of the place.

The factors of the gases of a place, are known as the gaseous factors. The gases of a place include the biologically important gases such as oxygen, which is involved in the aerobic respiration of the aerobes among the biota of the place and the carbon dioxide, which is important as a raw material in the photosynthesis of the photosynthetic plants of a place. Other gases include gases such as hydrogen sulphide and sulphur dioxide which are important as pollutants of the air of a place and occasionally find use in the nutrition of some chemosynthetic autotrophs within the habitat. Nitrogen is of course important as a natural diluent of the air of a place. It however finds use in the diet of certain nitrogen fixing bacteria found within the roots of leguminous plants.

1.5 Ecosystem

The word **'ecosystem'** is the shortened form of the term **'ecological system'**. The term is defined as an ecological unit

with **biotic and abiotic components**, together with recognizable **interactions** between the various groups of components.

An ecosystem is characterized by the presence of a habitat with its peculiar environment, and the presence of habitat factors within the habitat. These habitat factors include the living organisms, the climate, the soil, the parent rocks and other topographical factors.

In addition to the presence of the ecological factors within the habitat, an ecosystem is characterized by certain features which make it a functioning ecological entity. The most important of these features are:

i. The flow of the energy which gets into the ecosystem among the organisms living in the ecosystem. The most important source of this energy in natural ecosystems is sunlight.
ii. The cycling of the organic and inorganic materials within the ecosystem
iii. The various groups of interactions, some of which occur separately within the various groups of components, and some others between the various groups of components.

Ecosystems vary in sizes. Some are big, others are small, while some others are of medium sizes. Some ecosystems are **natural**. Examples of these include the seas, the rivers and other natural bodies of water. Others include the various groups of natural forests, savannas and deserts. Some other ecosystems are man-made. These are described as **artificial ecosystems**. In these, most of the functioning attributes and their sustenance are also ensured by man. Examples of these are fish ponds, aquaria and parks. Some other ecosystems are **semi-natural**. Examples of these are **agro-ecosystems** such as farmlands, forest plantations, man-made lakes and gardens. Ecosystem studies are important in ecology because, virtually all the ecological principles can be adequately studied by studying ecosystems. The fact that some authorities define ecology as 'the study of ecosystems', is a pointer to the importance of ecosystem concept in ecology.

1.6 Niche

The term **niche** is the biological status of an organism within its community. This term which is the shortened form of **ecological niche**, is a description of the functional role of an organism among others of its species, and among other organisms belonging to different species with which it is existing in the same habitat. Each species of organism, plays a number

of peculiar roles in its habitat. All these roles influence functioning of the ecosystem. Among the roles played organisms in their habitats are their feeding, their interaction other organisms and their interaction with the physical factor their habitat. Some of these roles of an organism may beneficial, while others may be detrimental to other member the community.

1.7 Adaptation

Adaptation is a natural phenomenon among liv organisms. It is the capacity possessed by the organisms liv in an environment to utilize the resources available within environment, undergo development, reproduce at maturity a participate fully in all the ecologically essential dynam processes that help in sustaining the ecosystem.

It is a fact that no environment no matter how conducive life, is devoid of ecological hazards. It is equally true that matter how great these hazards are, certain species organisms are still found because of their being adapted to existing ecological conditions there. Such organisms will d survive in other environments into which they may be introduc only if they are provided with ecological conditions similar those in their natural environments. This accounts for restriction of different species of plants and animals to cert habitats to which they are naturally adapted.

Most adaptive characteristics are inheritable, they therefore passed from one generation of organisms to anoth Three basic groups of these adaptive characteristics can recognized on the basis of their mode of display in the organis concerned.

These are **Structural, Physiological** and **Behaviou Adaptations**. Examples of each group abound in liv organisms, but the structural adaptations are by far the m obvious to any observer.

The examples of the structural adaptations are seen the external and internal structures of the various organs of body of living organisms. The limbs of the various groups animals are external structures that are variously modified as such, become adapted for different forms of movement in these animals. The teeth of mammals and the various forms mouth parts seen in many groups of animals, are also exte structures adapted for different modes feeding.

The various forms of modifications seen in different plant organs such as roots, stems and leaves, are also examples of adaptations in the external structures of these organs for certain specialized functions. Similarly, the various structural modifications and contrivances seen in flowers, fruits and seeds of the higher plants, are adaptations for certain aspects of their reproduction such as pollination (in flowers), and dispersal in seeds and fruits.

Investigations into the internal structures of certain organs of plants and animals found in various environments or those known to be performing some specialized functions, also reveal some interesting adaptations in these structures. This is the case with the internal structure of the stems of water plants that have air spaces within their cortex in order to ensure bouyancy of these plants in the water of their habitat. The villi of the intestines of mammals are also adaptations in these internal structures that help in the effective absorption of digested food.

The **physiological adaptations** include the production of specific enzymes for certain physiological activities connected with food digestion by living organisms. The exhibition of homoiothermy by birds and mammals, chlorophyll synthesis in plants, enzymes production and hormone secretion in plants and animals, are all examples of physiological adaptations.

Various aspects of the behaviour of living organisms are in some ways physiological, but they differ from the physiological processes in that they are displayed in the behaviour of the organisms concerned. Such **behavioural adaptations** include the various movements of some organisms and the organs of many others in response to certain stimuli. The behavioural adaptations connected with reproduction in many groups of organisms include the migratory movements seen in some fish species, some birds and certain mammals; the development of some attractive structures, such as the plumage of some birds during the breeding season, the peculiar vocalization of some birds and toads at this time, and the mounting of the backs of the female toads by the males. Some other behavioural adaptations are connected with self defence, preservation and survival, especially during unfavourable seasons. Examples of such behavioural adaptations are the deciduousness characteristic of some tropical plants that shed their leaves at certain periods of the year, the encystem seen in certain protozoans, dormancy in some organisms and the viviparous mode of development that

characterize the seedlings of *Rhizophora* – a ma... species.

An endless list of adaptations can be drawn for any species of organism. It is therefore not possible to exhaust the examples of adaptations that can be listed for all the species of plants and animals in the two kingdoms of living organisms in this brief discussion on the phenomenon of adaptation. The outline given below will however be useful as guidelines on subsequent studies on adaptation.

Adaptations shown by Living Organisms

(i) Adaptation to environments.
(ii) Adaptation to changes in environments.
(iii) Adaptation for self preservation in environments, including those for offence and defence.
(iv) Adaptation for special modes of life, including those for epiphytism, saprophytism and parasitism.
(v) Adaptation for different methods of feeding.
(vi) Adaptation for biotic interactions such as predation, competition, mutualism and commensalism.
(vii) Adaptation for reproduction and self perpetuation.

1.8 Biome

A **biome** is a major biotic community within a geographical region, which is characterized by its own set of peculiar ecological conditions. The world biomes and the local biomes are usually named either after the vegetation types that are dominant in them, or after some other peculiar physical features.

The main **terrestrial biomes of the world** are the following: the tundra, the temperate deciduous forest, the tropical forest, the savanna and the desert.

The main **terrestrial biomes of Nigeria** include the following: salt water and freshwater swamp forest, tropical rain forest, southern guinea savanna, northern guinea savanna, the Sudan savanna and sahel savanna.

In Nigeria, the local biomes fall within the vegetation belts (or zones) that characterize the Vegetation of Nigeria.

These local biomes and the States in Nigeria where they are found are listed below:

	Local Biomes of Nigeria	States where they are found in Nigeria
i.	Mangrove and Freshwater Swamp Forest	Lagos; Ogun, Ondo, Edo, Delta, Rivers and Cross River.
ii.	Tropical Rain Forest	Ogun, Ondo, Oyo, Edo, Delta, Imo, Abia, Anambra, Cross River, Awka Ibom
iii.	Semi Deciduous Forest	Oyo, Osun, Anambra and Abia
iv.	Southern Guinea Savanna	Kwara, Kogi, Oyo, Abuja, Benue, Niger and Gongola
v.	Northern Guinea Savanna	Sokoto, Bauchi, Plateau, Kaduna, Borno, Kano, Niger, Adamawa, Taraba, Jigawa, Yobe and Gongola
vi.	Sudan Savanna	Sokoto, Katsina, Kano, Borno, Kaduna, Yobe and Jigawa.
vii.	Sahel Savanna	Yobe and Borno

The features of the main local biomes of Nigeria, a
discussed in details in Chapter 6, 7 and 8 of this Handbo
Figure 1 below which is a Map of the Vegetation Zones
Nigeria, also helps to show the distribution of the main lo
biomes in Nigeria.

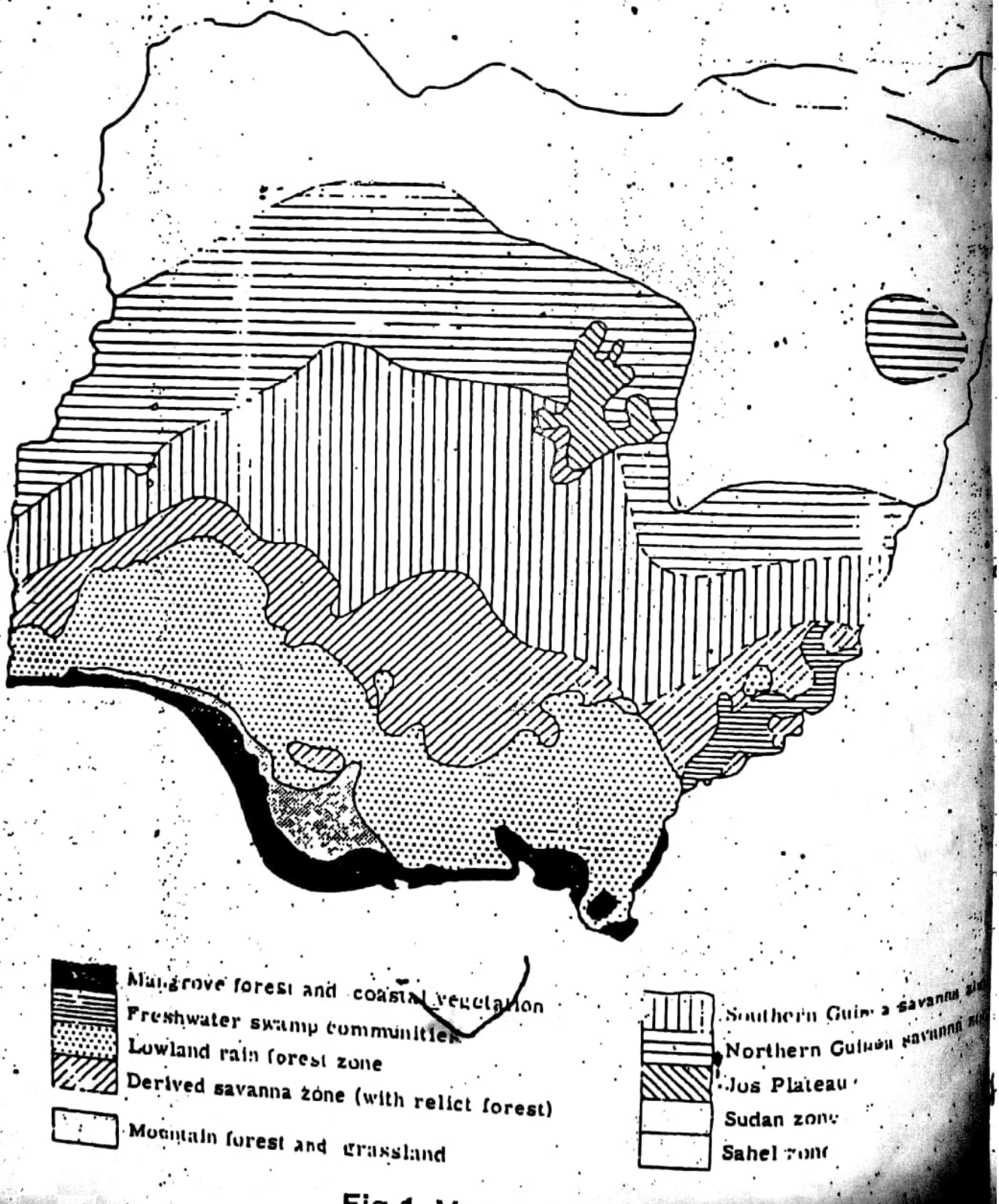


Fig 1. Vegetation Zones of Nige

1.9 Biosphere

This is the portion of the surface of the earth that is inhabited by living things. The biosphere is made up of the air, a thin portion of the soil harbouring living things, and on which plants and animals live; together with the oceans, the seas and inland bodies of water such as rivers, streams and lakes among others. All the world major ecosystems, make up the biosphere which is composed of the atmosphere, the hydrosphere and the lithosphere.

The biosphere though confined to the surface of the earth, is influenced by some of the other celestial bodies in different ways, notable among these ways are the following:

i. The sun sends to the earth, the solar energy on which life on the planet earth depends.
ii. The gravitational fields of the sun and the moon also influence the large coastal water bodies such as the oceans and seas by causing tides in them.
iii. Certain other radiations coming from various sources outside the earth, cause mutations in the organisms on earth. An example of such radiations are the UV rays.
iv. Cosmic dust of not less than 200 tonnes are believed to be emptied on earth on a daily basis.

1.10 Atmosphere

This is a portion of the biosphere made up of the large envelope of air surrounding the earth. This gaseous envelope is believed to be composed of a number of gases which include nitrogen, which is about 78%, oxygen of about 21% and carbon dioxide of about 0.03%. Other components of the atmosphere are the inert gases, moisture and particles of living and non living materials, suspended in the atmosphere.

1.11 Hydrosphere is a portion of the biosphere made up of the water bodies such as the coastal water bodies of the oceans, seas and the lagoons and the inland water bodies such as the rivers, the springs, the lakes and the subteranean bodies of water.

1.12 Lithosphere is a portion of the biosphere made up of the rocks. However for most of these rocks, only the outer portion harbours living organisms.

2. WEATHER AND CLIMATE

2.1 Introductory Remark

Climate is usually defined as the average of the weather conditions in a place over a period of years. Weather on the other hand, is the sum total of the atmospheric conditions in a place at a particular time. A number of factors or elements are used in characterising climate. These are referred to as climatic factors. These include rainfall, temperature, sunlight, humidity, wind and pressure. It is usual to hear people describing the atmospheric conditions of a place by such terms as cloudy, dull, dry, hot, cool, sunny and bright. In ecology, more precise and accurate descriptions based on measurements carried out on the climatic elements are usually made. These measurements are usually made with specific weather recording instruments appropriate for each element.

2.2 Rainfall:

Rainfall is a very important climatic factor in the tropics. Its importance is comparable with the attained by temperature in the temperature countries. Rainfall influences plant growth in the tropics. The spacial distribution of the vegetation zones in West African and most parts of Africa, follows the patterns of the annual distribution of rainfall in these places. The features of ecological importance about rainfall are its annual amount and distribution. Others include its intensity and energy content. The quantity of rainfall recorded in a year constitutes its amount, while the number of months for which rainfall is recorded in comparison with those for which no rain is recorded, determines the annual rainfall distribution. Any month for which less than 25mm of rainfall is recorded is regarded as a rainless month. In Nigeria, all parts of the country below Latitude 9°N are characterized by a two-peaked pattern of rainfall, while the portion of the country above this, is characterized by a one-peaked pattern of rainfall.

Rainfall is measured with Rainguages. A standard rain guage consists of funnel which is usually of a metal material, with a mouth diameter of between 150 and 200 millimeters. It also has a vertical side which is a round collar of about 50 millimeters in height. Below the funnel is a large cylindrical container which is also made of metal material. The water entering through the funnel usually runs into this cylinder.

Above Latitude 9°N ⟶ One Peaked Pattern of rainfall

Below Latitude 9°N ⟶ 2 Peaked Pattern of rainfall

The water in the rainguage cylinder is usually poured into a measuring cylinder each time the reading is to be taken. The volume of water in the measuring cylinder, divided by the area of the funnel, gives the amount of rainfall for the period. The units of the volume of water in the measuring cylinder and that of the area of the funnel must be the same before the calculation is done.

Rainfall readings are usually taken daily, weekly or monthly as thought appropriate. Care should however be taken not to allow the collecting reservoir of the rainguage to overflow before the reading is taken. This precaution is of importance particularly in the rainy months of the year when a week's rain may almost fill the rainguage reservoir in some African towns.

Where a standard rainguage is not available, it can be improvized by using this procedure. A funnel of known mouth diameter is placed on the rim of a cylindrical tin can which has its mouth diameter almost the same as that of the funnel. The tail of the funnel is made to hang freely in the mouth of a small measuring cylinder seated on the base of the tin can.

The rainfall over a period of time is obtained from the formula $d^2/D^2.h$ in which d is diameter of the measuring cylinder, D is the mouth diameter of the funnel and h is the height of the water in the measuring cylinder.

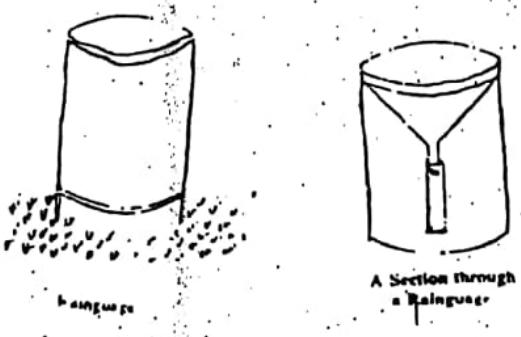


Fig 2.1 Features of a Rainguage

Importance of Rainfall

i. Rainfall is the most important source of water available for the use of living organisms. Other sources of water such as snow, ice, glacier et cetera, are secondary to rainfall as sources of water on earth.

ii. Rainfall influences availability of water and by so doing exerts some influences on metabolic activities in plants. Examples of these metabolic activities include

absorption of water, transpiration, photosynthesis, growth and germination. Others include flowering, fruiting and deciduous habit in some plants.

iii. Rainfall influences the distribution of vegetation in the topics. Rainfall duration is known to be more important in this influence of rainfall than rainfall amount. Longer duration of rainfall makes possible more luxuriant vegetation types such as the forests. while shorter duration accounts for the presence of savannas and deserts.

iv. Rainfall which influences water availability, also influences metabolic activities in animals in such activities as nutrition, growth, development, reproduction and hibernation noticeable in some animals.

v. Reproduction in aquatic and amphibious plants and animals is also influenced by rainfall. It also similarly influences the dispersal of these plants and animals.

2.3 Temperature

Temperature is a measure of the amount of heat energy of an object or place. It is often described as a measure of the "hotness" or "coldness" of an object or place. It is the most important climatic factor in the temperature regions of the world. It is also the major factor used in the grouping of the world into varying climatic zones. The main variations noticeable in temperatures include the following:

2.3.1 Daily or Diurnal Variation

Daily Variation is the difference between the highest and the lowest temperatures of the day in a place. Some habitats such as most deserts and rock surfaces, experience very high day temperatures and very low night temperatures. Such habitats and others similar to them, that have very sparse vegetation cover, usually show very high diurnal range of temperatures. The thickly vegetated habitats such as the forests, usually experience little variation in both day and night temperatures. Such habitats are usually characterized by low diurnal range of temperatures.

2.3.2 Seasonal Variation

Seasonal Variation is the difference between the temperatures of the various seasons of the year. The temperate environments usually experience greater seasonal variations in

High : diurnal → Day / Night | Low

their temperatures than the tropical environments.

2.3.3 Altitudinal Variation

"The higher you go, the cooler it becomes", is a familiar expression. There is usually a decrease of about 1°C for every 150 metres ascent.

Temperatures are measured with **Themometers**. The commonest types of thermometers for ecological purposes, are the **Mercury-in-Glass** (non-clinical) **Thermometer** (or **Mercury Thermometer**, for short) and the **Maximum-And-Minimum Thermometer.**

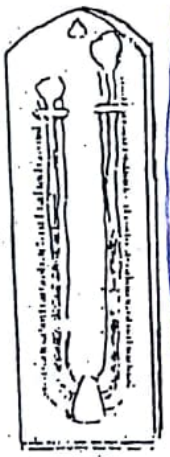
The mercury thermometer is very simple both in design and in manipulation. It is useful for comparing the temperatures of different parts of the same habitat.

The maximum-and-minimum thermometer is used to obtain the extremes of the temperatures in a day. It is therefore useful for obtaining the diurnal range of temperatures of a habitat.

Thermographs are also useful for obtaining a continuous record of the temperatures of the day, while the **thermistor** is useful for obtaining small variations in temperatures.

For comparing temperature of different part of the same habitat

Fig 2.2a
Mercury-In-glass Thermometer



For obtaining the extreme of the t in a day. Specifically diur range of tempo

Fig 2.2b.
Maximum-and-Minimum Thermometer

2.3.4 Importance of Temperature

Temperature is more important on a global scale than rainfall whose importance in vegetation distribution is only felt at the regional level.

i. Temperature influences the distribution of organisms over the different regions of the world, such as the temperate and the tropical regions.

ii. Temperature is a major factor influencing the action of enzymes in all living organisms.

* Diurnal variation → Varying day temperature.
* Seasonal Variation → Varying seasonal temperature.

iii. Temperature by influencing enzyme action, also influences such physiological activities of plants as photosynthesis, transpiration, seed germination and growth of plants.

iv. Similarly, temperature also influences such physiological activities of animals like homojothermy in birds and mammals and poikilothermy in other lower animals such as the lower vertebrates such as the fishes, amphibians and reptiles, and the invertebrates.

v. In plants, temperature also influences wilting.

vi. In animals, temperature influences hibernation and desication.

2.4 Sunlight:

Sunlight is the most important form of light. It is of great biological importance to all forms of life on earth. A property of light most often measured in ecological studies is its **Intensity.** This is measured with instruments known as **Photometers.** These instruments are useful in comparing the sunlight intensities in different habitats, and for obtaining the variations in the light intensities over different hours of the day within the same habitat.

A common form of photometer that is usually employed in terrestrial habitats is the **Photographic Light Meter** similar to that the photographers use. Light intensity is usually expressed in lux/m^2. Ecologists are also interested in **light duration.** This is a measure of the number of hours of sunlight in a day.

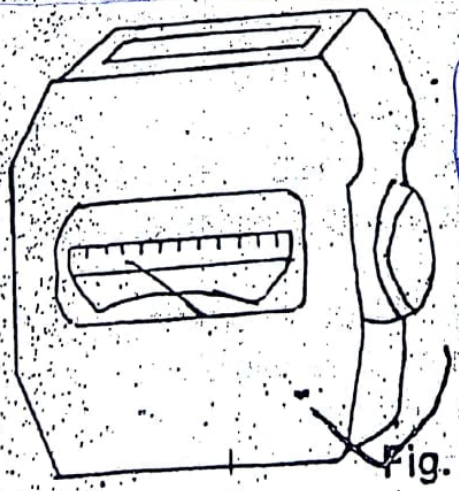


Fig. 2.3 Photometer

It is used for measuring light intensity

Light duration is the measure of hours of Sunlight in a day.

Importance of Sunlight

In general terms, the importance of sunlight implies the importance of light. This is because sunlight is the most important form of light as far as living organisms are concerned, irrespective of their habitat.

Light has three important properties, each of which has its own peculiar forms of importance. These properties are Intensity, wave length and duration. However in discussing the importance of light in this section, no differentiation is made on the importance of the separate properties. The properties listed are those of light as an ecological factor.

Among the importance of light are those outlined below:

i. Sunlight provides solar energy to the planet earth: It is this light that makes visibility possible on earth.

ii. Sunlight besides providing solar energy, also provides heat energy which has thermal influences on the metabolic activities of plants and animals living on earth.

iii. The solar energy from sunlight is the ultimate source of the energy for all living organisms on earth.

iv. Sunlight makes possible chlorophyll synthesis in plants.

v. Sunlight also makes possible photosynthesis in the green plants. It as a result of this influences the productivity of all ecosystems.

vi. Seasonal activities such as flowering and fruiting in plants, are under the influence of sunlight.

vii. Light is a major factor in the germination of the seeds of some plants. The seeds of plants fall into 3 major categories on the basis of their need for light for their germination. There are those described as **light – indifferent seeds,** whose germination is not affected by the presence or absence of light. Most seeds belong to this category. There are the **light sensitive seeds,** whose germination requires varying length of exposure to light for it to occur. Examples of such seeds are those of mistletoe, lettuce and tobacco. There are also the **light hard seeds,** whose germination is known to be retarded by light. Some species of Allium belong to this category

viii. The seasonal activities of some animals such as the migration of some fishes, birds and mammals are known to be influenced by light.

The feeding in certain birds and mammals and the swarming of insects such as termites are all daily activities that are influenced by light.

x. Reproductive cycles of animals are also influenced by length of day light which is also described as duration of light.

xi. Some animals such as cockroaches, earthworms and bats only come out of night. They usually shun light.

2.5 Humidity:

Atmospheric Humidity means the amount of water vapour in the atmosphere. A more useful measure of the moistness of the atmosphere for ecological purpose is the **Relative Humidity**.

Relative Humidity is the pressure of the water vapour in the atmosphere at a particular temperature in relation to the pressure of the water vapour enough to saturate the atmosphere at that temperature.

Relative Humidity is usually measured with **Hygrometers** or **Psychrometers**. Two common types of hygrometers are the **Wet-and-Dry Bulb Hygrometer** and the **Whirling Hygrometer**.

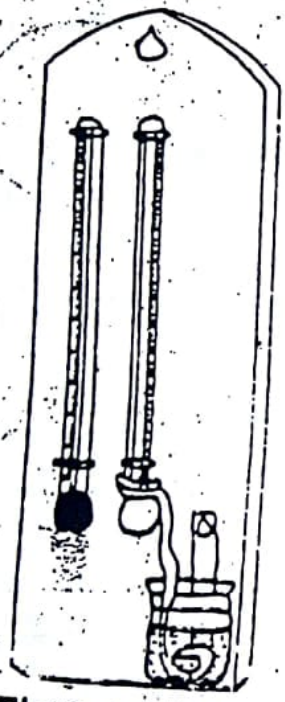


Fig 2.4a Wet-and-Dry Bulb Hygrometer

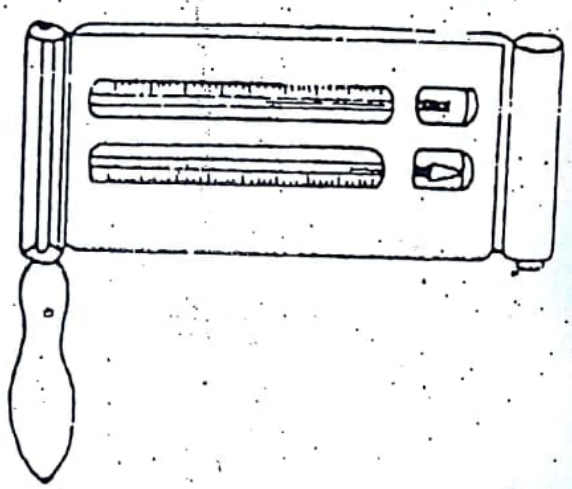


Fig 2.4b Whirling Hygrometer

Importance of Humidity

i) Humidity influences rate of transpiration and water absorption in plants. Low humidity brings about higher rate of transpiration and water absorption in plants, while high humidity reduces the rate of transpiration and water absorption.

ii. Similarly in animals, low humidity brings about more water loss in animals, while high humidity brings about lower loss of water in them.

Atmosphere. humidity: The amount of water vapour in

2.6 Wind

Wind is usually defined as air in motion. It is characterized by direction and speed of movements. The direction of wind is usually determined with a **Wind Vane**. A more sophisticated instrument known as the **Anemometer** measures both the direction and the speed of wind.

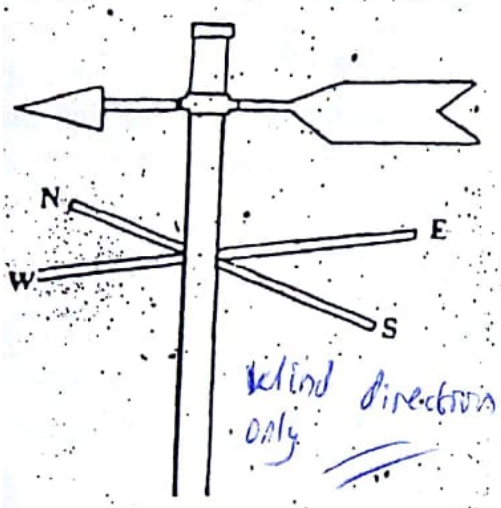


Fig 2.5a. Wind Vane

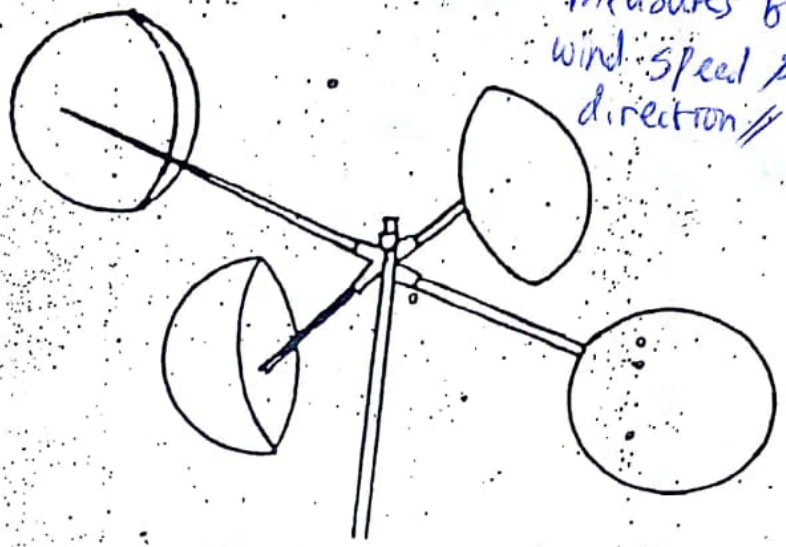


Fig 2.5b. Anemometer

Importance of Wind

i. Wind influences soils and inland bodies of water by increasing evaporation of water from them.
ii. Wind also influences rate of transpiration in plants by increasing this.
iii. High wind encourages erosion of soils in places which are sparsely covered by vegetation such as the arid lands.
iv. High wind breaks the branches of huge trees and the boles of some not-so-huge trees.
v. Wind assists the spread of fire in places with abundant conbustible materials
vi. Wind is important as an agent of pollination of wind pollinated plants such as the grasses.
vii. Wind is also an important agent of dispersal of the spores, seeds and fruits of certain plants.
viii. The speed and direction of winds are also known to influence the movement of insects and birds.
ix. Wind is also known to influence the shape of the crowns of trees which are known to tilt in the direction of wind.
x. Wind is an important agent in the physical weathering of rocks.

2.7 Atmospheric Pressure

Atmospheric pressure has to do with weight of air over a unit area. It varies from place to place over the earth surface and there is usually a decrease in the barometric pressure with a rise in altitude. Atmospheric pressure is measured with a barometer. Common examples of barometers are Aneroid barometer and Fortins barometer.

A barograph like a thermograph, not only gives a continuous record of the pressure of the air of a place, it also records this on a special type of graph paper.

Rainfall is usually recorded in millimetres (mm); temperatures in degrees Centigrade (^0C); humidity in percentages ($^0/_C$); while pressure is in atmospheres. Sunshine hours are often recorded on a daily basis, while the intensity of sunlight is recorded in luxes/m^2.

* Aneroid Barometer
* Fortins Barometer

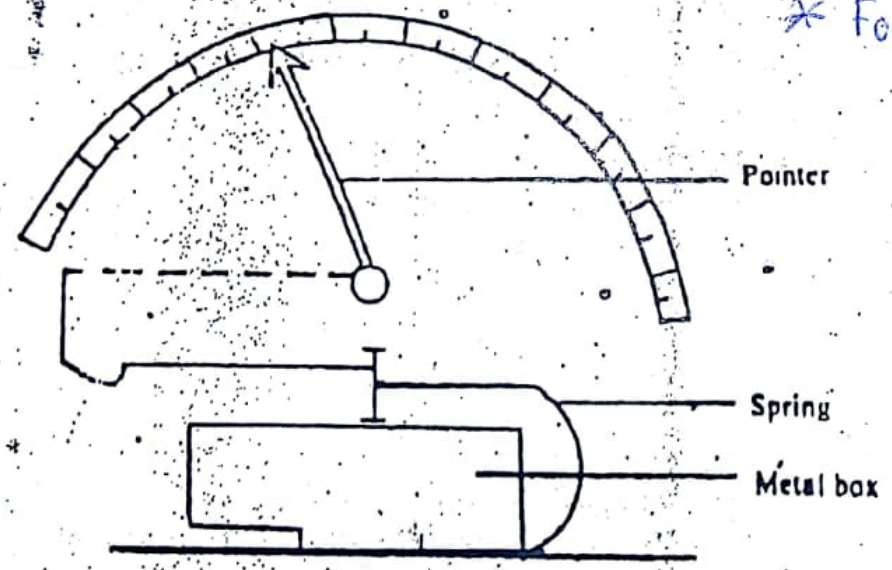


Fig 2.6 Anerold Barometer

Atmospheric Pressure: This is the weight of air per unit area.

$$\text{Atmospheric Pressure} = \frac{\text{weight of air}}{\text{Unit area}}$$

3. TROPICAL SOILS

3.1 Introductory Remarks

Soil is the outermost layer of the earthcrust capable of sustaining life. It is a heterogenous mixture of both organic and inorganic materials. Soil is also of importance as the edaphic component of many terrestrial ecosystems, the bottom sustratum of many natural water bodies and the material of the shores and banks of many of these. Soil is also a natural ecosystem of a special nature in which microorganisms feature prominently among the biotic components.

3.2 Soil Components

The soil of a place has as its components the following: mineral matter in both the solid and dissolved forms, organic matter, water, air and living organisms. The **solid mineral matter** originates from a parent rock material through the processes involved in **weathering**. The **dissolved mineral matter** of the soil usually occurs in the form of ions. These ions are derived from the solid mineral matter of the soil and the decaying organic matter. They are of importance in the growth and development of land plants. The soil ions such as potassium, calcium, magnesium and iron originate from the solid mineral matter of the soil, while other soil ions such as nitrate, phosphate and sulphate, are derived from decaying organic matter.

Soil organic matter is derived from the dead bodies of plants, animals and microorganisms that exist both within and over the soil of a place, together with the excreta of these organisms while still living.

Soil water occurs in various forms among which are **water vapour, gravitational water, capillary water, hygroscopic water** and **water of hydration**. Soil water is very important as the main source of water for plants growing on land. It is particularly important as the medium for the solution, absorption and transport of dissolved soil minerals.

Soil air occurs in the macro and micropores existing within the soil. Its constituents are similar to those of the atmosphere above the soil. However, the oxygen content of the soil air is usually less than that in the atmosphere above the soil, while the reverse of this is true in the case of carbon dioxide.

The **soil organisms** include the bigger ones known as **macro-organisms** and the smaller ones called

microorganisms. The soil is particularly rich in microorganisms and it is the natural habitat of many of them. These soil microorganisms include bacteria, fungi, algae, and actinomycetes, among the **microflora**. The soil **microfauna** include some protozoans and nematodes. The soil **macroflora** include the roots of higher plants. Others include root and stem tubers, rhizomes, bulbs, and corms. The soil **macrofauna** include a number of arthropods among which are mites, millipedes, centipedes, insects, and wood lice. Other soil **macrofauna** include molluscs such as slugs and snails, and annelids such as the earthworms. A number of vertebrates are also found occasionally in the soil. Among these are rats, rabbits, foxes and snakes.

3.3 Soil Properties

The soil properties include the physical, chemical and biological properties. These properties are influenced or actually determined by the soil biotic and abiotic components.

3.3.1 Physical Properties

The physical properties of soils include properties such as texture, structure, profile, pore space, depth, temperature and colour.

i. Soil Texture

Soil Texture is determined by the size of its particles. The diameter of a soil particle is taken as a measure of its size. The various classes of soil particles and their names are shown in Table 3.1

Table 3.1
Soil Texture

Particle Size	Soil Particle Name
2mm and above	Gravel or Stone
2mm – 0.2mm	Course Sand
0.2 –0.02mm	Fine Sand
0.02mm – 0.002mm	Silt
0.002mm and above	Clay

ii. Soil Types

Most soils are usually composed of varying quantities of the various soil particles. The proportion of these soil particles in soil, determines to a great extent the soil type. The main

Soil Properties

Physical

types recognized on the basis of their textural characteristics are sandy soil, clayey soils and loamy soils. **Sandy soils** have a sand fraction not below 70%, while the clay fraction is less than 20%. **Clayey soils** have a clay fraction up to 30%, with the sand fraction less than 40%. **Loamy soils** have their sand and clay fractions in roughly equal proportions. They in addition, usually contain some humus.

iii. Soil Structure

Soil structure is a description of aggregated **soil peds** or lumps that are usually formed by aggregated soil particles. The soil structures are usually given geometrical descriptions reflecting their shapes. These structures include **columnar, blocky, platy** and **granular structures.**

iv. Soil Profile

Soil profile is a description of stratification of the soil of a place into different horizons. These soil horizons are usually described as **A- horizon** and **B-horizon**. These horizons exist within the top soil and the sub soil. Below these is the underlying unweathered parent rock material.

v. Soil Spaces

Soil spaces are the spaces existing within the soil particles and soil peds, which are not occupied by soil water. The soil space within the soil particles are called **micropores,** while those between the soil peds are called **macropores.**

vi. Soil Depth

Soil depth is a measure of the vertical extent of the soil of a place. This is related to the thickness of the soil lying over the underlying parent rock material.

vii. Soil Temperature

Soil temperature is a measure of the hotness or coldness of the soil. This is usually slightly different from the air above the soil surface.

viii. Soil colour

Soil colour is usually determined by a complex of factors, among which are the nature of the parent rock material, the amount of organic matter and the conditions of the climate under which the soil is existing.

3.3.2 Chemical Properties

The chemical properties of the soils include such properties as soil pH and soil salinity. Soils vary in their hydrogen ion concentrations. Some are *acidic*, while others are *basic*. Factors influencing these include the nature of the parent rock material, the climatic conditions of the place, the nature of the flora growing over the soil and the activities of the soil flora and fauna.

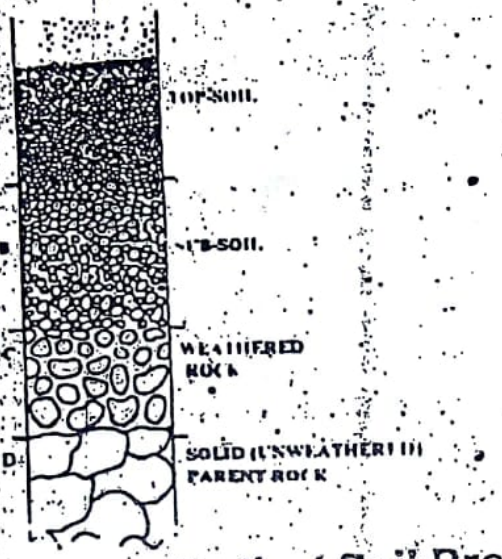


Fig. 3 A Hypothetical Soil Profile

Soil salinity is a property of the soil describing its salt types and quantities. These are themselves determined mainly by the nature of the parent rock materials.

3.3.3 Biological Properties

The biological properties of soils are closely tied with the activities of the soil organisms in the soil. These activities of soil organisms include those that are beneficial and others that are harmful.

A. The beneficial role of soil microorganisms include:

1. Decomposition of organic matter.
2. Helping in the cycling of nutrient materials in natural ecosystems.
3. Taking part in soil forming activities involved in biological weathering.
4. They constitute the primary producers of soil ecosystem. Examples of these are found among the autotrophic bacteria and the algae.
5. They also participate in ecological successions occurring on land.

Chemical Properties

B. The beneficial role of soil macrofauna

1. Mechanical reduction of ground litter to finer particles that can then be easily decomposed by soil microorganisms.
2. Soil-mixing into uniform and heterogenous mixture by the soil burrowing animals such as earthworms.
3. Soil loosening action of these burrowing animals allows for better aeration of the soil.
4. The excreta and dead tissues of soil macrofauna contribute immensely to soil litter.

C. The beneficial role of the soil macroflora

1. Protection of the soil from erosion hazards and insolation.
2. They add to soil litter.
3. The roots of certain species provide rhizosphere for some soil microorganisms. The legumes also have root nodules inside which certain beneficial nitrogen-fixing bacteria of the genus *Rhizobium* live.
4. The roots of the higher plants and the subterannean organs of perennation such as bulbs, corms, tubers and rhizomes, also help in rock weathering, and further fragmentation of bigger soil particles.

D. The harmful role of some soil organisms.

1. Some soil organisms reduce soil fertility. A notable example is seen in the group of bacteria called **denitrifying bacteria**
2. The soil microorganisms that are aerobic, compete with the roots of the higher plants for the oxygen present in soil air.
3. Many of the diseases of economic plants and animals are caused by the soil bacteria, and many other soil microorganisms.
4. Many soil microorganisms remove soil nutrients at such a fast rate and in such a quantity that tend to deplete the soil of these nutrients.

3.4 Soil fertility and its loss

3.4.1 Soil Fertility

The term **soil fertility** means the inherent capability of the soil of a place to sustain the production of a wide variety of high quality crops in large quantities. Soil fertility is therefore reflected in the primary production of the place where the soil is.

Among the factors influencing soil fertility are the following:

i. Climatic condition of the locality;
ii. The topography of the soil;

iii. Depth of the soil;
iv. Soil texture;
v. Soil surface conditions;
vi. Soil hydrogen-ion concentration (i.e., soil pH);
vii. Nature of the parent rock material;
viii. Soil mineral reserve;
ix. Soil salinity;
x. Soil organic matter content;
xi. Types and activities of soil organisms and the cov
vegetation.

3.4.2 Loss of soil fertility

The term **'loss of soil fertility'** means the loss o capability of a soil to produce good quality crops in quantity.

The different ways in which soil fertility is lost include following:

i. Mineral depletion due to the exhaustion of the mi nutrients in the soil through over cropping;
ii. Excessive cultivation of the soil;
iii. Burning;
iv. Erosion;
v. Leaching.

Erosion can be caused by **water** and **wind**. Both can e be **geological** or **accelerated**, with the latter being the m prominent and by far more hazardous.

Erosion usually results in loss of the mineral nutrients o soil and the transportation of the top soil materials to o places where they are usually deposited. The main type erosion recognized are ***sheet erosion, rill erosion*** and ***gully erosion.*** Other forms of erosion include ***stream erosion,*** **slide** along the sides of slopy hills and **soil creep** involving movement in thin layers.

3.4.3 Method of controlling water erosion

i. Land use planning;
ii. Keep any plot of land not under any immediate use und permanent vegetation of woody plants. Vegetation hel holding the soil in place;
iii. Contour cultivation;
iv. Strip cropping;
v. Terracing;
vi. Crop rotation;

vii. Gully control by using terraces to divert the course of flowing water before it gets to the drainage area and planting the drainage area and the channels through which the water is flowing with soil-binding vegetation.

3.4.4 Methods of controlling wind erosion

i. Regulation of land tilling;
ii. Irrigation of land;
iii. Use of wind breaks;
iv. Allowing stubbles of previous crops to remain on the land before next planting.

3.5 Soils in relation to Plant Life

Soils have been defined as the topmost layer of the earthcrust on which plants grow. The reference made to plants in the definition of soils is in recognition of the importance of soils in plants' life. Secondly, it is noteworthy that plants are highlighted in the definition in preference to animals. This does not mean that animals are not found in the soil. It only goes to further reflect the belief widely upheld by ecologists that all other forms of life are closely tied to plant life. Animals are only found in places where plants of their preference are growing. The life of these plants themselves, is dependent on soils.

A plant is known to require sunlight, support, aerial and soil space, oxygen, carbon-dioxide, water, mineral nutrients and warmth, for its growth and development. All these requirements except sunlight, atmospheric carbon dioxide and atmospheric warmth, come directly from the soil. The presence or absence of any one of these requirements and the adequacy of its supply, influence the presence or absence of a plant and the luxuriance of its growth in a place.

A soil which is capable of supplying all these requirements in adequate amount to the plants growing on it, is said to be fertile. Any soil which is not able to meet these requirements of plants is described as being infertile.

3.6 Soil Components and Plant Life

The major components of the soil include the minerals, water, organic matter, air and soil organisms. All these components influence plant life in one form or the other.

The **soil minerals** provide the bulk of the substratum in which plants' roots are anchored. The soil minerals also provide

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the inorganic nutrients of the plant in form of inorganic dissolved in soil water.

The **soil water** serves as the medium for the solution and absorption of the inorganic materials needed by the plant in its nutrition. It is also the medium for the entry and transportation of the soil oxygen needed for the respiration of the roots. It also provides the respiratory gas-oxygen, needed by the soil organisms that are beneficial to the plant.

The **soil organic matter** contributes to the bulk of the substratum needed for providing support for the growing plant. It contributes to the essential nutrient elements needed for the growth of the plant. It also provides the medium for the nutrition, growth and development of the soil organisms beneficial to the plant.

The **soil air** provides oxygen needed for the respiration of the roots of plants and the respiration of soil aerobic organisms. Certain gases present in the soil of some places, also constitute part of the raw materials used in synthesizing the food of some soil autotrophic organisms. The role of **soil organisms** has been discussed in an earlier part of this chapter.

3.7 Soil as an ecosystem

Earlier in this chapter, the soil was defined as the outermost layer of the earthcrust capable of sustaining life. It was also described as a special type of ecosystem. The soil is an ecosystem because it is an ecological entity. It is like other ecosystems composed of biotic (i.e., living) and abiotic (i.e. non-living) factors, which are in constant interaction. The series of interactions result in a stable system which is termed an ecosystem.

The biotic components of the soil which constitute the biotic community or biota, include the soil microflora and the soil microfauna. Others include the roots of land plants and organs of perennation (among macroflora), and some larger invertebrates and vertebrate groups (among macrofauna). These biotic components also belong to two main classes on the basis of their modes of feeding. These are **autotrotophic** and **heterotrophic** components. The abiotic components of the soil include the soil climate and those of the physical and chemical properties of the soil.

The soil climate is characterized by factors such as soil temperature, soil air and soil humidity, and other forms of precipitation in the soil. Other abiotic factors of the soil relate to

its physical properties such as texture, structure, profile, pore space and colour, and others relating to such chemical properties of the soil, like soil water, pH, salinity, organic matter, and minerals.

The soil like other ecosystems, is characterized by a number of other attributes. These include the structural attributes and the functional attributes. The structural attributes of the soil include its **Physical Structure**. This is characterized by certain geometrical shapes that soil particles usually aggreate into. The smallest of these soil lumps are termed **soil peds**. These usually aggregate further into structure depicting producer – consumer type of arrangement. The photosynthetic and chemosynthetic plants constitute the producers. They are also known as autotrophs. The animals which are either herbivorous, carnivorous or omnivorous, constitute the consumers. Soil organisms such as some bacteria and fungi, constitute the decomposers. Both the consumers and decomposers constitute the heterotrophs.

The functional attributes of the soil like those of other ecosystems, are features involving the interactions among and between the various components of the ecosystem. These are described by such terms as **Action, Reaction** and **Coaction.** All influences of the soil physical components on the soil biota, constitute **Actions**. The reciprocal effects of the soil biota on the soil physical factors, come under the term **Reactions**, while the influences of the various groups of soil biota on themselves, constitute **Coactions**.

The soil functional attributes like those of other ecosystems, are characterized by features such as the following:

i. Functional interdependencies between the biotic components and their environment;
ii. Ecosystem dynamics involving dynamics of the various ecosystem components.

Others include self perpetuation and reproducibility, homeostasis, adaptiveness and interdependence between the soil and the neighbouring ecosystems.

4. MARINE HABITATS

4.1 Nature of Marine Habitats

Marine habitats are **aquatic habitats** that are characterized by very **high salinity**. This is as a result of the large amounts of salts in them. This salinity is estimated to be up to 35 parts per thousand. This is 35 parts of salt per 1000 parts of water by weight.

Marine habitats are also characterized by the presence of waves, currents and tides.

4.2 Examples of Marine Habitats

The main examples of marine habitats, are the seas, the oceans and the salt water lakes.

4.3 Distribution of Marine Habitats

Marine habitats are coastal water bodies which link the various continents of the world and also separate them. The oceans are in essence continuous as they all link together.

4.4 Extent of Marine Habitats

Marine habitats are very vast in extent and it is estimated that they cover close to 70% of the earth surface. They are the largest of the habitats that make up the biosphere.

4.5 Habitat Conditions in Marine Habitats

Marine habitats are in general very large, and are relatively stable in their physical, chemical and biological properties. In fact, the marine habitats are regarded as the most stable of all ecosystems.

4.5.1 Physical Properties

i. **Size:** As earlier noted in 4.4 above, the marine habitats are very vast in extent. They are said to cover up to 70% of the earth surface.

ii. **Depth:** Expectedly, marine habitats are very deep, extending up to 11,000 metres in the mariana trench.

iii. **Density:** Marine waters have a density of 1.028

iv. **Temperature:** The temperature at the surface is usually higher than what it is at great depths of the water. In fact, it is estimated that a temperature which is about 30°C in the surface water of a marine habitat in the tropics, may

t 4°C at a depth of 15,000 metres in the ody.

nly penetrates to the first 200 metres in the narine habitat. This zone to which light described as the **photic zone.** It is also tic zone.

here is increase in pressure with depth in ter bodies. It is estimated that there is an ne atmosphere for every 10 metres of

Properties

on Concentration (pH). The water of marine ghtly alkaline.

ncentration

en concentration in marine water bodies is ier at the surface than at the great depths. ncentration normally decreases with depth of ody.

ter bodies are highly saline. This implies that n a large amount of salt which is estimated at arts per 1000 (i.e. 35%).

minent among the salts that contribute to the salts in marine habitats is Sodium Chloride. lude cations such as those of Calcium, n and Potassium. The anions include chloride, oide, nitrate and bicarbonate.

Marine Habitats

nments are habitats for a large number of organisms include coelenterates, annelids, sponges. Others include crustaceans and als. Bacteria and algae are also very many.

Marine Habitats

aracteristic of marine habitats is their **zonation.** f zonation are found in marine habitats. These nation and **vertical zonation.** The zones are n their **location,** they are also different in their

physical and chemical characteristics. They also differ in the types of organisms found in them.

4.6.1 The Main Horizontal Zones of Marine Habitats

The main horizontal zones that can be recognized in an ocean which is taken as a typical example of marine habitats are the following:

i. The Supratidal zone
ii. The Littoral zone
iii. The Oceanic Zone

i. The Supratidal zone

This is a zone which is also known as the **Splash Zone.** It is a zone situated on the land at the shore of the water body. It is usually sprayed by the water of the ocean any time the waves beat against the shore.

ii. The Littoral Zone

This is the zone next to the Supratidal Zone. It is situated on the shallow portion of the water body adjacent to the mainland. It extends to a depth of about 200 metres within the water body.

The Littoral Zone is made up of two parts. These are the **Intertidal zone** and the **subtidal zone.**

(a) The Intertidal Zone

This zone is also known as the **Ocean Edge.** It is the portion of the Littoral Zone nearest tot he Supratidal Zone. It is a zone that is under pronounced wave action.

This zone is usually covered up whenever there is a high tide and it is usually exposed when there is a low tide. In essence therefore, the organisms living in this zone usually experience alternate bout of immersion and exposure. These organisms are equipped with peculiar adaptations that enable them to survive the hazards of this peculiar environment. The hazards are discussed below in Section 4.8 of this Chapter, together with the adaptations for surviving them.

(b) The Subtidal Zone

This is a portion of the littoral zone that comes after the Intertidal zone. It is always submerged below the water level.

iii. The Oceanic Zone

This is a portion of the water body that extends from the subtidal zone all through the open ocean. It is the zone where most of the ecological properties used in characterizing marine habitats occur.

4.6.2 The Main Vertical Zones of Marine Habitats

The Vertical Zones within marine habitats are the zones recognizable within the water body of the marine habitat. This water body is also known as the **pelagic zone** to differentiate it from the portion of marine habitat that is not under permanent water cover. An example of this is **Supratidal zone** earlier described in 4.6.1

Two main vertical zones are recognized within the water body. These are the **neritic zone** and the **oceanic zone.**

i: The Neritic Zone

This is the portion of the water body in a marine habitat that is nearer the surface of the water. It lies over the littoral zone and as such extends up to 200 metres from the surface in the water body. It is under pronounced wave action. The upper portion of it up to 50 metres has sunlight penetrating it, while the portion below this is only dimly illuminated by sunlight.

ii. The Oceanic Zone

This is the main body of the marine habitat, often referred to as the **open sea.**

The upper portion of this open sea to which light penetrates is referred to as the **photic or euphotic zone.** This is the zone where most photosynthetic activity occurs within this water body. It is the zone where marine algae and other marine flora abound.

Below the photic zone is the **disphotic zone.** This is within the middle of the water body. It is only slightly illuminated. It is therefore dark. It has only very few marine flora in it.

The bottom zone of the marine water body is the **aphotic zone.** This extends from the middle zone of the ocean bed which may be more than 7000 metres in depth. This zone is very dark. It is also expectedly very cold. The pressure there is also very high and only very few species of organisms live in this zone.

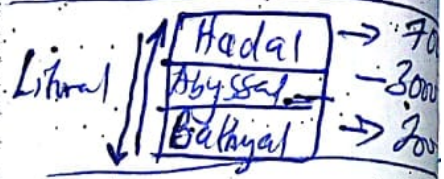
Details of the ecological features of the various zones important in the marine habitats are described in Section 4.7 below.

The Oceanic Zone is also the equivalent of the Benthic Zone in some other classifications in which the upper zone is the Littoral Zone.

This Benthic Zone is the bottom zone which extends from the lower limit of the upper Littoral Zone of 200 metres to the very base of the water body which is the sea bed.

This Benthic Zone is further subdivided into 3 distinct zones. These are:

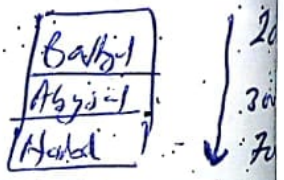
i. The Bathyal Zone
ii. The Abyssal Zone and
iii. The Hadal Zone



The Bathyal Zone extends from the lower base of the Littoral Zone of 200 metres to 3000 metres.

The Abyssal Zone extends from 3000 metres to 7000 metres.

The Hadal Zone extends from 7000 metres to well over 7000 metres.



4.7 Ecological Features of Marine Habitats

4.7.1 The Littoral Zone

This zone has earlier on been described in 4.6.1 as part of the horizontal zones of marine habitats

It is composed of the **intertidal** and the **subtidal** zones. It is a zone that extends from the bank of the ocean to about 200 metres in depth within the ocean body.

Its main ecological features are outlined below:

i. The zone has its substratum made up of sand, rock or mud
ii. The depth of the water in this zone is never above 200 metres
iii. The whole depth of its water is penetrated by sunlight. The zone in essence falls within the **photic (euphotic) zone.** The sunlight is very bright for the first metres in the water body and slightly dim for the next metres.
iv. Because of the presence of sunlight all through the water body in this zone, marine plants are much abundant in this zone. Examples of such plants are the algae (examples which are the diatoms which constitute the phytoplankton species) and the sea weeds which are macroscopic plants
v. Photosynthetic activities commonly occur in this zone.
vi. Oxygen which comes from the atmosphere above the water and as a byproduct of photosynthetic activities in this zone is abundant.

vii. Mineral salts in dissolved form are much abundant in this zone. Prominent among these dissolved mineral salts are sodium chloride, and cations such as those of calcium, magnesium and potassium and anions such as those by chloride, iodide, nitrate, bicarbonate, sulphate.

viii. As a result of the tidal changes occasioned by the high and low tides in this zone, the water of this zone and its dissolved materials such as the minerals and oxygen, are always in constant circulation.

ix. Animal life is also abundant in this zone. These animals also show some form of zonation in their distribution in this littoral zone.

The animals include certain tiny crustaceans which constitute the bulk of the **zooplankton species** and the **pelagic species** which include the larvae of many marine invertebrates, numerous lobsters and crabs and some species of marine fishes.

This zone is important for its economic products which include edible sea weeds and other sea foods such as the lobsters and crabs and mineral oil such as petroleum.

4.7.2 The Oceanic Zone

This zone which is often described as the **Open Sea** has been described to some extent in Section 4.6.2 where the Main Vertical Zones in marine habitats are described. The main vertical zones are influenced by the following abiotic ecological factors which influence the biota marine habitats, particularly the open sea. These important abiotic factors include the following **physical factors** of: i. Sunlight ii. Temperature and iii. Pressure. Others include the following **chemical factors** of i. Oxygen and ii. Salinity.

There are also the peculiar factors of **waves** and **storms** and **sediments**.

If the main Ocean body is literally speaking divided into three vertical zones of surface, middle and bottom zones, it will be noticed that the surface zone is equivalent to the **Littoral Zone** earlier described in 4.6.1 and 4.7.1, while the **middle zone** corresponds to the **Bathyal zone** of the Benthic zone; and the bottom zone corresponds to the **Abyssal and Hadal zones**.

Hadal

Generally speaking, the following ... used to characterize the surface middle and bottom zones of the ocean body.

i. **Sunlight** penetrates to the bottom of the surface zone of about 200 metres. It is absent in the middle and bottom zones. The middle and bottom zones in marine water bodies are therefore usually dark.

ii. **Temperature** which shows both daily and seasonal variations, decreases with increase in the depth of the water body. The bottom is usually very cold; though the water may not be frozen, even when the upper layers have frozen.

iii. **Pressure** is fairly low at the surface waters whereas the middle and particularly bottom waters, are under a very high pressure imposed on the bottom waters by the huge water column of the overlying waters.

iv. **Oxygen** is much abundant at the upper or surface waters, This oxygen decreases in its concentration with the depth of the water body. It is usually very low at the sea bed.

iv. **Salinity** is uniformly high all through the depth of water bodies in marine habitats.

vi. **Waves and Storms** only affect the surface zone of marine habitats. They bring about the mixing of the water of this zone and such materials as oxygen and dissolved mineral salts which they contain.

vii. **Sediments** which may be several thousand metres in thickness are confined to the bottom zone of marine water bodies.

4.7.3 Plant Life in the Oceanic Zone

Only the Littoral Zone found within the surface zone of marine habitats have plant life in them. Such plants have been described in 4.7.1 They include marine phytoplankton species and sea weeds.

The middle and bottom zones of marine habitats lack plant life. This is obviously so because light does not penetrate to these depths.

4.7.4 Animal Life in the Oceanic Zone

Animals of diverse forms are found in virtually all the horizontal and vertical zones of marine habitats. Even though these animals are more abundant in the upper zones.

The animal communities of the upper zone of water bodies include **Zooplankton species** and **pelagic species** earlier described In 4.7.1

Few species of fishes are found in the middle zone, while only special animals such as worms and echimoderms inhabit the bottom zone.

4.8 Adaptations of Marine Organisms

4.8.1 Adaptations of Marine Flora

The marine flora are very few both in their number of species and the abundance of each species. They include the plants living in the supra tidal zone and those found within the littoral zone.

The main adaptations of such plants include:

i. Possession of tiny body which is less dense than the water of marine habitat. This enables them to float within the water body at the surface zone. Examples of such plants are the bacteria and marine phytoplankton such as marine algae.

ii. Possession of structures that enable them to get firmly attached to the solid material that forms the substratum of marine habitat. Sea weeds possess hold fasts which enable them to be attached to rocks. They can therefore not be easily swept away by the marine water under the action of waves and storms.

iii. Possession of the ability to tolerate the salty nature of marine waters.

4.8.2 Adaptations of Marine Fauna

The adaptations marine animals possess to survive in marine habitats are outlined below under the various ecological hazards of marine habitats.

i. **Living and Floating in the Water body**

Possession of tiny body. This is the case with the zooplankton species such as the tiny crustaceans and the larvae of many invertebrates.

Other animals such as the marine bony fishes employ their swim bladders for ensuring bouyancy in the water body.

ii. **Movement in the Water body**

Marine animals (known as nektons) such as lobsters, fishes, whales and seals, employ diverse body organs for

actively swimming in the water body of marine habitats. Examples of these organs are the fins, swimmerets and flippers.

The streamlined shape of marine animals also help to facilitate their movement in marine waters.

iii. **Surviving the salinity of the Water**

Marine animals possess gills for excreting salts.

iv. **Respiration in Water**

This is facilitated in marine animals by their gills which ar special organs for respiring in water.

v. **Wave Action**

Many marine animals which are not active in the movement, employ special structures such as suction discs ar encrusting hairs for attachment. Examples of these animals a the coelenterates. Some others such as the burrowing cla actually burrow into muddy substratum.

vi. **Escape from their natural enemies**

Fishes use the lateral lines on their body to detect vibratio within the water body. Such vibrations help to alert them abo possible dangers within their environment. The abllity of many run fast through swimming and diving, also enable them escape from dangers.

vii. **Feeding in Water**

Many marine animals employ their sharp homodont teeth not only hold their prey, but also chew them.

viii. **Attack of enemies**

Many marine animals employ special body structures s as fishing poles and fluorescent organs for offence and defe This is particularly so far the deep sea animals.

ix. **High pressure within deep waters**

Many bentic animals have the ability to tolerate the pressure of deep seas.

5. FRESHWATER HABITATS

5.1 Nature: The freshwater habitat is an aquatic type of habitat characterized by low salinity. It also lacks waves and tides which are present in the sea.

5.2 Distribution: Freshwater habitats are inland bodies of water. They are like the lands (and unlike the seas), separated. They include rivers, lakes, pools and ponds.

5.3 Types: Two broad types of freshwaters are recognized on the basis of the presence or lack of a unidirectional current in them. Those characterized by the presence of a unidirectional current and which as a result move along the direction of the current, are said to be Lotic. These include all flowing freshwaters such as rivers, streams and springs. The other group lack a unidirectional current and are therefore stagnant or stationary. These are described as Lentic. Examples of these are lakes, ponds, pools, swamps and bogs.

5.4 Habitat Conditions:

5.4.1 Physical Conditions

The most important physical conditions of the fresh water habitat, are those of its size (as determined by its surface area and depth), material of the **bottom substratum** and its **temperature** and **light intensity** at different depths. Some other important physical factors of the freshwater habitat, are those of the **transparency** or **turbidity** of the water, the **colour** of the water, its **specific gravity**, nature of the **current** in the water and **velocity** of the water.

5.4.2 Chemical Conditions

A few other habitat factors in freshwaters are those of the chemical conditions of the water. Such factors include the **salinity** of the water, the concentration of the **vital** (i.e. biologically essential) gases such as oxygen and carbon dioxide, the concentration of the **minera: substances** of biological importance and the **hydrogen-ion concentration** (i.e: pH) of the water.

Condition / Factors

Chemical Condition

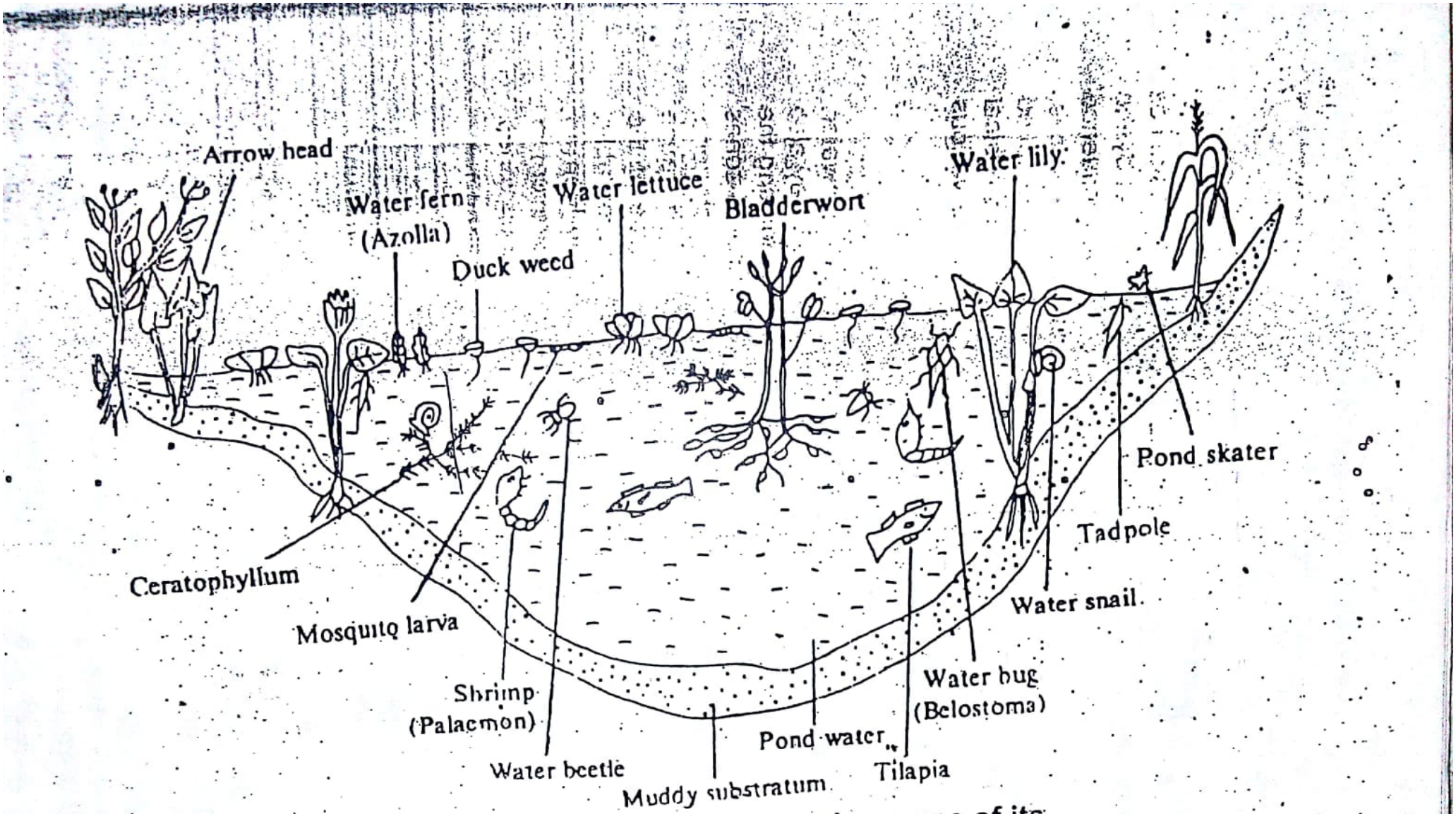


Fig. 5.1 A Diagram of a Pond showing some of its physical features and the distribution of the Plant and Animal Communities

5.5 Seasonal variations in the habitat factors

A number of seasonal variations occur in some of the ecological factors. These variations are experienced by temperature, light intensity, transparency, colour and specific gravity of the water. Other factors that experience seasonal variations include the concentration of the vital gases, the pH of the water and the concentration of dissolved mineral substances in the water. These seasonal variations are brought about by the changes in the weather conditions, which themselves influence the amount of water getting into the water from various sources. The amounts of organic and inorganic materials being emptied into the water, also alter. All these changes in the physical properties of the water influence the populations of the various species of organisms in a body of water.

5.6 Freshwater Organisms

A number of zones can be recognized in a freshwater. These zones not only differ in their physical conditions, they also differ in the types and abundance of the organisms inhabiting the various zones. The physical conditions of the various zones influence the types and abundance of organisms in each zone. The organisms in each zone are restricted to the zone, because they are able to derive the maximum benefit from those of the physical conditions of their environment that are favourable. They also possess a number of adaptations that enable them to survive those ecological hazards to life that may be present in the same zone. The diagram in Fig. 5.1 shows the various zones in a freshwater and the organisms inhabiting these zones.

5.7 Freshwater Flora

The plant communities inhabiting different parts of a freshwater habitat and the examples of plants in each community are listed below:

A. Phytoplankton

Photoplankton are small photosynthetic plants drifting about on the water surface and in the direction of the water current. These organisms are particularly important as the basis of all food chains in aquatic environments. Examples of freshwater phytoplankton include green algae such as *Chlamydomonas etc.* blue-green algae, diatoms and dinoflagellates.

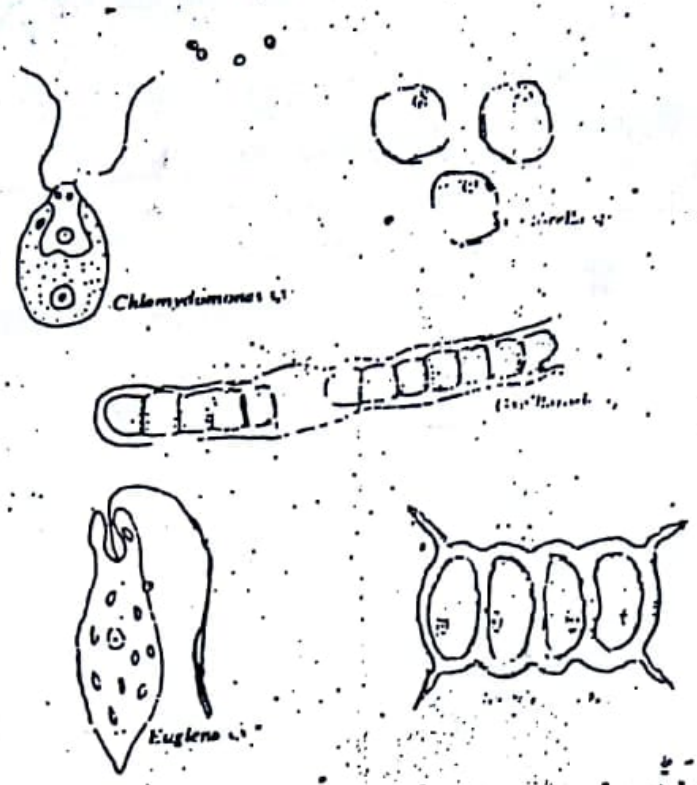


Fig 5.2 Some common microscopic plants of aquati habitats

B. Freely floating macrophytes.

Freely floating macrophytes are represented in tro freshwaters by the duck weed (*Lemna sp*), water fern (*Sal sp*), water lettuce (*Pistia stratiotes*), *Wolfia*, *Azolla*, v hyacinth (*Eichhornia crassipes*), etc.

C. Submerged macrophytes.

Submerged macrophytes are large plants that suspended within the water body but without their anchored to any substratum. Examples include hor (*Ceratophyllum*), bladder wort (*Utricularia sp*), *Vallisneria Chara*.

D. Rooted macrophytes with long petioles and flo leaves.

These include water lily (*Nymphaea sp*)

Fresh water Plant

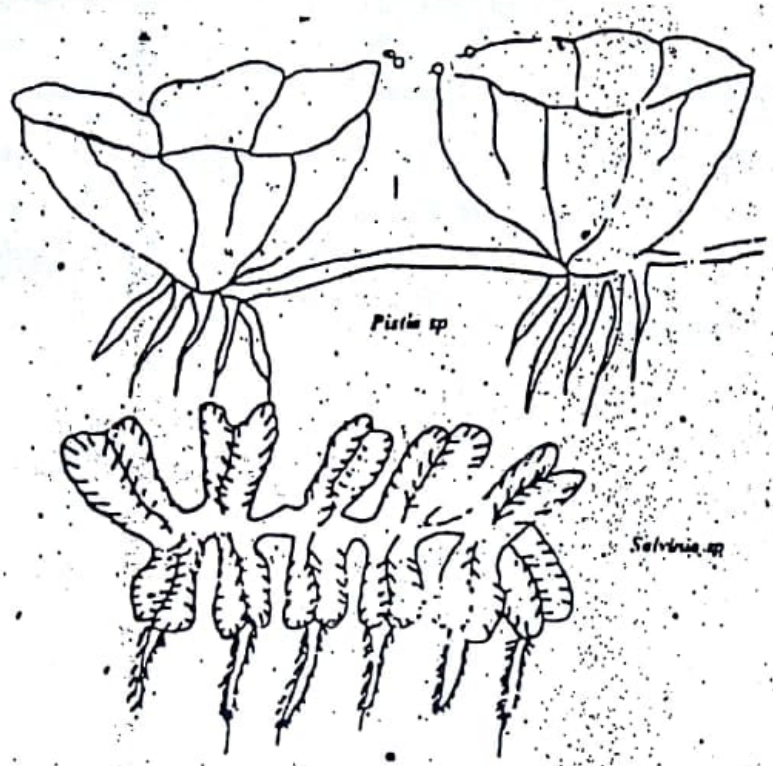


Fig. 5.3a. Some other common Aquatic Plants.

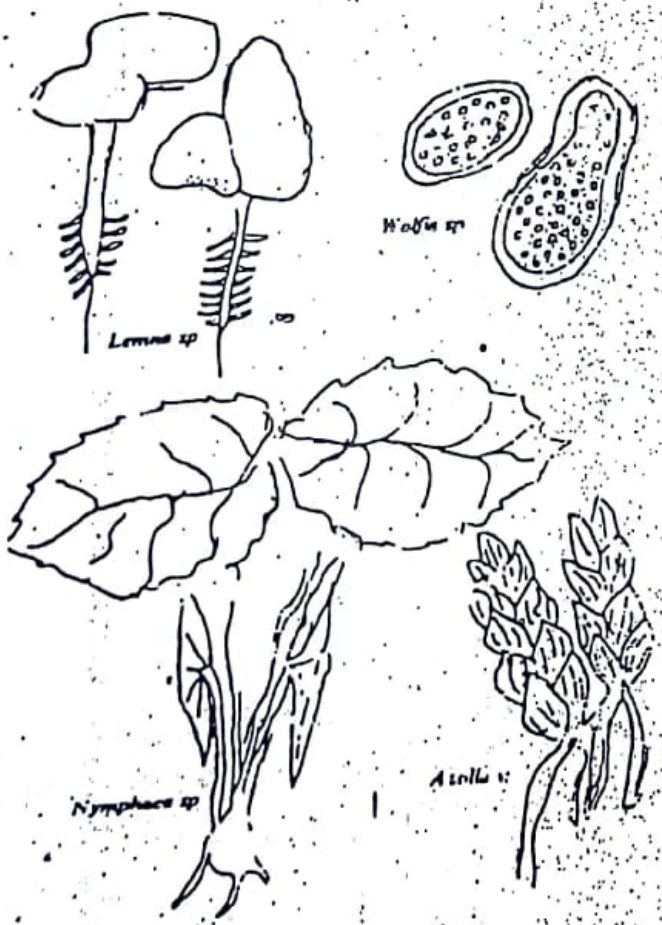


Fig. 5.3b Some other common Aquatic Plants

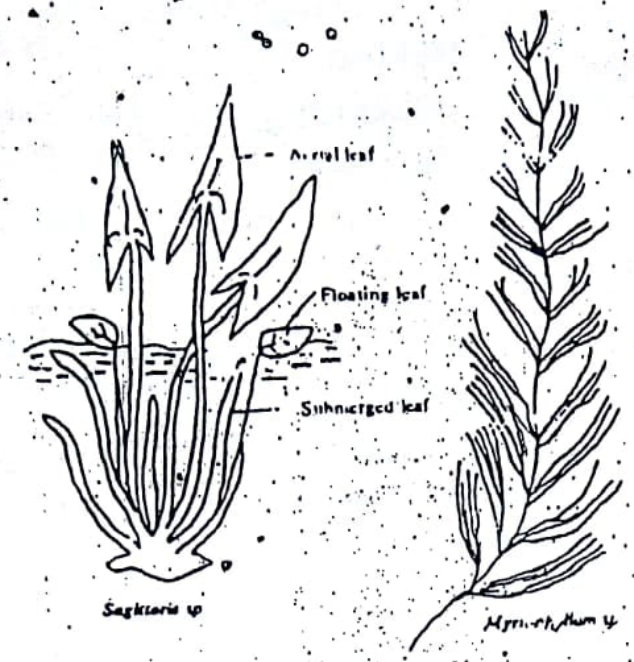


Fig. 5.3c Some other common Aquatic Plants

E. Rooted emergent macrophytes

Rooted emergent macrophytes are found occasionally in some freshwater bodies. An example of such plants is *Oryza sp.*

5.6.2 Aquatic Fauna

The freshwater fauna belong to the following groups:

A. Zooplankton

Zooplankton are the freely floating microscopic animals. The zooplankton include the permanent members known as **Holoplankton** and the temporary members called **Meroplankton.** The holoplankton include protozoans, some crustaceans, some molluscs, copepods and some polychaetae, echinoderms, crustaceans and some fishes, tadpoles, pondskater *(Gerris)*. water bug and water mite.

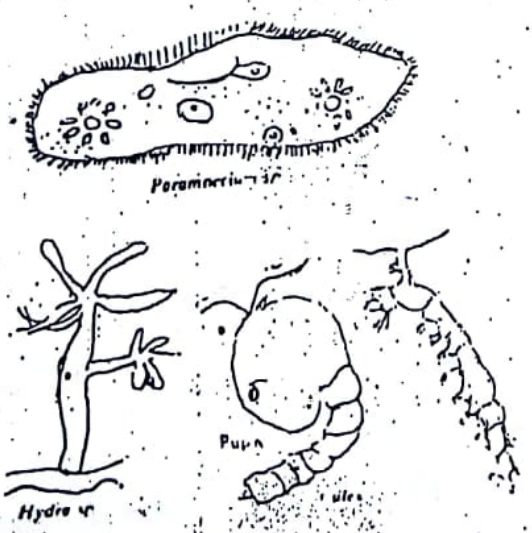


Fig. 5.4 Some common microscopic animals of aquatic habitats

Zooplankton — Holoplankton (The Permanent member of aquatic

B. Nekton

Nekton are actively swimming animals such as fishes and amphibians.

C. Periphyton:

Periphyton are animals which attach themselves to vegetation or hold temporarily to plankton. They include dragon fly nymphs, hydroids, rotifers, flatworms, snails and water mites. Some of these are carnivorous, while others feed on the phytoplankton to which they are attached.

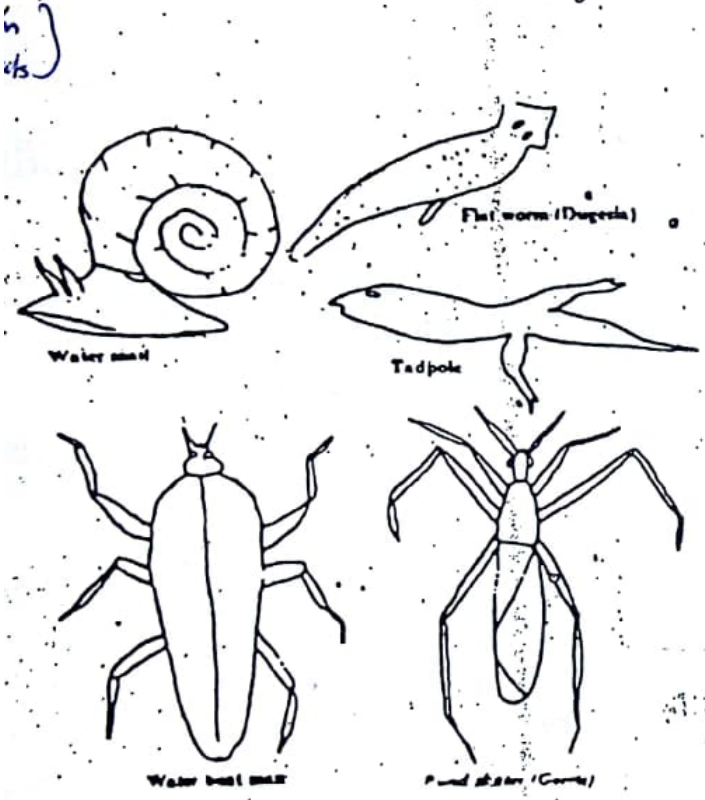


Fig. 5.5a Some other common aquatic animals

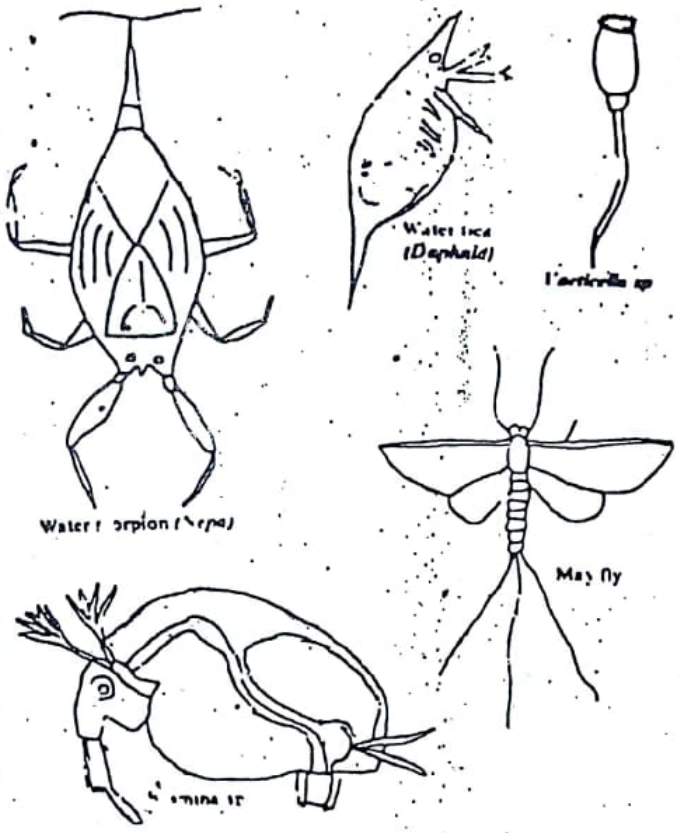


Fig. 5.5b Some other common aquatic animals

Fig. 5.5c Some other common aquatic animals

D. Benthos:

Benthos are the bottom-dwelling animals. The smaller ones are called microbenthos, while the larger ones are called macrobenthos. Examples of the benthic animal species include various annelid worms, rhizopods, nymphs of various species of insects and many other burrowing animals. Sponges are also macrobenthos.

5.8 Ecological Hazards and Adaptations of Plants in Freshwater Habitats

A. Bouyancy in water

Adaptations

1. Possession of aerenchymatous tissue (e.g. in *Nymphaea*, and *Eichhornia*).
2. Possession of elongated body (e.g. in *Spirogyra*, and *Ceratophyllum*).
3. Possession of mucilagenous sheath (e.g. in *Spirogyra*)

B. Obtaining enough sunlight for photosynthesis:

Adaptations

1. Possession of leaves with large surface area
2. Presence of chloroplasts in their epidermal layer
3. Rapid surfacing by floating plants that are occasionally submerged
4. Possession of different means of getting rid of the water adhering to the surface of their leaves. These include water-repelling hairs and waxy covering.

C. Obtaining enough dissolved oxygen in water

Adaptation

1. Thin cell walls of the epidermis
2. Absence of cuticle or any impermeable material on the epidermis of submerged aquatics
3. Presence of extensive aerenchymatous tissues with plenty of air spaces in them. These facilitate the circulation of air within the tissues, and the diffusion of the oxygen produced during photosynthesis to all parts of the tissues.

D. Reproduction and dispersal in water

Adaptations

1. Production of numerous gametes by those species that

reproduce sexually

2. Asexual reproduction through vegetative means is highly developed in many aquatic plants. This vegetative reproduction is carried out by different methods, among which are fragmentation of the body of the plant, and by the production of rhizomes, runners and stolons. These vegetative structures also help in the dispersal of these plants. In species such as *Elodea canadensis*, reproduction is exclusively by the vegetative method.

E. Absorption of water and mineral nutrients

Adaptations

1. Absence of cuticle or any waxy covering on the epidermis and other surface layers of the body of the submerged aquatic plants. Direct absorption of materials is thereby facilitated.
2. Presentation by many of the submerged aquatics of a large surface area to the water of their habitat. This is achieved either through the possession of large leaves as in *Nymphaea*, or through the leaves of many being highly dissected as in *Ceratophyllum*. The large surface area makes the absorption of materials easy for these plants.

5.9 Ecological Hazards and Adaptation of Animals in Freshwater Habitats,

A. Bouyancy in water and water current

Adaptations

1. Light weight of many, especially the zooplankton
2. Attaching to stationary objects such as rooted macrophytes and rocks. This is the case with water snails, sponges, leech, and mayfly nymph.
3. Actively swimming in direction opposite that of the water current. This is the case with fish species which in addition to their fins which facilitate active swimming, also possess streamlined body form. Other animals such as stonefly and the nymphs of mayfly, have flattened body which offers very little resistance to the flowing water.
4. Hiding in crevices such as those in rocks and other available holes

B. Breathing in water

Adaptation

1. Many aquatic animals possess gills which enable them to breathe in the oxygen dissolved in water. This is the case with fishes and many insect larvae
2. Many also utilize the oxygen of the air above the water surface.

Examples of these are seen in many insects and water snails such as *Planorbis* and *Limnaca*.

C. Feeding in water

Adaptation

1 Many are able to sieve water for tiny aquatic organisms on which they feed. (e.g. the larva of *Simulium)*

2 Some of the carnivores are able to catch their prey through different methods (e.g. the use of prehensile antennae by the larva of the insect *Chaoborus*, while the nymph of the dragonfly uses an extensible mask to catch its preys).

D. Reproduction in water

Adaptations

1. Production of numerous gametes
2. Cyst formation in some, especially when the water of habitat dries up.
3. Asexual reproduction by fission in many protozoans

E. Protection from enemies

Adaptations

1. Fast movement in the actively swimming aquatic animals
2. Hiding by many
3. Protective colouration in many (e.g. fishes and tadpoles of amphibians).

6. THE BRACKISH WATER HABITATS

6.1 Environmental Features.

The brackish water habitat exists in a place where the freshwater of an inland river, empties into and mixes with the marine water of the sea. It is a tropical habitat characterized by the same type of environment in which the **mangrove vegetation** type exists.

This environment which is a highly hazardous one, is characterized by the following environmental features:

i. Hot and humid climate
ii. Tidal influence from the sea. There are both high and low tides
iii. Daily and annual fluctuating salinity. The salinity is low at low tide and high at high tide. The nearer a portion of this habitat is to the sea, the more the saltiness of the water, and the nearer to the inland, the less the salt content.
iv. There is a seasonal rainfall. The rainfall months are however more in the year than the months of no rain. The rain months are also characterized by heavy rainfall
v. There is intense sunlight in the daytime. The scorching sun is also with its attendant effects of insolation and desiccation, coupled with high rate of transpiration in the plants.
vi. The environment is poorly aerated, with low oxygen content and high content of hydrogen sulphide and sulphur dioxide. These gases also account for the rotten egg odour of this environment.
vii. The water of this environment is characterized by high turbidity. This accounts for the low light penetration in the water of the environment. This also accounts for the low depth of the photosynthetic zone in the water body.
viii. The water is slightly acidic. This is probably due to the higher concentration of dissolved acidic gases. Examples of these gases are hydrogen sulphide, sulphur dioxide and carbon dioxide
ix. This environment has a high salt content and a high amount of organic detritus. The quantities of these nutrient-producing materials are higher than in inland water bodies such as rivers and streams and even the ocean. The high nutrient status of the brackish waters, accounts for their high productivity.
x. The brackish water bodies are not only under appreciable wind action, they are also under the influence of wave

action. These account for the shifting nature of the muddy or sandy substratum of this environment.

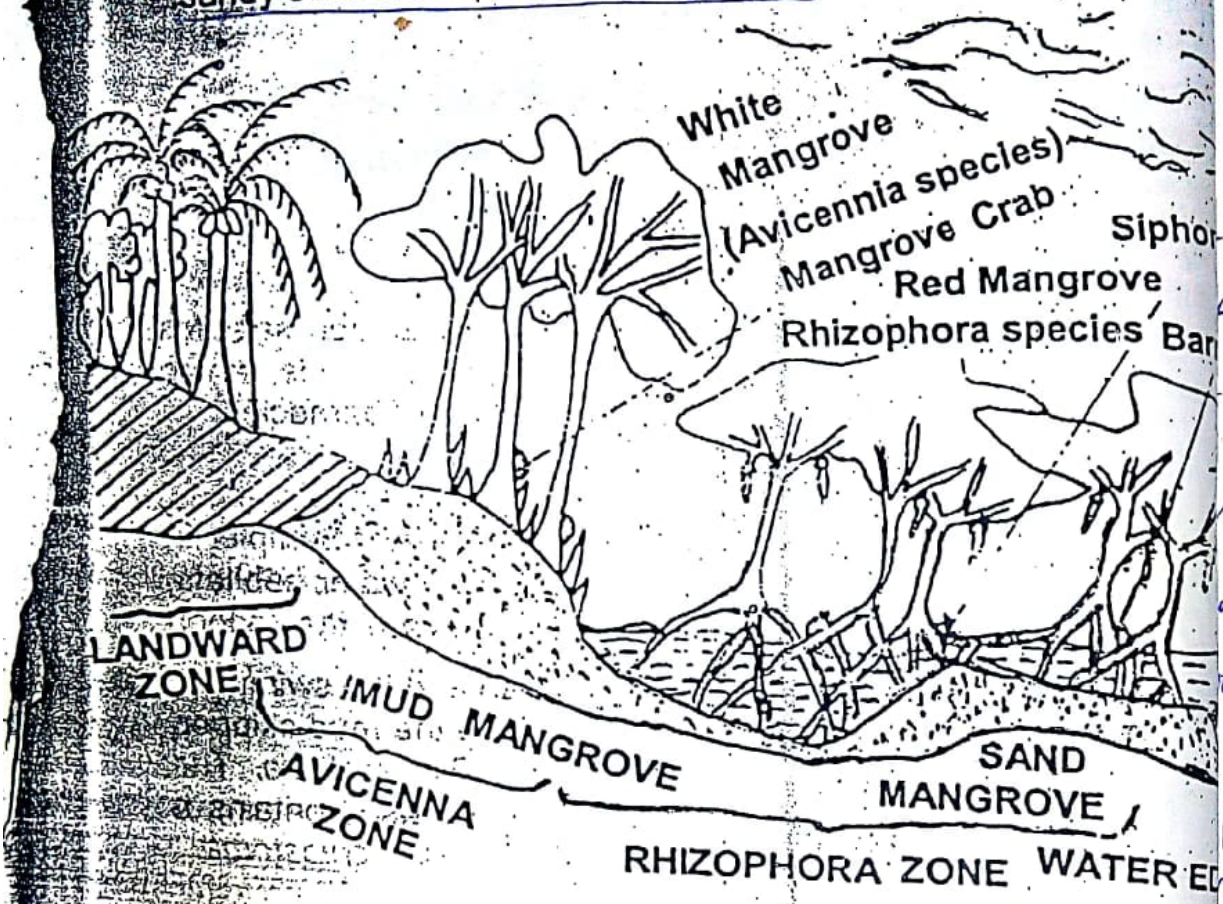


Fig. 6.1 A transect through the plant communities in brackish water environment

6.2 Plant Communities of the Mangrove Swamps

The plant species listed for each zone are as obtained nea Ikorodu on the mainland shore of the Lagos lagoon in Nigeri The lagoons and estuaries are in general characterized by lo species diversity both in terms of the flora and their fauna. Th plants of the various zones of the lagoon are:

6.2.1 Zone A: Water Edge of Thicket Zone

Dalbergia ecastaphyllum, *Ormocarpon verrucosu* *Drepanocarpus lunatus* and *Ipomea cairica*

6.2.2 Zone B: The Sand Mangrove Zone

Rhizophora species such as *R. racemosa*, *R. mangle* *R. harisonii*. Other plants include *Panadanus* species *Acrostichum aureum* – a fern

6.2.3 Zone C: The Mud Mangrove Zone

Avicennia nitida, *Pterocarpus santalinoides*, *Phyllan*

reticulatus, *Vossia cuspidata* – a grass, and *Echinochloa pyramidalis*.

6.2.4 Zone D: The Landward Zone

Palm trees and some shrubs and grasses

6.3 Animal Communities of the Mangrove Swamps.

6.3.1 Zooplankton

The zooplankton commonly found in the plankton samples in the brackish water habitats include diatoms, copepods, larvae of crabs and those of *Amphioxus* and the nauplii of barnacles.

6.3.2 Bottom living fauna

Bottom fauna collected with the aid of a bottom sampler in the muddy and sandy substratum of the brackish water habitats, include different types of crabs. Among these are the lagoon crab, the fiddler crab, the hairy mangrove crab and the swimming crab with flattened limbs. Other animals include the mud skipper, lagoon snails such as *Tympanotomus* and *Pachmelania*. The sandy substratum of the sand mangrove zone, also contains a number of worms, a type of bivalve mollusc and *Branchiostoma*.

6.3.3 Other Mangrove Fauna

Other Mangrove fauna include: Oysters, various annelid worms and crabs, *Littorina* – a snail, flat barnacles (such as *Chthamalus)* and upright barnacles (such as *Balanus)*. There are also a number of fish species, shrimps and lobsters.

6.4 Ecology of Brackish water habitats

The ecology of the brackish water habitat is very interesting from an important point of view. This is in the fact that a detailed study of this habitat, can provide an opportunity for demonstrating a number of ecological phenomena. Among these are the following: succession, regression, zonation of plant communities and zonation of animal communities. Others include natural cycles, fluctuations, allogenic changes, euphamonic convergence and the phenomenon of adaptation. In this section, the phenomenon of adaptation is highlighted for discussion.

6.5 Adaptations of Mangrove plants.

Two species of mangrove plants are selected for discussion

because of the numerous adaptive characteristics they display. These plants are *Rhizophora* species (Red mangrove) and *Avicennia* species (White mangrove).

Rhizophora [Red mangrove]

Avicennia [White mangrove]

Fig. 6.2a Features of common woody plants of mangrove swamps

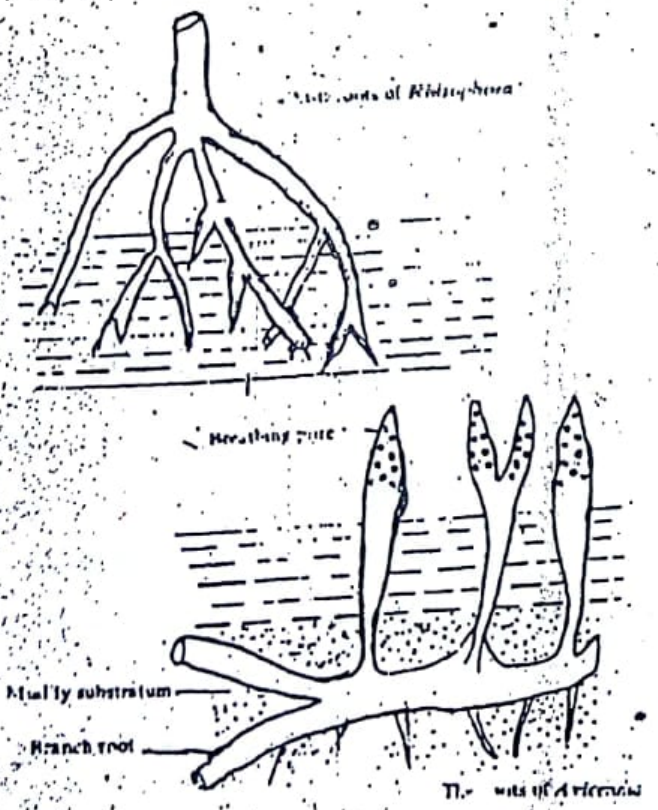


Fig. 6.2b Features of common woody plants of mangrove swamps

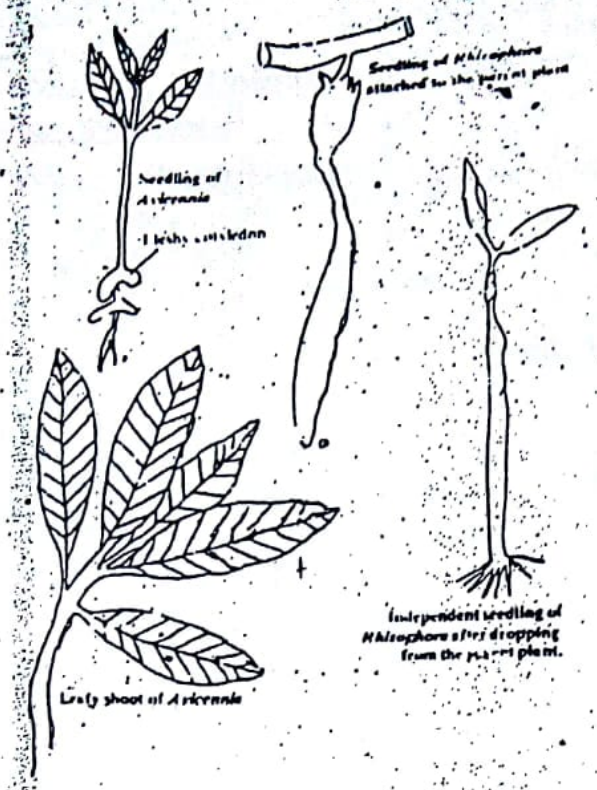


Fig. 6.2c Features of Common Woody Plants Of Mangrove Swamps

The red mangroves (*Rhizophora* species), are found as pure stand communities at the edge of the lagoon. These plants are able to effect the accumulation of sand around their roots, and by so doing, help in holding the shifting sand in place, and thereby helping to initiate plant succession around the edge of the lagoon. The adaptations displayed by the red mangroves include those outlined as follows:

i. **Roots** produce abundant strut-like and arching stilt roots which enable the plant to withstand flooding by keeping the branches of the plant above the high tide level. These roots by their physical presence, cause the deposition of silt and consequent building up of the surface which is necessary for the stabilization of the substratum.

ii. Seeds germinate while still attached to the parent plant. This mode of development is described as **viviparous development.**

The resulting seedings are light and bouyant – hence when they drop from the tree, they can be water-borne to a favourable portion of the habitat where they can resume normal growth. The

seedling usually drops root downwards. The tip is therefore easily driven into the mud. This tip forms anchoring lateral roots within a few hours of its landing on the mud.

iii. **Leaves** of *Rhizophora* are flat and dorsiventral, green above and lighter beneath. They are arranged on the branches in such a way that all the leaves are equally exposed to sunlight.

→ The white mangroves (*Avicennia* species), are usually found growing on a relatively more stable substratum of the mud a little towards the inland. These plants display the following adaptive features:

i. **Roots** of *Avicennia* produce conical spikes of pneumatophores. These pneumatophores are usually borne above the water level in the muddy substratum. They enable these plants to breathe from atmospheric air.

ii. The **fruits** are light in weight and can float in water for a considerable length of time before drifting to a suitable substratum, where they can germinate.

iii. The **Leaves** of *Avicennia* species exhibit active salt secretion, and in dry weather, the secretions show as white crystals on the leaves. This is an adaptation that enables the plants to regulate the concentration of salt in their tissues.

6.6 Adaptations of Animal communities in brackish water habitat.

A. Wave Action

1. Many animals hide in crevices in rocks and other available holes.
2. Some animals are firmly attached to rock, while others are attached to the roots of mangrove plants. The barnacles are known to be cemented to rocks and the roots of *Rhizophora*. This prevents them from being swept off by the waves.

B. Salinity of the water of the habitat

Many brackish water animals escape from this problem by their being covered by impermeable structure such as shells in snails, and the exoskeletal coverings of some others like shrimps and crabs. The body fluids of most of the brackish

7.3 Classification of the forest vegetation of West Africa:

The main zones of forest vegetation in West Africa are the Mangrove Swamp, the Fresh Water Swamp, the Tropical Low land Rain forest and the Semi-Deciduous forest. Others include the Riparian Forest and the Forest-Savanna mosaic. All these with the exception of the riparian forests, lie parallel to one another.

7.4 Climatic conditions within the forest:

The tropical forests are characterized by a high amount of annual rain-fall, which is more or less evenly distributed throughout the year. They also have a well-marked two-peaked pattern of annual rainfall – a feature characteristic of all parts of West Africa occurring below Latitude 9^0N.

The mean annual rainfall is usually above 1,250mm. More than 6 months of the year are in the wet season and less than 2 months are in the dry season. The short dry season usually intercepts the rainy season months.

The tropical forests like other parts of West Africa, experience very little variation in their temperatures within the year. The monthly range of temperatures in the forest zones, is usually below 8^0F. The West Africa forests have a characteristically high relative humidity. In most parts of the forests, the mean monthly relative humidity is never below 70%.

The West African forests usually have up to 7 hours of sunshine daily in the dry season months. These sunshine hours may not be more than two each day in the wet season months.

The mean annual evaporation of the forests is never above 1,250mm.

The Climate of the tropical forest is usually described as being equable – a term implying that the climate is more or less constant, and therefore experiences no appreciable fluctuations in its conditions from time to time. The features of the climate of the forests can be summed up as follows:

The tropical forests are characterized by an *Equable Climate*, which is usually fairly *Wet*, *Hot* and *Humid*, and with a fairly *Still Atmosphere*, characterized by occasional breeze and moderate sunshine in the day time with a low rate of *evaporation*.

7.5 Characteristics of forest soils

Forest soils are usually fairly deep and permeable. They are

inherently fertile, except in places where they have been much disturbed through repeated cultivation. They are fairly rich in organic matter, but highly leached of their bases. They therefore have very little mineral reserve and are usually acidic in reaction.

7.6 Physiognomy of Forests

Undisturbed natural forests in West Africa, are dense luxuriant vegetation types with complete structure and numerous huge trees, that are in more or less well defined storeys.

7.7 Stratification of Forest Plants

Profile transects taken in the forests, reveal a characteristic well defined stratification of the component plant species into horizontal layers. The strata of plants include:

a. The **tree strata**, composed of 3 horizontal layers of trees named A, B and C storeys (or upper, middle and lower strata of trees).

Fig. 7.2 Profile of a typical tropical lowland forest

The **A-storey trees** also known as **Emergents**, are huge trees whose heights range from 40 to 50 metres. The trees which are few in number, are scattered among the trees of other storeys. They have large spreading crowns and huge buttresses. The typical examples in West Africa include *Terminalia superba*, *Piptadeniastrum africanum* and *Triplochiton scleroxylon*.

The **B-storey trees** range in height from 15 to 40 metres. They are not as huge as the emergents, but they are more in number in any forest. They too have buttresses. Examples of these in West Africa include *Celtis zenkeri* and *Sterculia*

A - storey Trees [Emergent] 40-50

...are also almost of the same concentration as the water of their habitat. This constancy of the osmotic concentration of the body fluid, is ensured through excretion of water as fast as this enters their body and by retaining salt in their body from the water entering their body.

Water Current

i. Many of the animals living in brackish water, have flattened body, hence they offer very little resistance to the flowing water.

ii. Some of the brackish water animals such as the fishes, are capable of swimming actively up stream.

7.1 Introduction:

The Tropical Forests are among the major types of terrestrial habitats in West Africa. Others include the tropical savannas, the deserts and the montane vegetation. The classification of these terrestrial habitats is done on the basis of the types of vegetation they support.

The tropical forests are characterized by a vegetation type in which Trees predominate over other life forms, both in terms of species composition and the abundance of each species. The trees are usually closely spaced, with the crowns of many of them touching, thereby forming a more or less continuous canopy over the forest interior. Other woody species such as the shrubs, lianes, other climber species, and a few herbs, are also present in the forest; but grasses which characterize the tropical savannas, are virtually absent in the forests. They are only represented by a few specialized species.

7.2 Distribution of Forests in West Africa

Most of the forests in West Africa, are found in the areas bordering the Guinea Coast. All Countries bordering the West Africa coast except Dahomey (now Republic of Benin), have coastal low land forests which extend several kilometres into their interior, sometimes reaching up to 320 kilometres, or more in some Countries.

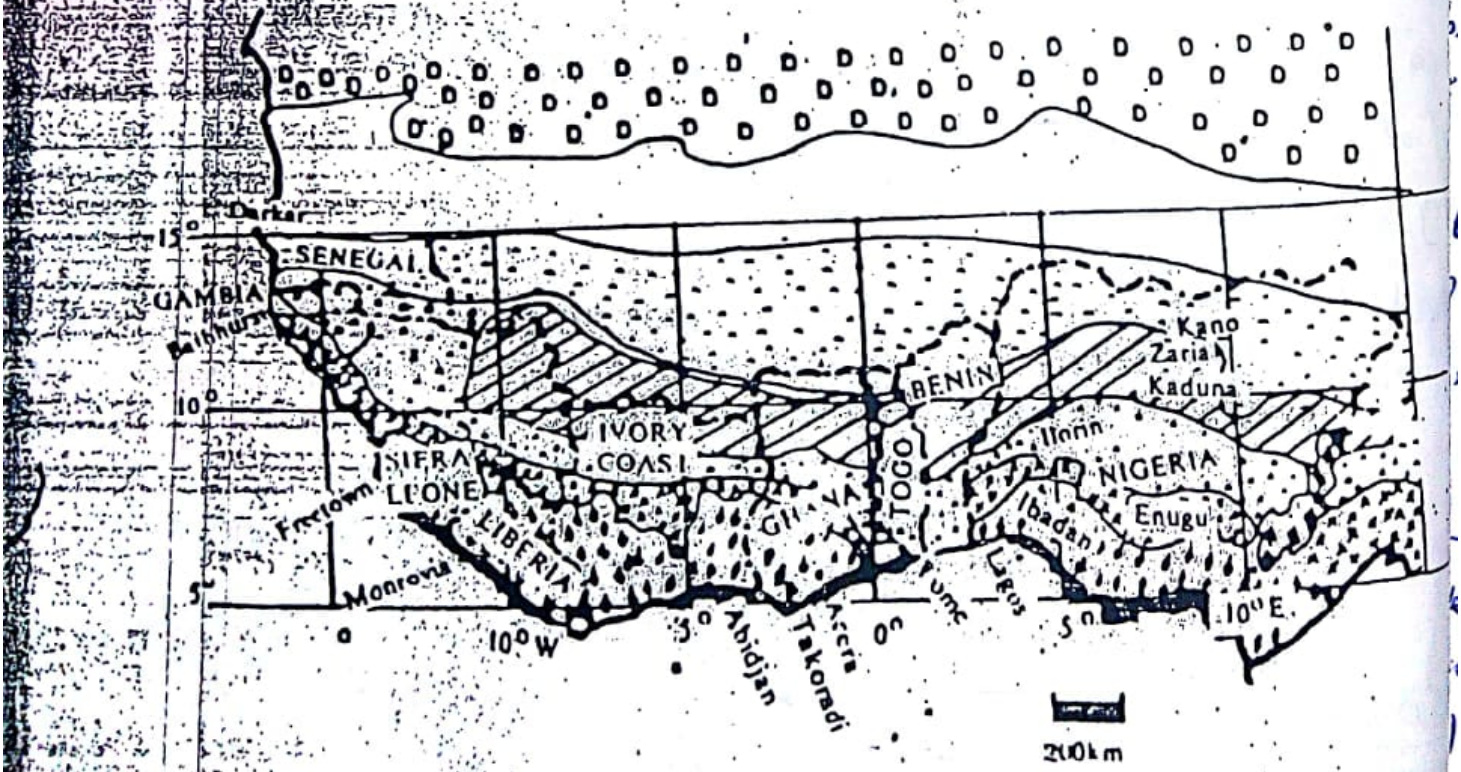


Fig. 7.1 The main Vegetation zones of West Africa

The **C-storey trees** range in height from 7 to 15 metres. They are the most numerous of the forest trees. They have narrow crowns which being in close contact, contribute immensely to the continuous canopy formed by tree crowns over the forest interior. The trees rarely have buttresses. Their examples include *Uvariopsis diolca* and *Desplatsia dewevrei*.

The **D-storey** which is also known as the **Shrub stratum**, is composed mainly of fully grown shrubs and many young trees. *Sphenocentrum jollyanum* and *Angylocalyx oligophyllus*, are members of this group.

The **E-storey**, which is also known as the **Herb-stratum**, is composed mainly of herbs and the seedlings of many trees. The plants in this group are usually below 1 metre in height. They are few in number and are usually restricted to those parts of the forest floor to which sunlight manages to penetrate. The herb stratum plants include some herbs, ferns, and some specialized forest grasses with characteristic broad leaves and false petioles. Examples of these forest grasses are *Leptaspis cochleata* and *Olyra latifolia*. The **Ground Stratum** plants include the mosses, some saprophytes and root parasites of forest trees.

7.8. Forest life forms

The main life forms of the species of plants in the forests include **Trees, Shrubs** and **Herbs**. Others include the **woody** and **herbaceous climbers**. There are also other life forms such as **epiphytes, saprophytes** and **parasites.** These forest plants also belong to various life forms based on **Raunkiaaer's classification.**

7.9 The forest flora:

The common woody species of the various zones of the West African forests include the following.

(A) **Mangrove swamp**: *Rhizophora* species (the Red Mangroves), and *Avicennla nitida* (the white mangrove).

(B) **Freshwater swamp**: *Mitragyna ciliata, Raphia* species, *Nauclea popeguinii* and *Xylopia rubescens*.

(C) **Tropical low land rainforest**: *Piptadeniastrum africanum, Albizia ferruginea, Tetrapleura tetraptera, Chlorophora excelsa, Antiaris africana, Musanga cecropioides, Entandrophragma angolense, Lovoa trichilioides, Khaya*

ivorensis and *Diospyros* species.

(D) **Semi deciduous forest:** *Triplochiton scleroxylon, Hildegardia barteri, Sterculia rhinopetala, Cola millenii, Mansonia altissima, Celtis zenkeri* and *Holoptelea grandis.*

(E) **Riparian forest:** *Brachystegia nigerica, Berlinia gradiflora, Pterocarpus santalinoides* and *Cleistopholis patens.*

7.10 Forest Fauna:

The animals living in forests are usually found in the numerous microhabitats existing in these forests. The animals include the following groups:

Insects: Army ants, termites, butterflies, cicadas, grasshoppers and beetles

Other Invertebrates: Millipedes, spiders, earthworms and snails

Amphibians: Tree frogs and *Bufo.*

Reptiles: Snakes, skinks, geckos and tortoise. Examples of the snakes are the black spitting cobra and python.

Birds: Hawks, crested guinea fowls, African grey parrot, wood owls and West African toraco

Mammals: Rodents, squirrels, fruit bats, duickers, monkeys, gorilla and chimpanzee.

7.11 Adaptations for Life in the Forests

The tropical forests in their undisturbed state, are characterized by an equable climate. A major effect of this constant environment, is the very few ecological hazard to life in them. There is however a remarkable hazard to plant life in tropical forests. This is the poor light condition within the interior of these forests. The adaptations plants display to survive this, include different mosaic patterns of arrangement of the leaves of plants of the herb stratum, and the development of long petioles and simple leathery leaves with large surface. The climbing habit in some forest plants, is also an adaptation that enables them to have access to better light condition in the region around the forest canopy.

7.12 Productivity of tropical forests:

The tropical rainforest is reputed for being the most productive of all terrestrial ecosystems. The bulk of this productivity is locked up in the trunks and woody branches of the trees.

8. TROPICAL SAVANNA HABITATS

8.1 Introduction:

The savanna habitats, have grasses as the most important group of plants, with trees and shrubs present in quantities which vary with the type of savanna vegetation. The woody species when present, are very few both in terms of the number of species and the abundance of the individuals of each species. They are usually scattered among the grasses, which together with the numerous species of forbs, constitute the herbaceous flora of the herb stratum in the tropical savannas.

8.2 Distribution of the savannas in West Africa

Well over 80% of the vegetation of West Africa is one type of savanna or the other. All West Africa Countries, have one or more zones of savanna vegetation.

8.3 Classification of the West African Savannas:

The savannas of West Africa are classified into different zones on the basis of **their ecological features**. The savanna zones include:

1. The Derived Savanna
2. The Forest Savanna Mosaic
3. The Guinea Savanna, which includes the Southern Guinea Savanna and the Northern Guinea Savanna
4. The Sudan Savanna, and
5. The Sahel Savanna

The savanna zones lie parallel to one another, and to the north of the forest region that borders them in the south.

Another classification of the savannas is that based on their **physiognomy**. The main types of these are the **savanna woodlands** typified by the Derived Savanna and the Southern Guinea Savanna; and the **Tree Savanna**, an example of which is the Northern Guinea Savanna. In this, the trees form park lands. The trees occur in more or less pure stands of single species, with the individuals of other species, dotted here and there among the numerous individuals of the dominants species forming each parkland. The **Shrub Savanna**, another type of savanna is typified by the Sudan Savanna. Here, the shruby species are the commonest, with very few individuals of trees species scattered among the shrubs. The **Savanna Grasslands** are typified by the Sahel Savanna and the northern portion of the Sudan Savanna. It is however pertinent to note that all the

savanna types recognized on the basis of their physiognom have grasses as the dominant flora, but these are confined to t herb stratum.

8.4 Climatic conditions in the Savannas

The climate of the West African savanna, is characteri by rainfall of low intensity and small annual amount, long season, dry and hot environment and high monthly range temperatures, coupled with high rate of evaporation. climatic conditions increase in their severity as one mo further away from the savanna zone nearer to the forest belt the south, to those nearer to the desert in the north. While savanna zones south of latitude 9°N have rainfall character by double maxima, the zones above this have a single pea their rainfall with the year.

8.5 Characteristics of Savanna Soils

The savanna soils are characteristically shallow and of fertility. They too are leached, but not as heavily leached a forest soils. They are therefore richer in mineral reserve tha forest soils. However, the soils of most parts of the sav region, do not have certain mineral nutrients essential for growth in abundance. This accounts for the low fertility of savanna soils. Examples of these important plant nutrient may be lacking in savanna soils are nitrogen, phosphoru potassium.

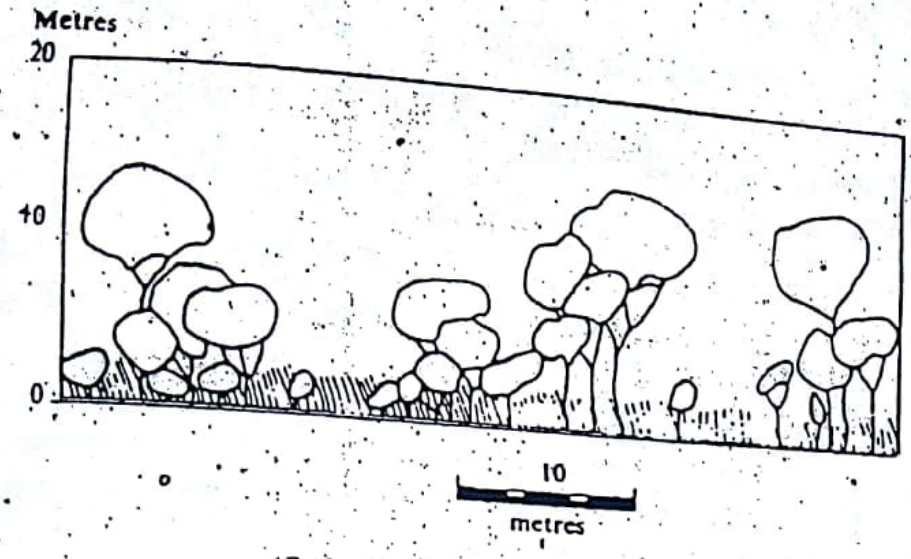
8.6 Physiognomy of the Savanna:

The West African savanna vegetation, is not as luxur the forest vegetation. Where woody species are present are not numerous and are not big. Their crowns are also and are not close enough for them to form a canopy o interior of the savanna.

8.7 Stratification of Savanna Plants

The trees of the woodland savannas correspond to Storey i.e. the lower tree stratum of the tropical forest range in height from 4.5 to 9 metres and a little above.

The shrubs are also few in number, and are scattere savanna habitats. Their crowns which are also narrow touch. The herb stratum is dominated by the grasses. T also many sedges and some lilies and amarylids. N dicot forb species are also represented in the herb stratu



(Strip dimension : 50m x 5m)

Fig. 8.1 Profile Diagram of a typical woodland and savanna

ORO FOREST RESERVE, NIGERIA

8.8 Savanna Flora

The common woody species and grass genera of the various zones within the savannas of West Africa, include the following:

8.8.1 Derived Savanna Zone

The woody species represented here include the drier and hardy forest tree species and some colonising savanna species typical of the Southern Guinea Savanna. Examples of the drier forest species are *Phyllanthus discoideus* and *Trema guineensis*. The colonising savanna species include *Daniellia oliveri*, *Hymenocardia acida* (a shrub) and *Lophira lanceolata*. The grass genera include *Andropogon*, *Pennisetum*, *Imperata* and *Ctenium*.

8.8.2 Southern Guinea Zone:

The woody savanna species listed under Derived Savanna are also present in this zone. Other peculiar species of this zone include *Terminalia glaucescens*, *Vitex doniana*, *Parkia clappertoniana* and *Butyrospermum paradoxum*. The grass genera include Andropogon, Cymbopogon and *Hyparrhenia*.

8.8.3 Northern Guinea Zone:

The woody species include, *Isoberlinia doka*, *Uapaca togoensis* and Combretum species. The grass genera include *Andropogon*, *Cymbopogon*, *Hyparrhenia* and *Setaria*.

8.8.4 Sudan Savanna

The woody species of this zone include *Acacia* species, *Balantites aegyptica*, *Combretum* species and *Hyphaena thebaica* – the doum palm with branched habit of growth. The grass genera include *Pennisetum*, *Aristida*, *Ctenium*, *Loudetia*, *Eragrostis* and *Cenchrus*.

8.8.5 Sahel Savanna

The woody species of the Sahel Savanna include *Acacia* species, *Commiphora africana*, *Grewia* species and *Leptadenia pyrotechnica*. The grass genera include *Aristida*, *Chloris* and *Cenchrus*.

8.9 Savanna Fauna:

The animals found in the West Africa savannas, include a variety of invertebrate groups such as insects and arachnids. Many of the insects belong to the insect Orders of Orthoptera (e.g. grasshoppers, crickets and locusts), Isoptera (the termites) and Hymenoptera (e.g. the true ants, bees and wasps). Many insect Orders are also represented. There are also many millipedes and centipedes. The lizards and snakes are very common among the reptiles. There are also many birds and mammals. The savanna birds include owls, vultures and ostriches. Others include guinea fowls and cattle egrets. The mammals found in the savannas include elephant, giraffe, antelope, gazelle, duicker, hare, lion, hyena and leopard.

8.10 Adaptations for Life in the Savannas:

The tropical savannas are characterized by many ecological hazards to life. These hazards include:

i. **The periodic drought,** characterized by lack of precipitated water, extreme temperature conditions, excessively windy environment and extreme solar insolation, especially in the savanna grasslands.
ii. **Poor conditions of savanna soils** which are shallow and non fertile. Many are particularly poor in primary nutrients of nitrogen, phosphorus and potassium
iii. **Dry season fires**
iv. **Seasonal scarcity of food and shelter** for the savanna animals.

8.10.1 Adaptations for Drought Resistance

Drought is either evaded, and in some of the savanna plants, resisted through the possession of a number of *Xeromorphic Features* by many plant species. Many of these xeromorphic features are of the external morphology, and are therefore, externally visible on the plant species possessing them. Others are anatomical and are only seen in the internal structures of different organs of the plants displaying them.

The more important of the **xeromorphic features of savanna plants** for combating drought include the following:

i. Reduction in the size of their leaves
ii. Leaf – rolling mechanisms
iii. Possession of thick cuticle over the epidermis of their leaves
iv. The leaves of many have a wide variety of substances secreted over their surfaces.
v. Reduction in the number of stomata present on their leaves
vi. Reduction in the size of the intercellular spaces within the tissues of the leaves.

8.10.2 Adaptations for the annual grass fires

i. Thick and corky barks of the savanna trees
ii. Thick and fire-resistant twigs
iii. Vigorous regeneration by the savanna plants by suckering and coppicing following the annual fires
iv. The annuals among the herbaceous plants, produce numerous fire-resistant seeds, which can remain buried in the soil for a long time and still retain their viability. They therefore germinate readily when the environmental conditions improve.
v. The perennials among the herbs, possess underground perennating organs such as tubers, bulbs, and rhizomes.
vi. A number of **physiological adaptations** are also noticeable in the savanna species.

These include:

i. Deciduous habit in the woody species. (Shedding of leaves at dry season.)
ii. Pre-rain flushing of most species.
iii. Pre-rain flowering of most species.

9 ARID LANDS

9.1 Introductory Remarks

Arid Lands are those terrestrial habitats with very little rainfall – a situation that arises as a result of very sparse rainfall (in terms of its total amount in the year) and very irregular nature of the little rainfall (in terms of distribution within the months of the year). Some arid lands are so described because the water in such habitats is in frozen form for most part of the year. This is the situation in the tundra.

Sparse rainfall — in term of yea
irregular rainfall — in term of mon

9.2 Types of Arid Lands

i. **Hot arid lands:** examples of which are the hot deserts and the semi-deserts. In Africa, the hot deserts include Sahara desert, while the Sahel Savanna is an example of a semi-desert.

ii. **Cold arid lands:** examples of which are the cold deserts also called tundra.

9.3 Characteristics of Arid Lands

Because of the widely differing characteristics of the hot and cold arid lands, it is therefore usual to describe their features separately. Described in outline below are the features of the tropical arid lands, which are of greater interest to us in the tropics.

Features of tropical arid lands

9.3.1 Climatic Features

i. Very little annual rainfall (usually below 250 millimetres per annum)

ii. Very irregular distribution (with very few months recording any rainfall in the year)

iii. The very sparce rainfall is seasonal, unpredictable, brief and local in extent. The rain is torrential and usually accompanied by thunderstorms;

iv. The day temperatures are usually very high and very low at night, thus resulting in very high diurnal (or daily) range of temperature;

v. The atmospheric humidity is usually very low and much below its saturation point;

vi. The sun shine in the day is usually intense and highly penetrating as a result of very little cloud cover in the atmosphere;

vii. The mean annual evaporation is very high and usually well above 2250mm;

viii. The environment is naturally windy because of the scanty vegetation cover.

9.3.2 Soil Features

Desert soils are sandy and brownish in colour. They are very low in organic matter content. Some have numerous stones and gravels.

9.3.3 The Plant Communities

The arid lands have sparse vegetation cover. The plants are widely scattered in each locality and are of low structure.

The vegetation is composed of some annuals and some perennial drought resistant plants. The bulk of these plants are xerophytes, examples of which include cacti, lichens, thorny shrubs and some grass species. Certain date palms occur around the oases. Other plants include: *Tamarix, Euphedra, Acacia* and *Bryophyllum.*

9.3.4 The Animals Communities

The animal species in arid lands are very few. They include some antelopes such as the addax found in the Sahara; rodents, some flightless birds, some insect species of the tenebrionid beetles and the praying mantis of the genus *Ereniaphila*.

9.4 Adaptations of the Plants in Arid Lands

i. They have ability to obtain water from great depths of the soil;

They are because of this feature known as **phreatophytes** which are plants that have deeply penetrating roots. The grasses have large root system that spread among a large volume of soil.

ii. The plants can endure severe and prolonged drought.

iii. They have morphological adaptations to cut transpiration to the barest minimum. Examples of these include reduced surface of the leaves and stems, with leaves reduced to scale – like structures and spines. Stomata are very few on the leaves. The stems of such plants which may completely lack leaves take up the function of photosynthesis in the plants e.g. *Euphorbia* spp;

iv. Some of the plants of arid lands have underground stems which remain alive even when the parts above ground die off.
v. Plants such as cacti, *Euphorbia species* and *Bryophyllum pinnatum* store a lot of water in their stems.
vi. Many of the plants of arid lands that are annual, perish immediately after the short rains but they would have produced numerous seeds which can survive the dry season.

A survey of these adaptations will reveal the fact that in the plants of arid lands, the adaptations they show include those for obtaining water, those for storing the water and those for preventing loss of water.

9.5 Adaptations of the Animals in Arid Lands

The adaptations of the arid land animals are mainly for conserving water and for avoiding excessive heat of these dry lands. The adaptations include:

i. Living in burrows by many. This enables them to conserve water in day time and avoid the very high day temperatures. Many of them only come out at night time to feed;
ii. Many, such as the desert rats use very little water and can go on food alone without water for quite some time. In fact, many of them feed only on dry seeds for a long period, using only metabolic water;
iii. Desert animals have sweat glands which are inactive. This enables them to remain functionless thereby preventing loss of water in form of sweat
iv. Many desert animals have pale colour which is homochromous with their habitat;
v. Besides reduction in sweat formation, desert animals also have reduced urine formation, hence they excrete only solid waste substance;
vi. The camel, a typical animal of dry land can go over a long distance and for several days without water;
vii. Some desert animals such as the reptiles have scales – an adaptation for reducing water loss.

A survey of the adaptations shown by the animals of arid lands reveals the fact that the adaptations include those for making minimum demand for water, those for storing the water

10. MICROHABITATS

10.1 Introductory Remarks

A microhabitat is a place or locality of small dimension, where small-sized organisms live. Microhabitats normally exist within "macrohabitats", and it is not unusual for one to be able to locate numerous microhabitats within a macrohabitat. It is also remarkable that many of the bigger plants within a macrohabitat, also provide suitable microhabitats for certain smaller organisms.

10.2 Features of Microhabitats

Microhabitats are habitats whose dimensions are smaller than those of the macrohabitats in which they occur. Like the macrohabitats, the microhabitats differ in size. They may be as small as a hole containing water on the trunk of a tree, or they may be as large as the forest canopy in a tropical rainforest habitat

Microhabitats as will also be expected, naturally support **micro-environments**. The environmental factors that determine the nature of these microenvironments, also differ from one microenvironment to another. These microenvironments however share a common feature which is the presence of microclimates in them. The microclimates show some minor variations in the operating climatic conditions of the macro - habitats concerned. These minor variations are seen in the climatic factors such as sunlight, rainfall, humidity, wind and temperature of the macrohabitat. The variations in the macroclimates of macrohabitats, result from the physical presence of some habitat factors. The habitat factors that are likely to give rise to microclimates in habitats, are the topography and vegetation of a habitat. In order to measure accurately microclimatic factors, very sensitive instruments are often required. These are necessary in order to detect minor variations occurring in microclimatic factors.

Another important environmental factor of micro-environments is the **substratum**. This as will be expected, is also of a small dimension. It also varies in nature. The substratum of a microhabitat may be soil, decaying debris or living tissue of a plant or of an animal. Because of their size, microhabitats usually harbour microorganisms and some plants and animals whose body size is very small.

10.3 Examples of Microhabitats

10.3.1 Forest Microhabitats

All terrestrial macrohabitats such as forests, savannas deserts, mountains, the less spectacular medium-sized habitats such as farmlands, rock outcrops, animal tracks (e.g. cattle track) and arboreal habitats, usually have numerous specialized microhabitats. In the terrestrial habitats, the microhabitats exist in the following locations: subterranean horizon (e.g. the substratum of the habitat), soil surface which is the floor of the habitat, the bark of trees and the crown of trees.

The forest macrohabitats are characterized by their possession of numerous microhabitats. This is so because the physical presence of many trees in the forest, has a tremendous moderating influence on the climatic conditions of the various strata of the forest. The crowns of the forest trees where they touch, form the canopy of the forest. The canopy intercepts sunlight, thus causing a slightly dark environment within the interior of the forest. Sunlight only gets to the forest floor in those places, where one or more trees contributing to the formation of the forest canopy have been felled. The forest trees also intercept rain drops so that only a relatively small amount of water, succeeds in getting to the forest floor. The trees also constitute an effective "wind break". This helps in decreasing the force of wind within the body of the forest. This accounts for the characteristic stillness of the atmosphere within the forest interior. The atmospheric humidity is also generally high – a situation resulting from the transpiration of the forest trees. The air temperature which as will be expected, is always less within the forest body than outside it, is even for most of the day.

In addition to the microclimatic conditions resulting directly from the physical presence of trees in the forest, fallen logs of wood and forest floor litter of leaves and other decaying debris create sheltered and moister habitats for numerous microorganisms. In the subterranean horizon of the forest especially within the top soil, there exists a large amount of humus. This locality within the forest is also very damp and with moderate and even temperature. It is therefore a natural microhabitat where numerous soil bacteria, soil fungi actinomycetes, a few specialized protozoans and algae earthworms, millipedes, termites, spiders and many insects permanently reside. In addition, the soil microhabitat of the forest, is also a temporary abode for some soil fauna such

certain insects, reptiles, and some rodents. These soil organisms show some preference for the type of soil and the part of the soil in which they live. The factors influencing these and those influencing the population of these organisms in a soil include the amount of humus in the soil, the soil water content, its oxygen content and its hydrogen-ion and mineral salt concentrations.

The forest floor is usually littered by fallen leaves, twigs, dead logs of wood and dead bodies of animals, which are at various stages of decay. In the microhabitats created by these decaying materials, there occur numerous ants, millipedes, beetles, termites, snails woodborers, spiders, grasshoppers and snakes. The plants of the forest floor include mosses, fungi, and a few specialized soil algae.

The bark of forest trees, are also special microhabitats where there are numerous beetles, epiphytes such as the fern *Platycerium stemaria*, the filmy fern *Hymenophyllum*, orchids and figs. Water patches held with the hollows formed by tree braches are also favourable microhabitats for the larvae of mosquitoes. The tree crowns are also inhabited by some lizards, snakes, tree frogs, birds and arboreal mammals like squirrel and tree *hyrax*.

10.3.2 Savanna Microhabitats

There are fewer microhabitats in the savanna than within the forest. This is because the existing habitat conditions within the savanna are not as favourable to living organisms (especially microorganisms), as those of the forest. The subterranean horizon and the savanna floor are however the abode of some plants and animals. In the tropical savannas, there are numerous **termite mounds**, which vary in shapes and sizes. These termite mounds are also microhabitats with their own microclimatic conditions. In both the forest and the savanna, wherever there is a swamp, specialized flora and fauna are seen inhabiting them.

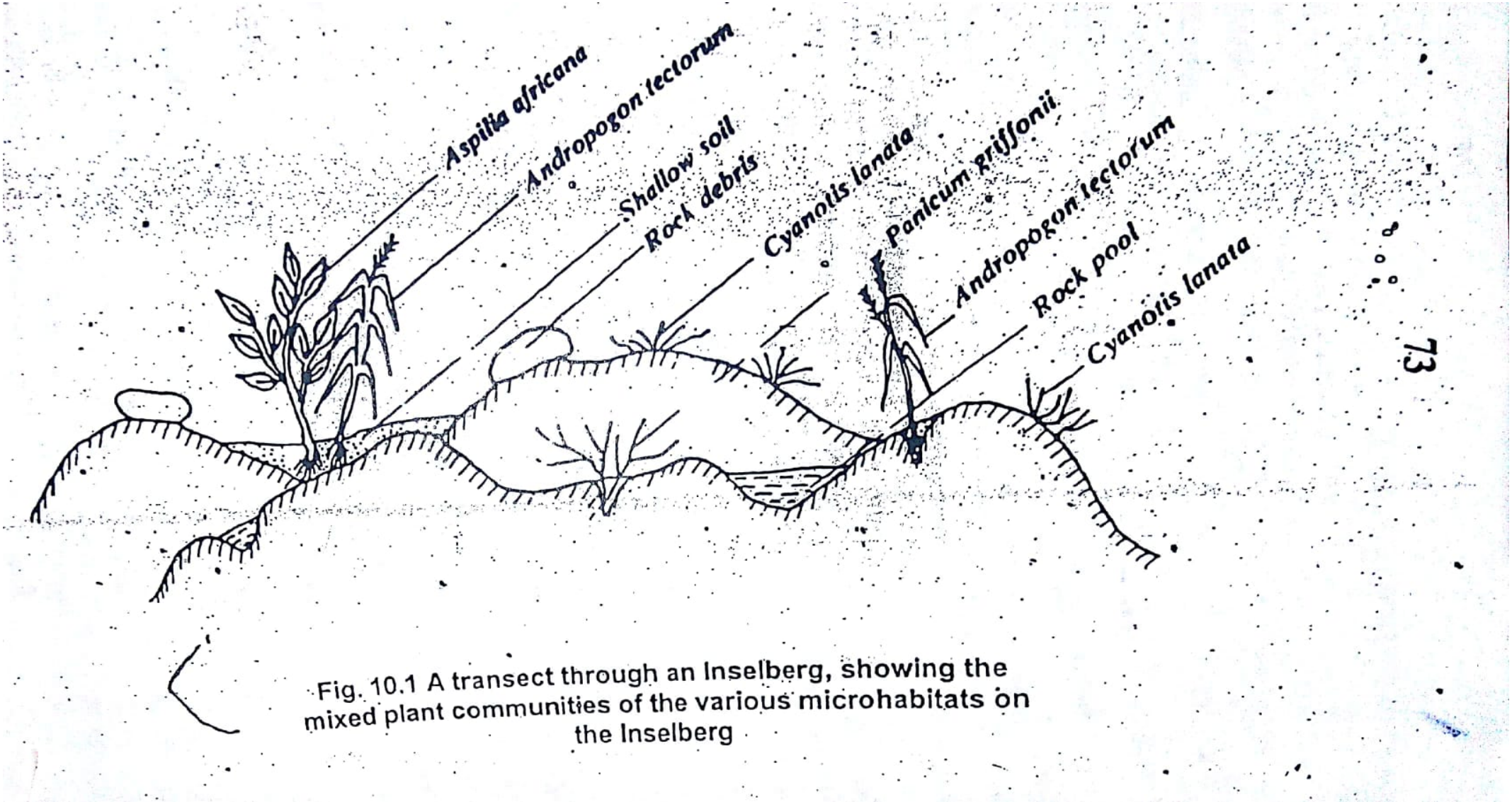


Fig. 10.1 A transect through an Inselberg, showing the mixed plant communities of the various microhabitats on the Inselberg

10.3.3 Microhabitats of rock outcrops

Rock outcrops have a number of places on them which have peculiar microclimatic conditions. Such places are also microhabitats. Some peculiar microorganisms live in these places. In a typical rock outcrop, the microhabitats are seen on the **exposed rock surfaces**, in the **small cracks, crevices** and **hollow places** on the rock outcrops, on the larger crevices, and in the **sheltered localities** on the rock outcrops. The exposed rock surfaces are characterized by extremely unfavourable climatic conditions. The rock surfaces are extremely hot in the day and are very cold in the night. There is always a rapid runoff of water on the rock surface whenever there is rain and there is very little of the water retained. In addition to these, there is very little soil on the rock surfaces. These habitat conditions characteristic of the exposed rock surfaces, cannot support plants with big life forms which make much demand on those factors of their habitat which they require. However, the exposed rock surfaces serve as the abode of low forms of plant life, such as bacteria, blue green algae and some species of lichens. The small crevices and cracks, help in retaining some water in the crevices. The microhabitats formed by the crevices and cracks have therefore, more favourable environments than those formed by the exposed rock surfaces. The crevices and cracks, harbour in them small animals. In the larger crevices with a larger amount of soil and milder climatic conditions, there are usually more plants which are also of bigger life forms. The **stagnant pools** on exposed rock surfaces, also serve as the habitats of the larvae and pupae of insects like mosquitoes and dragon flies, and the larval stages of toad. Where a vegetation of some sort occurs near the rock outcrops, some animals such as insects, spiders, lizards, snakes and some mammals, may occasionally visit the rock outcrops.

10.3.4 Microhabitats of trees

The organisms of bigger life forms in a macrohabitat, especially the trees, may also serve as habitats for a number of microorganisms and plants and animals of smaller life forms such as **epiphytes** and **epizoans**. Those organisms inhabiting trees, occupy different different locations on such trees. Those places inhabited by these organisms, normally have local microclimatic conditions and some other peculiar habitat factors related to soil factors.

The microhabitats recognizable on a tree, are seen in s places as the **roots of the tree** which constitute subtrerranean portion of the tree; the **bark of the tree**, **hollows** and **cracks** on a tree trunk which may be filled water or decaying organic debris.

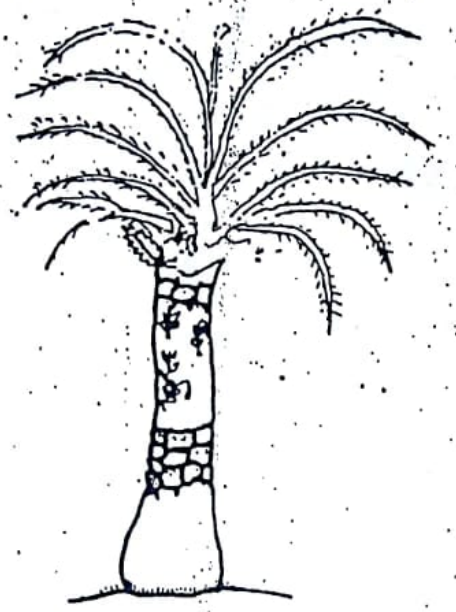


Fig. 10.2a A Palm Tree - an example of an arboreal habitat

Other places include the branches and other parts of a tree f form the **crown of the tree**. These microhabitats recognizable palm trees and many forest and savanna trees, usually ca specialized fauna and flora.

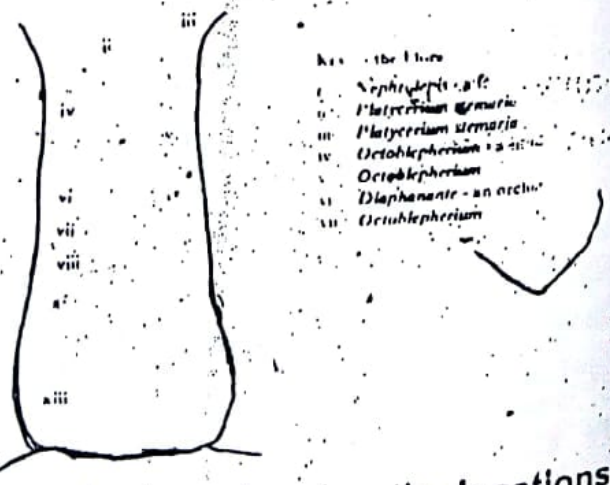


Fig. 10.2b The palm tree showing the locations of some of its epiphytes

10.4 Why organisms prefer staying in microhabitats

As will normally be expected, plants and animals naturally occupy habitats of their preference. The microhabitats which because of their special local microclimatic factors, are the abode of numerous microflora and fauna, other plants and animals of small life forms, are preferred because these microhabitats provide the basic needs of living organisms. These needs include **shelter** from the inclemencies of the weather, **food** for growth and for the maintenance of the body in a healthy condition and for providing the energy necessary for other life processes. In the case of the animals, the microhabitats also offer them **protection** from their natural enemies. In addition, the local climatic and edaphic conditions in the microhabitats, are suitable for carrying out the normal life processes. The organisms living in the microhabitats, are therefore able to **reproduce** in these habitats, thereby leaving behind some offspring when they die in the habitats.

Fig. 10.3a Common epiphytes of arboreal habitats

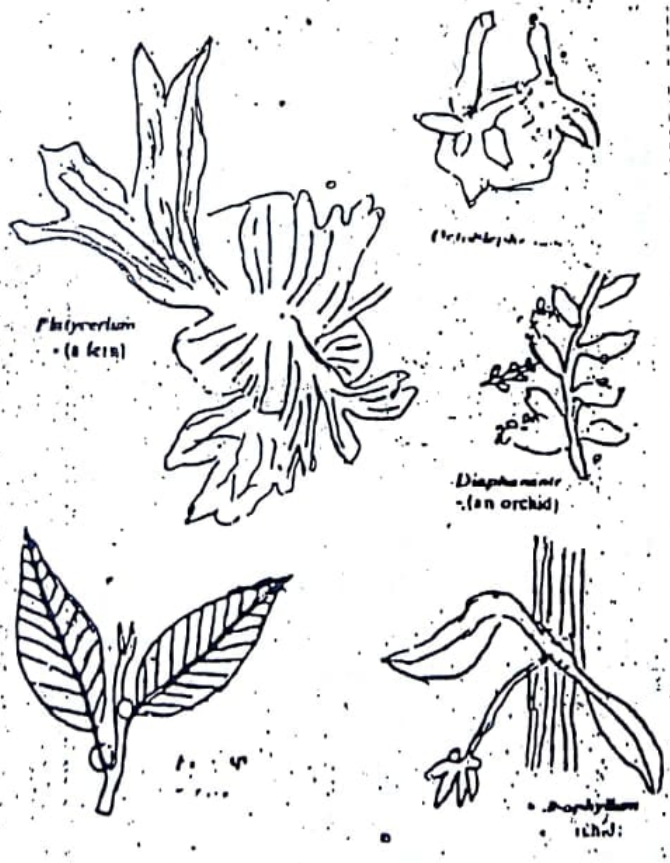


Fig. 10.3b Common epiphytes of arboreal habitats

11. POPULATION STUDIES

11.1 Introductory Remarks

Population Studies in ecology, deal with the study of populations of plant and animals species in their natural environments. In Population Studies, one is interested in how populous certain species are in a place and the factors that regulate the sizes of populations.

11.2 Terms in Population Ecology

Species is the term for genetically related organisms capable of interbreeding.

The term **Population** or **Species Population** in the biological sense, means a group of organisms belonging to the same species inhabiting the same place. The individuals of a species population, are genetically related. They are also reproductively isolated from the individuals of another population belonging to a different species. They are however capable of exchanging genetic materials during sexual reproduction among themselves, and with individuals of other populations belonging to the same species with them. A population is characterized by features such as population density, population pressure, age distribution, sex distribution, birth rate, death rate, reproductive potential and population growth.

Apart from these terms, a number of others are important in population studies. These other terms include the following: Population size, Biotic potential, Environmental resistance, Habitat resistance, Biotic resistance and Carrying capacity. Others include Natality, Natality rate, Mortality, Mortality rate, Fecundity, Migration, Immigration, Emigration, Recruitment, Open and closed populations, Sample, Sampling, Density dependent factors. These terms constitute the active vocabulary of population studies and must therefore be learnt.

11.3 The Assessment of the Sizes Of Populations

The techniques used for assessing the sizes of different populations of living organisms are not the same. A number of considerations influence one in one's choice of procedure for assessing the size of the population of a species of organisms. These include:

i. The abundance of individuals of the species whose census is being taken based on one's previous idea of this
ii. The nature of the habitat of the species

iii. The size of the body of the individual organisms
iv. The nature of the species, that is, whether it is dangerous or not, whether it is active in its movement or stationary.

The methods employed in assessing the sizes of populations can be divided into two broad groups: These are the *Direct* and the *Indirect Methods.*

Direct Method

This involves carrying out a total count of all the individuals of the species whose population size is being assessed.

Indirect Methods

i. **Quadrat Sampling**)
ii. **Transect Sampling**) Formula: $N = \frac{n}{a} \times A$, where

N is the population size of the species
A is the total population area
a is the average of the number of sample plots
n is the average of the number of individuals in the sample plot

iii. **Population Sampling in liquid media**

Formula: $N = \frac{n}{v} \times V$, where

N = Total population size
V = Total population Volume
v = Average of the volume sampled
n = Average of the number of individuals in the sample volumes

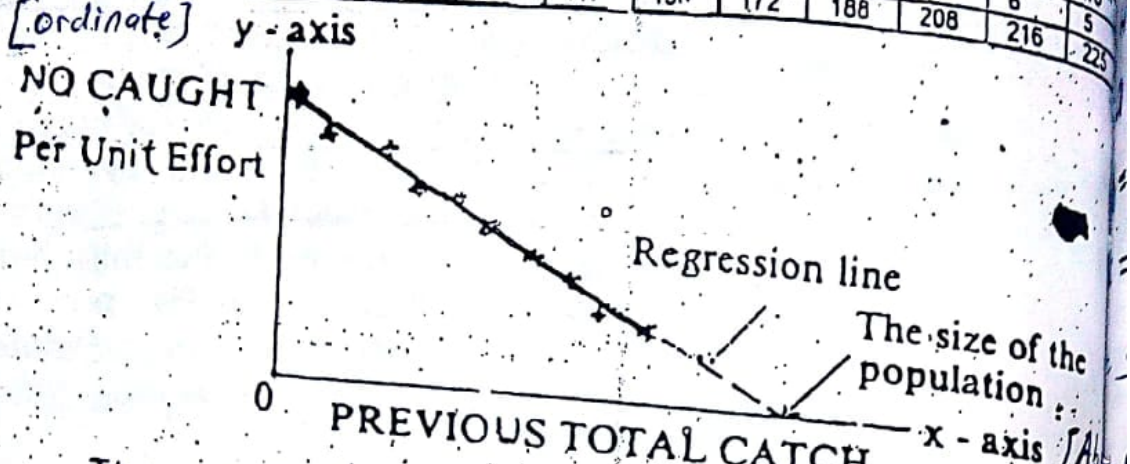
iv. **The Regression Method:**

This method which is also known as **Removal Sampling Method,** involves the removal of the individuals of a population from their habitat without replacing them back into the habitat. A note is taken of the number caught per unit effort employed. Enough time is allowed for the remaining individuals to redistribute themselves in the habitat before the next removal of some other members of the population. This procedure is repeated for about 10 times, and a graph is drawn with the data obtained.

In the graph, the number removed at each period of removal, is made the **Ordinate** i.e. the y-axis, while the previous total removed becomes the **Abscissa** i.e. the **x-axis.** The

regression line is then extrapolated to intercept the x-axis. The point of intercept of the regression line on the x-axis will give a value, which is the approximate estimate of the population size of the species concerned in that habitat.

REMOVAL PERIOD	1ST	2ND	3RD	4TH	5TH	6TH	7TH	8TH	9TH	10TH
NO CAUGHT	42	40	35	33	22	16	15	13	6	5
PREVIOUS TOTAL CATCH	0	42	82	117	150	172	188	208	216	225



The assumptions underlying the use of the regression method include the following:

i. That the population size is not affected by the effects of migration of mortality
ii. That the catchability of the individuals of the species is constant throughout the period of investigation
iii. That the number of times the individuals are removed within each period of sampling, is constant for the period of investigation.

vi. **Mark and Recapture Method**

Mark and Recapture method also known as **Marking-recapture method** is another indirect method of estimating the sizes of populations of animals. It is suitable for estimating the sizes of populations of certain species of animals such as insects, crustaceans, fish, amphibians, reptiles, birds and mammals. The use of this method involves catching a large number of individuals of a population under study, and marking each of these captured individuals. These marked individuals are then released into the population and allowed enough time for redistribution among other members of the population. Later on, a large proportion of the population, is again captured. These individuals captured on the 2nd occasion, include both the marked and unmarked members of the populations. The size of the population is then estimated from the equation:

$$N = \frac{a \times b}{c}$$

Where N = Size of the population
a = No of individuals marked on the first occasion
b = Total no. of individuals captured on the second occasion.
c = No. of individuals marked out of the lot captured on the 2nd occasion

The Mark –and-Recapture method, is based on the following assumptions:

i. That the marked individuals redistribute themselves uniformly throughout the population within the period allowed for this before recapture.
ii. That the marked individuals do not lose the identification marks they carry on them throughout the period of investigation, so that they can still be recognized on recapture.
iii. That there is no immigration of some individuals of the same species from another population into the population under study
iv. That the method of marking does not lead to mortality or enhance this in the marked members
v. That both the marked and unmarked members of the populations are susceptible to capture in the same degree.

11.4 Population growth and population growth curves

Growth is one of the characteristics of a species population. It is one of the dynamic attributes of a population. Growth in population leads to increase the number of individuals making up the population. The rate at which this occurs is termed **Rate of Growth** of the population. This is usually expressed by the relationship below:

$$\text{Rate of Growth} = \frac{\text{Increase in Population}}{\text{Time}}$$

Population Growth Curves are mathematical or graphical expressions of the growth pattern in a species population. A typical population growth curve can be produced by plotting the Figure for the population size of a species on the y-axis (i.e. vertical axis), against the Time within which the growth in population occurs. Time is usually on the x-axis (i.e. the horizontal axis).

Two main types of population growth curves are recognized on the basis of their general features. These are the **J-Shaped Curves** and the **S-Shaped Curves.**

The **J-Shaped Growth Curve** is characteristic of microscopic organisms such as bacteria, yeast and *Amoeba*. These organisms can when provided with all environmental factors necessary for growth, increase at fantastic rates. They therefore, theoretically show **exponential rate of growth** characterized by increase in the rate of increase of growth..

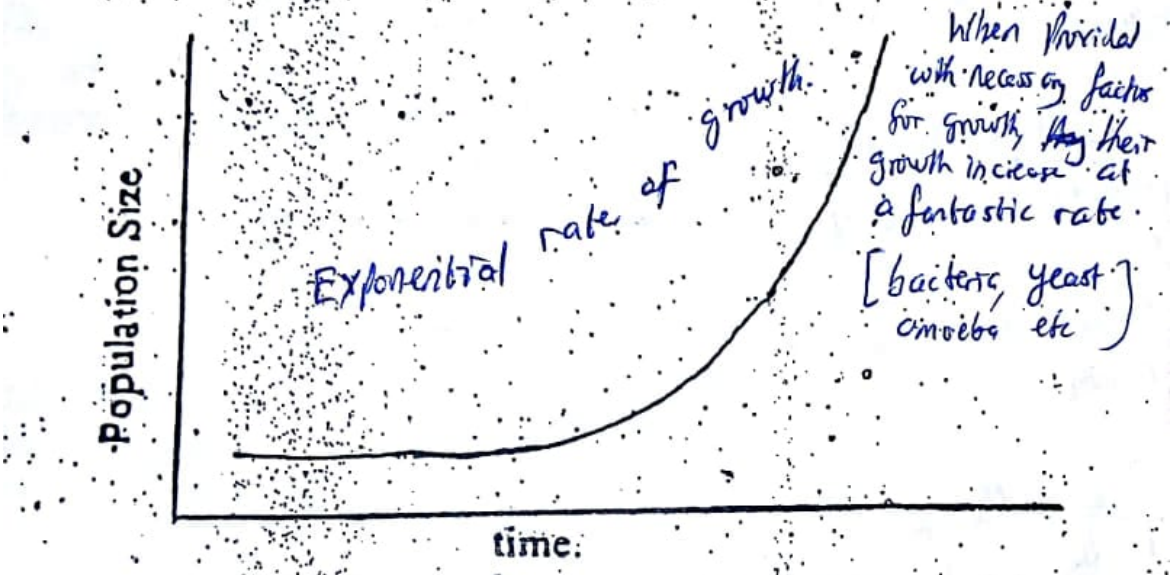


Figure 11.1 J-Shaped Growth Curve

The J-Shaped type of growth curve is not common. For most other organisms therefore, the more usual form of Population Growth Curves are the S-Shaped curves. These are also known by the terms **Sigmoid Growth Curves** and **Logistic Growth Curves**.

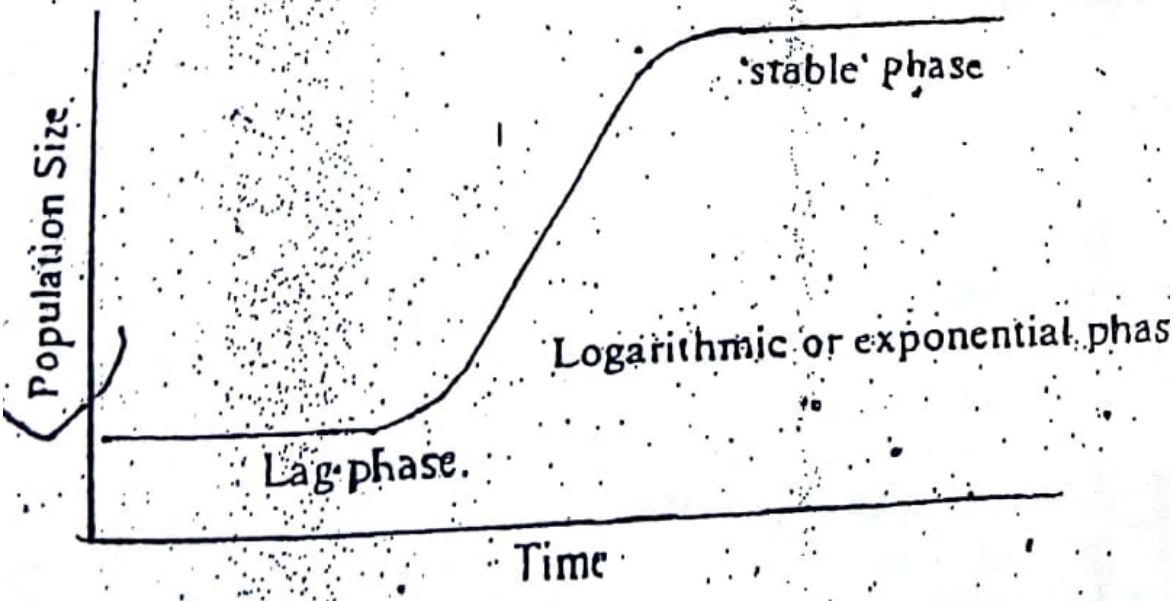


Figure 11.2 S-Shaped Growth Curve

The **S-Shaped Growth Curve** is characterized by 3 main phases termed **Lag phase, Logarithmic or Exponential-phase** and the **Stable phase**. The lag phase is the taking off phase of growth. It is characterized by little or no growth. It is in actual fact preparatory for actual growth.

The logarithmic phase is so called because a straight line would be produced if the data plotted were plotted logarithmically. This phase marks the period of rapid growth.

The *Stable* phase is the period at which there is a slowing down of the rate of growth, such that the population size remains constant and neither increases nor decreases to an appreciable extent.

11.5 Factors affecting Sizes of Populations

The factors affecting the sizes of species populations influence these by either increasing or decreasing birth rate (i.e. natality), or by increasing or decreasing death rate (i.e. mortality) in the species population concerned. Many of these factors are **innate factors**, that is, they are **hereditary factors**, while others are **ecological factors** having to do with the nature of the environmental conditions. The innate factors are also factors of the biotic potential of the population, while the ecological factors constitute the factors of environmental resistance within the population. These two main groups of factors operate as interacting forces in influencing the sizes of the populations of organisms.

The factors of the biotic potential influencing the sizes of populations include:

i. Number of gamete, i.e. eggs and sperms produced by the males and females of the species.
ii. The extent of the success of fertilization i.e. the external and internal conditions surrounding the fertilization process.
iii. The size of the uterus.
iv. The length of time required for the embryo to mature.
v. The amount of care received by the young from the parent.
vi. The length of time required by a species to reach reproductive age.

The **factors of environmental resistance** influencing the sizes of populations include:

i. **Diseases**, which may be infectious, examples of which include influenza, pneumonia, tuberculosis and intestinal diseases. Others may be non-infectious. These may include heart attack, cancer, cerebral haemorhage, haemophilia,

hypertension, and others. A disease-infected parent has le
capacity to reproduce than a healthy parent.

ii. **Predation**

Predation affects the population when the reproductiv
among the females are removed by predators.

iii. **Competition**

Competition can be for space, nutriments and reproductive
mates in animals populations. It can result in psychological
disorders, malfunctioning of the endocrinal system, reduce
mating and death of young ones and weaklings. Other
results include lowering of the rate of reproduction, reductio
in maternal care, cannibalism, and fighting, which may be
climaxed by war as is seen in human populations.
Competition may also result in emigration of some of the
members of a population to another place

iv. **Unfavourable climatic conditions**

v. **Physical accidents**

vi. The pests of the species population.

Factors Affecting Size of Population

Hereditary / Innate factor :— This is the factor that

12. PLANT SUCCESSIONS

12.1 Introduction

Plant succession is one of the main types of changes communities undergo with passage of time. The changes in communities are themselves, part of the dynamic attributes used in characterizing ecosystems. The changes in animal communities depend to a great extent, on the changes in the plant communities with which these animals are closely associated. Hence the greater emphasis placed on the changes involving plant communities in studies on successional changes.

A number of different types of changes have been recorded for vegetations. Some of these changes are predictable, others are not. Some of them are short-term changes, while others are long-term changes. Some of the more important changes that have been recorded for vegetations, include successional changes, regressional changes, seasonal changes and cyclic changes. By far the most important and probably the most widely investigated of the community dynamics, are the successional changes occurring in plant communities.

Succession is a long-term predictable series of changes occurring along one direction in the community of a locality. Succession is one of those ecological phenomena in which many ecological principles can be demonstrated. It is also much laden with terms and concepts. Among the most important of the terms that need be mastered in order to fully grasp the principles behind succession are the following:

- Sere
- Hydrosere
- Halosere
- Xerosere
- Psammosere
- Pioneers
- Developmental communities
- Climax communities
- Autogenic succession
- Allogenic succession
- Seral community
- Bare areas
- Primary bare areas
- Secondary bare areas
- Primary succession
- Secondary succession
- Prisere
- Subsere

12.2 Notes on aspects of the Phenomenon of Succession

12.2.1 Primary Succession

Primary succession is a type of succession which starts on primary bare places such as rock surfaces and sand masses.

The vegetation development then progresses from this pioneer stage, through series of developmental communities, until the climax community, which is in equilibrium with the ecological conditions of the locality is attained.

The factors that can give rise to primary bare surfaces include the following:

i. Erosion of a place by erosive agents such as flowing water, wind and glacier
ii. Deposition of solid materials, sand dunes or volcanic ash in a place, is completely buried under sediments, and the bare surface of deposited materials is exposed to the atmosphere.
iii. Emergence of bare surface of newly outcropping rocks and drying up of a body of water,
iv. Lightning accompanied by terrific thunderstorms, which result in huge conflagration that burns off the existing community of a place.
v. Strong winds in the form of hurricanes and tornado, which uproot existing vegetation and lead to their being buried under sediments.
vi. Extreme drought
vii. Prolonged agricultural, mining and construction activities by man.

12.2.2 Secondary Succession

Secondary succession is another type of succession in which, the succession is initiated on a surface which has a community existing on it before. This community is later destroyed and a new one is now developed in its place. Secondary successions are usually more rapid, and therefore take less number of years before the climax community develops in the locality. This is because the succession takes advantage of the propagules of the previously existing community in initiating the development of the earliest community in the secondary succession. The types of succession seen on abandoned farm land, overgrazed rangeland, and that on an abandoned cattle holding ground, etc. are all secondary successions.

12.2.3 Series of plant communities in a succession

The plants that constitute the first group of plant community in a succession, are known as **Pioneers or Colonisers** or **Colonists**. These are usually small plants, whose ecological

requirements in form of space, substratum, nutriments, etc. are minimal. They are also highly adapted and they have the capacity to establish and grow on bare surfaces. The pioneers are also important for their role in ameliorating the ecological conditions of the colonized locality thereby making it more conducive to other series of communities. The pioneers are usually succeeded by the developmental communities.

The **Developmental Communities** are also known as **Developmental or Intermediate or Transistory Communities.** The developmentals constitute a series of communities, with each succeeding stage being more complex than the stage it replaces.

The developmentals usually include herbaceous plants and some shrubs. The developmental communities are usually less open than the pioneering communities. They are also more diverse species-wise, and with larger number of individuals per species.

The Climax Community is the community that terminates the series of stages in a plant succession. It is the community that attains a state of equilibrium with the ecological conditions operating within the locality. Climax communities are the most complex communities in seres. They are also characterized by greater species diversity, greater species population density, and bigger life forms.

12.2.4 Processes involved in ecological successions.

The processes occurring in plant successions include nudation, migration or colonization, ecesis, reaction and stabilization.

Nudation is the term for describing the activities that initiate a succession by giving rise to bare areas.

Migration is the process that follows nudation. All activities involved in the colonization of a bare area by the pioneering community, come under the term **migration**.

Ecesis is the term for the activities for the establishment, growth and development of the plant species that have successfully migrated into the locality, where plant succession is taking place. Ecesis leads to aggregation of the individuals of various species, which itself results in the individuals competing for material resources within the locality.

Reaction is the term for the processes and activities carried out by the communities of the various stages of succession.

These reactions of the various stages of succession, result in the orderly replacement of one community by another.

Stabilization is the term for the process that terminates a succession. This is the process occurring at a time when the climax community is existing in the locality. It is the process characteristic of the stable community.

12.3 Plant succession in selected habitats.

12.3.1 The stages of plant communities in a hydrosere taking place in a pond, may include the following:

Stage 1: Freely floating hydrophytes,
Examples: Phytoplankton and floating macrophytes such as *Pistia, Lemna, Salvinia, Wolfia etc.*
Stage 2: Submerged and Rooted hydrophytes,
Examples: *Elodea, Ceratophyllum, Potamogeton etc.*
Stage 3: Rooted hydrophytes with floating leaves,
Example: *Nymphaea*
Stage 4: Woody plants growing on water-logged soil
Stage 5: Climax forest vegetation

12.3.2 The stages of plant communities taking place on a bare rock surface, may include the following:

Stage 1: Some species of terrestrial algae and autotrophic bacteria
Stage 2: Crustose lichens
Stage 3: Foliose lichens
Stage 4: Fruitcose lichens
Stage 5: Mosses
Stage 6: Herbaceous plants. These may include sedges and broad-leaves weeds
Examples include *Afrotrilepis pilosa* and *Cyanotis lanata*, and grasses such as *Ctenium elegans, Andropogon linearis* and *Loudetia arundinaceae.*
Stage 7: Shrubby species
Stage 8: Climax forest vegetation

12.3.3 The stages of plant communities that feature in a succession occurring on an abandoned farmland.

Stage 1: Annual weeds
Stage 2: Grass species (with annual grasses coming before biennials, and these before perennial grasses)
Stage 3: Shrubby species
Stage 4: Climax forest vegetation

Ecological successions are in general usually characterized by increasing trends in the features of certain attributes as they progress from younger or earlier stages to mature or latter stages. These attributes include species diversity, size of individuals, biomass of individuals, gross production within the community, life cycle of species, community structure and ecosystem stability.

13. BIOTIC INTERACTIONS IN NATURAL ECOSYSTEMS

13.1 Introductory

Interactions between the various components of a habitat, constitute a major group within the fundamental characteristics of an ecosystem. Three broad categories of such interactions are recognized. These include those interactions resulting from the influences of the abiotic (i.e. physical) factors of the habitat on the biotic components of the habitat. Such interactions are collectively known as **Actions.** There are some other interactions that are counter influences or reciprocal actions of the living components on the non-living components of the habitat. This group of interactions is known by the term **Reactions.** The third category of interactions involves those interactions occurring between the various groups of living organisms within the ecosystem. The interactions in this category are known as **Coactions.** Other names by which this category of interactions are known are **Biotic Interactions** and **Biological Interrelationships.**

Biotic interactions include all the various ways in which one species of organism influences by its ecological status and its peculiar mode of life, another species of organism inhabiting the same environment with it. These interactions have effects on the functioning of the ecosystem within which they are taking place. The organisms inhabiting the same environment, naturally interact in the process of obtaining their material and other physiologically essential requirements from within the environment. Such requirements include food, home, shelter, anchoring substratum, physical support, respiratory oxygen and certain activities in the process of reproduction, examples of which are pollination and dispersal. Some of the interactions are beneficial to both species involved, some others to one of the two species and some others still, are known to be harmful to either both or one of the species involved. The biotic interactions that may be of interest of the level of students for which this text is designed include **symbiosis, predation, parasitism, competition** and **epiphytism.** Of equal importance are **saprophytism** and **scavenging** which are special modes of feeding.

13.2 Symbiosis:

Symbiosis is a collective term for those forms of interactions involving living organisms in which no harm is suffered by any of the species involved. The forms of biotic interactions under symbiosis are *mutualism*, *protocooperation* and *commensalism*.

13.2.1 Mutualism is the term for any biotic interaction between two species of organisms, in which both species are benefiting and without any of them suffering any harm as a result of the interaction. Examples of mutualism are seen in green *Hydra*, and the algal species which colours this species of *Hydra* green, in the legumes and the symbiotic bacteria of the genus *Rhizobium* inhabiting their root nodules and in the termites and the symbiotic protozoan inhabiting their gut.

13.2.2 Protocooperation: is a form of symbiosis which like mutualism is beneficial to both organisms involved, but unlike mutualism, is not obligatory since the organisms involved can exist without the association. Examples include the association between cattle and cattle egret and that between flowering plants and their animals pollinators and dispersal agents.

13.2.3 Commensalism: is another form of symbiosis in which only one species benefits with the other with which it is associated, neither benefiting nor suffering any harm as a direct result of the association. Some familiar examples of commensalism include that of epiphytes and the host trees on whose trunks these epiphytes live, and the association between the microscopic animal known as *Opalina* and the toads, inside whose intestine these animals live and obtain their food.

13.3 Predation:

Predation is another form of biotic interaction between two species of organisms, in which one species – the *Predator* kills and feeds on the other, its *Prey*. Examples of predation can be seen in the interaction between carnivores such as the lion and its prey – the antelope, and the predatory interaction involving some predatory birds such as hawks and their preys, examples of which are the domestic fowls. Others include the association between some carnivorous plants such as *Drosera* and their insect and crustacean preys.

13.4 Parasitism:

Parasitism like predation, is a hostile type of bio interaction, in which one of the species involved benefits at t expense of the other with which it is associated. In parasitism the species benefitting from the interaction is known as th *parasite* and the one which suffers some harm as a direct resu of the interaction is known as the *host*. A fundamental differenc between predation and parasitism is the fact that parasitism unlike predation, does not result in the death of the hos Examples of parasitism include the association between ma and the animal parasite known as tape worm. (but gradual

13.5 Competition:

Competition is a form of biotic interaction which is a direc result of the inadequacy or non-availability of some or all the requirements of the individuals of the species of organisms inhabiting the same place. The requirements of plants that are important in this respect include water, light, biologically essential mineral nutrients, oxygen, carbon dioxide and living space. The requirements of animals whose non-availability or inadequate supply can lead to competition include space, reproductive mate and nutriments.

Competition can occur between organisms of the same species and between organisms of different species. The former type is usually referred to as *Intra Specific Competition*, while the latter is known as *Inter Specific Competition*.

Competition is peculiar among all biotic interactions in that it usually results in some measures of harm being suffered by all the individuals of the species of organisms involved in the interaction. The individuals involved may however differ in the extent to which they suffer and in the form of loss suffered by them. Competition brings harms/sufferences to organism but the sufferings differ in respect to difference in the species.

13.6 Saprophytism:

Saprophytism is strictly speaking not a form of biotic interaction, rather it is a **mode of feeding** or a **mode of life** seen in certain groups of plants which do not have chlorophyll and can therefore not prepare their food in the same way in which green plants prepare theirs. They therefore depend on the dead tissues of other organisms for their food. The fungi and some species of bacteria, are the most important examples of **saprophytes**. These organisms actually settle on the dead tissues of plants and animals of their choice, and obtain their nutriments from

depends on dead & decay substance of other organism

these. They are also able to colonize such dead tissues and bring about their decay and decomposition through the secretion of certain enzymes on these dead or non-living organic materials. These enzymes perform extra-cellular digestion on these materials and the end-products of digestion absorbed into the tissue of the saprophytes.

Saprophytes are beneficial to man in helping to clear off organic debris from the surface of the earth. They are also useful in the ecosystem where they are found, in helping in the process of **mineralization** of dead plant and animal materials. The minerals released in this process can again become available for plant use. They may on the other hand constitute a nuisance to man. This is because many of them spoil the wood of valuable timbers by staining them. They also cause a reduction in the tensile strength of the materials made from these timbers. They by using part of the materials of the wood, reduce its fuel value. Some species of microscopic animals also feed in the same manner in which the saprophytes feed. This group of animals is collectively known as **Saprozoites**.

13.7 Scavenging

Scavenging is like saprophytism **a peculiar mode of feeding** in which some animals feed on the dead tissues of other animals. These animals are holozoic, which implies that they feed in the typical way in which animals feed, but unlike most other animals, the scavengers feed on the remains of other animals. They are therefore different from the saprozoites not only in their body size, but also in the fact that unlike the saprozoites which take to extracellular digestion, the scavengers like most species of animals digest the food materials they ingest in their gut. A familiar example of the scavenger is the **vulture** – a species of bird commonly seen around abatoirs and carcasses of animals in town and villages in the more-northern (savanna) parts of most West African countries.

The savengers are also of economic importance in helping to effect a quick clearance of the dead tissues of animals, which apart from constituting eye-sore would have made the surrounding filthy and unwholesome for man.

13.8 Epiphytism:

Epiphytism is a form of commensalism involving two species of plants in which one of the species serves as the host to the other known as the *Epiphyte.* The host plant only provides

the substratum in form of its bark, onto which the epiphyte which is usually smaller than the host plant is anchored. The host plant also provides a much-needed shade for the epiphyte. The host plant neither benefits nor suffers any form of harm as a direct result of its association with the epiphyte.

There are also some animal equivalents of the epiphytes. These animals which are mostly microscopic in size, are known as **Epizoites.**

EPIPHYTISM

The [illegible] the Host Providing

14. ENERGY AND MATERIAL RELATIONS OF ORGANISMS

14.1 Energy Concept:

Energy which is usually defined as the capacity to do work, is needed by all living organisms for the physiological activities in which their body is engaged. As a result of the importance of energy to living organisms, all functioning ecosystems must have a regular supply of energy in order to sustain them in a dynamic state.

Energy unlike the material requirements of living organisms that are ever present as part of the abiotic components of an ecosystem, has to be supplied to the ecosystem from outside it. The ultimate source of the **Sunlight**. Sunlight supplies **Solar Energy** into an ecosystem. The solar energy is usually trapped by the green plants in the ecosystem. These plants convert the solar energy into **chemical energy** through a series of activities involved in the process of photosynthesis. The chemical energy or organic food materials is now available for the use of the plants involved, and the use of other living organisms in the ecosystem in the form of the carbohydrate, starch. Part of the carbohydrate may be utilized in that form and the remaining converted into other organic food substances such as proteins and fats.

The green plants which prepare organic food that is utilized by all the organisms in an ecosystem, constitute the **Primary Producers** of the ecosystem. All other organisms within the ecosystem that are not capable of trapping solar energy and as such cannot prepare their own organic food, depend directly or indirectly on the organisms that are nutritionally dependent on the green plants are collectively known as **Consumers.**

Those plants and animals that can obtain their food supply exclusively by feeding directly on the green plants, i.e., the primary producers, are known as **Primary Consumers.** Examples of the organisms in this group are the herbivores such as cattle, goat, sheep, elephant and rats, and those plant-eating parasites such as the root parasite (*Loranthus*), and the stem parasite dodder. Those organisms that feed exclusively on animals are known as **Secondary Consumers.** They include some plant species such as the insectivorous plants and the carnivorous animals such as lion, dog, cat and some species of birds like hawks, fish species and snakes. There are also some other carnivores that feed on other carnivores. These **Top-Level**

Carnivores (as they are often called), constitute the **Terti**
Consumers.

Those microscopic organisms that feed exclusively
saprophytes and saprozoites (i.e. on the dead tissues of or
living plants and animals), and which in the process of feedi
effect the decomposition of the tissues on which they
feeding, are known as **Decomposers.**

14.2 Concept of Energy Transfer

The solar energy which enters an ecosystem from sunligh
is trapped and fixed into utilizable organic materials by the gree
plants. These primary producers are said to be in a **Lowe**
Trophic Level. This is the level nearest to the source of energ
The energy which on chemical transformation becomes chemic
energy, passes from the green plants to other biotic component
of the ecosystem which are said to occur at **Higher Tropi**
Levels. This one-route pattern of movement of energy in a
ecosystem, is usually described as **Energy Flow.**

The flow of the energy in any ecosystem is usually along a
single pathway, which is usually described as a **Unidirectional**
Pathway of Energy Flow.

The pathway is outlined in Figure 14.1

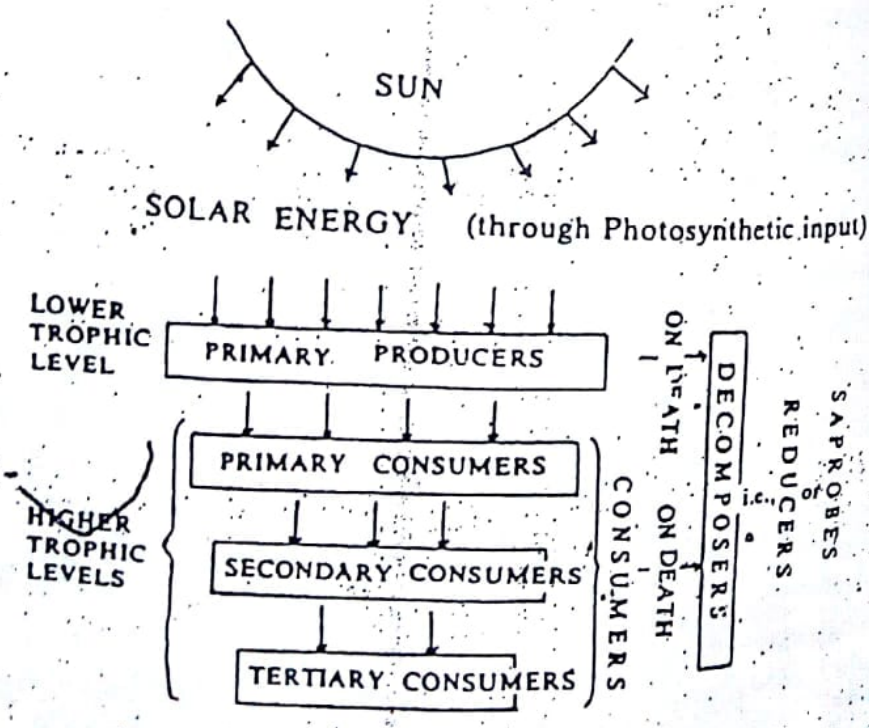


Figure 14.1: Pathway of energy flow in an ecosystem

A unique feature of energy transfer in an ecosystem, is the fact that once the energy gets to an organism at one tropic level, the organism utilizes a portion of the energy and makes the remaining portion available to the organism at a trophic level higher than its own level. It can therefore be seen that the energy leaving a trophic level, is less than the amount of energy that gets to that level. The primary producers have the largest amount of energy getting to their level.

14.3 Trophic Interactions

The organisms in an ecosystem participate in different types of interactions, one of which is in their feeding habits. Some organisms provide the food of some others within an ecosystem. This type of interaction is usually referred to as **Trophic Interaction.**

Three broad forms of trophic interactions can be recognized on the basis of their complexity.

The **simplest form** is a 2-member trophic interaction, in which one species provides the food of the other. This implies that the energy in one species which provides the food, flows to the other-its feeder. This type is known as a **Food Link.** It is usually denoted with the sketch: A → B, in which A stands for the species providing the food and B for the feeder. The arrow indicates the direction of the energy flow.

Another form of trophic interaction involves more than 2 species of organisms. It is a linear or chain-like type of trophic interaction. In this type, one species serves as the source of food of the species next to it. This species itself provides the food of the species following it along the line, and so on. The energy flows among the species involved in the trophic interaction, in a unidirectional pattern as the following description shows:

A → B → C → D

This type of trophic interaction is usually referred to as a **Food Chain.**

The **third form** of trophic interaction involves many of or all the species in an ecosystem. This type is usually the most complex. It is known as a **Trophic Web.** It is a trophic interaction depicting the **Food-Feeder relationship** of most or all the species of organisms in an ecosystem.

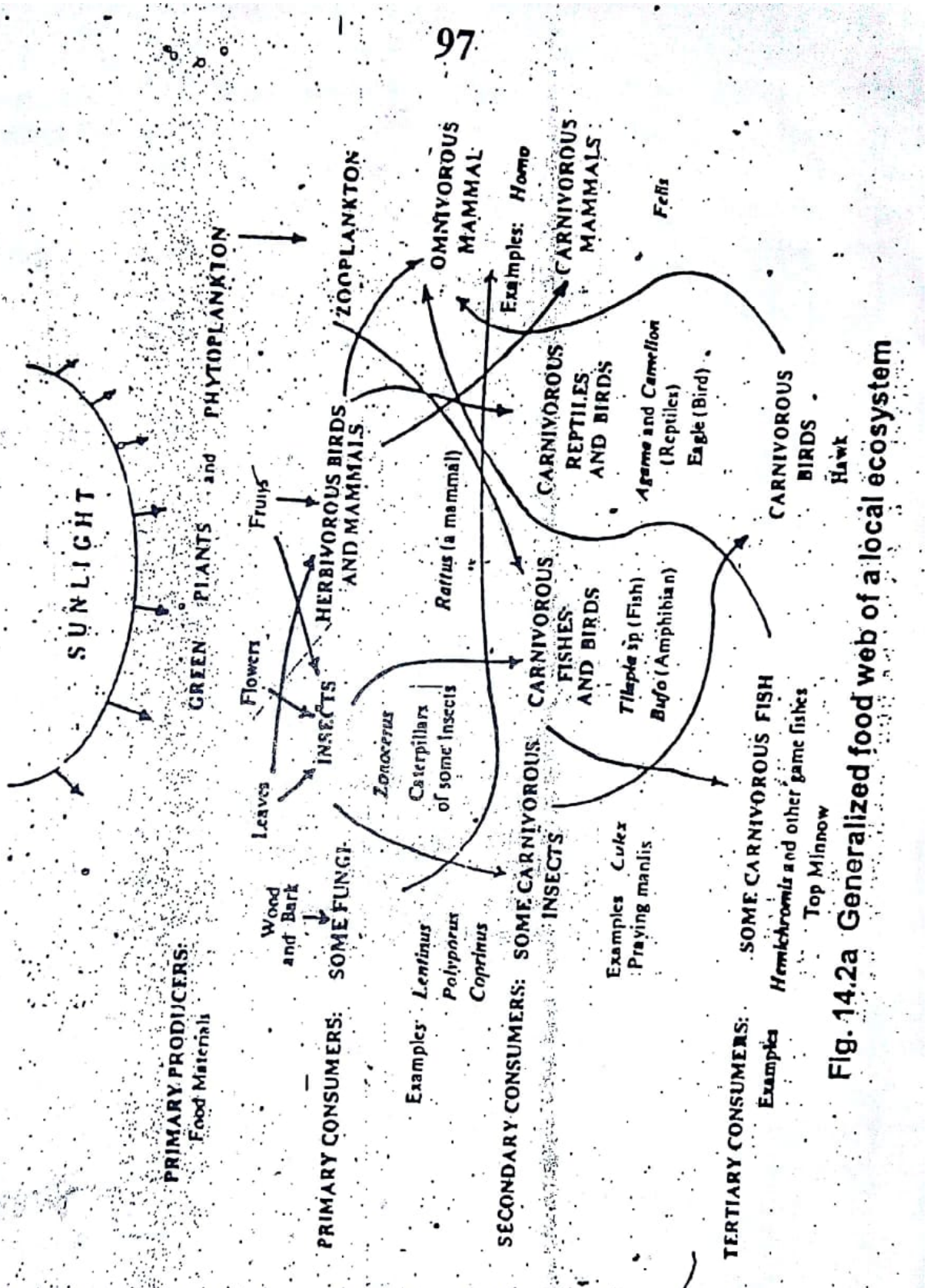


Fig. 14.2a Generalized food web of a local ecosystem

14.4 Further Notes on Trophic Interactions

Food chain has earlier on been defined as a linear or chain-like pattern of representation of the trophic interaction between a group of organisms belonging to different species living within an ecosystem. It is also depicting the pattern of energy flow among the species of organisms in the food chain.

Food chains are composed of food links and the food chains together with food links make up food webs. Food chains

etween 3 and at most 5 species of organisms.
in all food chains in an **autotrophic plant.**
photosynthetic plant. Other organisms that
first may be composed of plants (non-
ls) and animals. The first organism in a food
ic plant) is also known as a **producer.** Other
ne after this producer (i.e. the heterotrophs),
wn as **consumers.** The consumers are made
– the organism that feeds directly on the
– the phtotosynthetic plant and the
he organism which feeds on the herbivore.
ed upon by another carnivore, usually termed
ore. The positions of the herbivore and the
wever be occupied by an **omnivore** which is
on plants and animals. The energy content of
sumers usually becomes available to the
death of these producers and consumers. It
energy content of the organisms in a food
ases along the length of the chain from the
series of consumers.
s of food chains are recognized. These are
hains and the **detritus food chains.** The
mmonly found in aquatic and grassland
he latter is peculiar to forest ecosystems.
chains are again referred to as **the grazing**
flow and the **detritus channel of energy**

composed of several **trophic levels.** These
esent the number of links by which the
chain are separated from the natural source
light. The producer – also called the primary
hain, is at the **1st trophic level** in a food
earest the source of energy. The herbivores
ic **level,** while the carnivore is in the **3rd** and
nt nearest the source of energy is said to be
level, while the heterotrophs are said to be
els.

od Chains.
→ Zooplankton → Water Snake
onas *e.g. Mosquito larva*
n a freshwater habitat e.g. a pond.

ii. Grass species → Grasshopper → Toad → Land Snake
e.g. *Pennisetum*
An example from an abandoned farmland – a terrestri habitat

iii. Forest tree - - -> Tree hyrax - - -> Cobra - - - > Man
An example from a tropic lowland forest e.g. Origamba Forest Reserve in Nigeria

iv. Grass - -> Grasshopper - - > Lizard - - > Snake - - > Hawk

v. Grass - - > Antelope - - > Lion
Two examples from a tropical lowland savanna, e.g. Yanka Lake Game Reserve, in Nigeria.

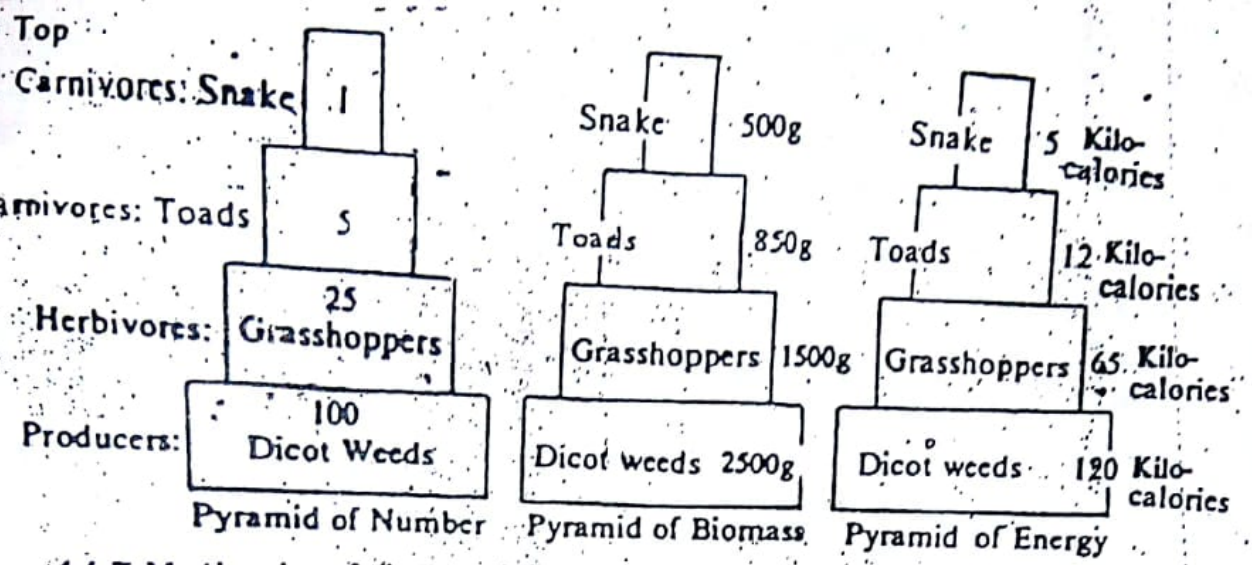
14.6 Methods of expressing Food Chains

i. **Use of arrows.**
In the use of these arrows, the tail of each arrow originates from the food, while the head points to the feeder. Examples are as given above for the different examples of food chains.

ii. **Use of biotic pyramids**
These pyramids are also termed **ecological pyramids** or **Eltonian pyramids.** The pyramids are essentially graphic or pictoral representations of the pattern of trophic interaction among groups of organisms. These are 3 types of these biotic pyramids. These are:
(a) Pyramids of numbers
(b) Pyramids of biomass
(c) Pyramids of energy

Pyramids of numbers are based on the number of individuals of the species of organisms in a food chain
Pyramids of biomass are based on the fresh or dry weight of these individuals, while **Pyramids of energy** are based on the energy content of the individuals of the species of organisms in the food chains. This is about the most accurate estimate of energy flow.

Examples of biotic pyramids



14.7 Methods of determining Trophic Interactions

i. **Direct observation of feeding by an organism.**
   - Most reliable method, but not always feasible

ii. **Observation of close association** between an organism and its probable food e.g. Observation of an insect hovering over the flowers of a plant.
   - Not reliable. This is because not all close associations result in feeding

iii. **Analysis of the gut content** of animals captured in the field
   Not conclusive. The food inside its gut might have got there through an indirect route e.g. through another organism which fed on the food which is itself fed upon the captured animals.

iv. **Laboratory observation** on an animal in captivity
   - Not conclusive. An animal may be forced to feed on substitutes for its usual food when in captivity

v. **Experimental observation** involving use of radioactive isotopes of some elements such as C^{14}
   - Not conclusive. Besides, it is too sophisticated, expensive and hazardous.

14.8 Application of knowledge of trophic interaction

i. Biological control of agricultural pests and pathogens. E.g. control of Cactus through the use of the moth *Cactoblastis cactorum* whose larvae feed voraciously on cactus.

ii. Biological control of household pests.
E.g. Control of mosquito by introducing certain species of fish such as *Tilapia* and top minnow into ponds to feed on the larvae and pupae of mosquito.

14.9 Ecological Cycles of Materials:

The biologically essential elements, unlike energy that comes from an outside source, are already present as part of the abiotic components of each natural ecosystem. Again unlike energy which flows along a unidirectional pathway, these elements are constantly being cycled in the ecosystem in which they are present. Each cycle is usually named after the principal element or compound that is involved. Thus we have carbon (or carbon dioxide) cycle, nitrogen cycle, sulphur cycle, water cycle etc. Outline descriptions of carbon and nitrogen cycles are given as follows:

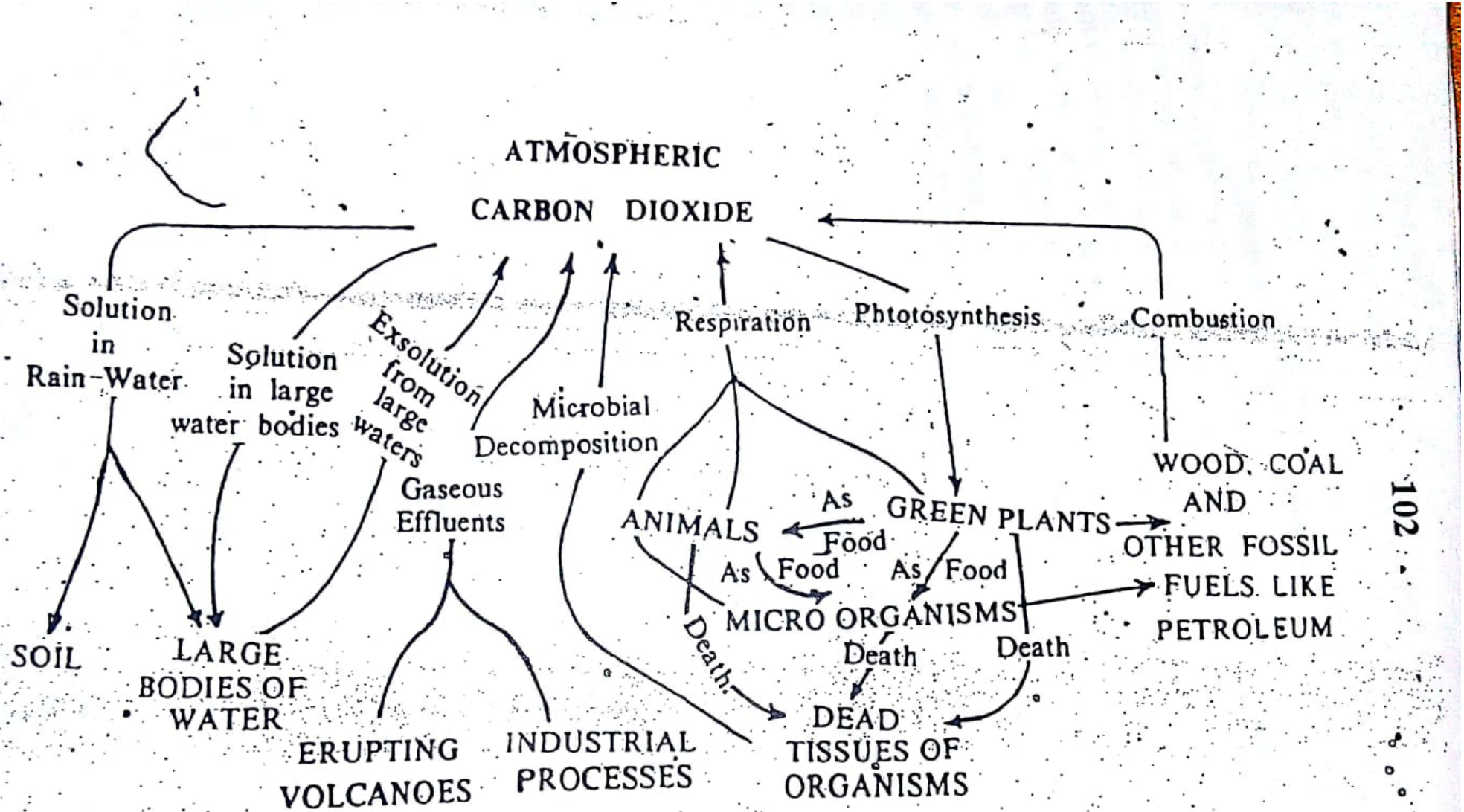


Fig. 14.3 Carbon Cycle

14.9.1 The Carbon Cycle

The most important natural reservoir of carbon dioxide is the atmosphere where it constitutes about 0.03% of the atmospheric gases. This percentage is known to remain constant for most of the time, despite those processes that tend to remove this gas from the atmosphere. This is because a number of other processes tend to add carbon dioxide to the atmosphere. The two groups of processes involved in the depletion and replenishment of atmospheric carbon dioxide constitute the processes that sustain the cycling of carbon in nature.

Processes Removing Atmoshperic Carbon Dioxide

i. Photosynthesis
ii. Solution in rain water
iii. Solution in large bodies of water such as the oceans and the seas.

Processes Returning Carbon Dioxide to the Atmosphere:

i. Respiration
ii. Burning of organic compounds
iii. Certain industrial processes involving the burning of limestone
iv. Eruption of volcanoes.

14.9.2 The Nitrogen Cycle:

The atmosphere is the most important natural reservoir of nitrogen. There the gas makes up to 70% of the total gaseous constituents. It is from this reservoir of the gas that a number of physical and biochemical processes remove the gas. Some other processes also help in returning the gas to the atmosphere. In-between the journey of the gas from and to the atmosphere, it undergoes some transformations into organic and inorganic compounds. Many processes are involved in the circulation of this gas within natural ecosystems. Examples of these are listed below.

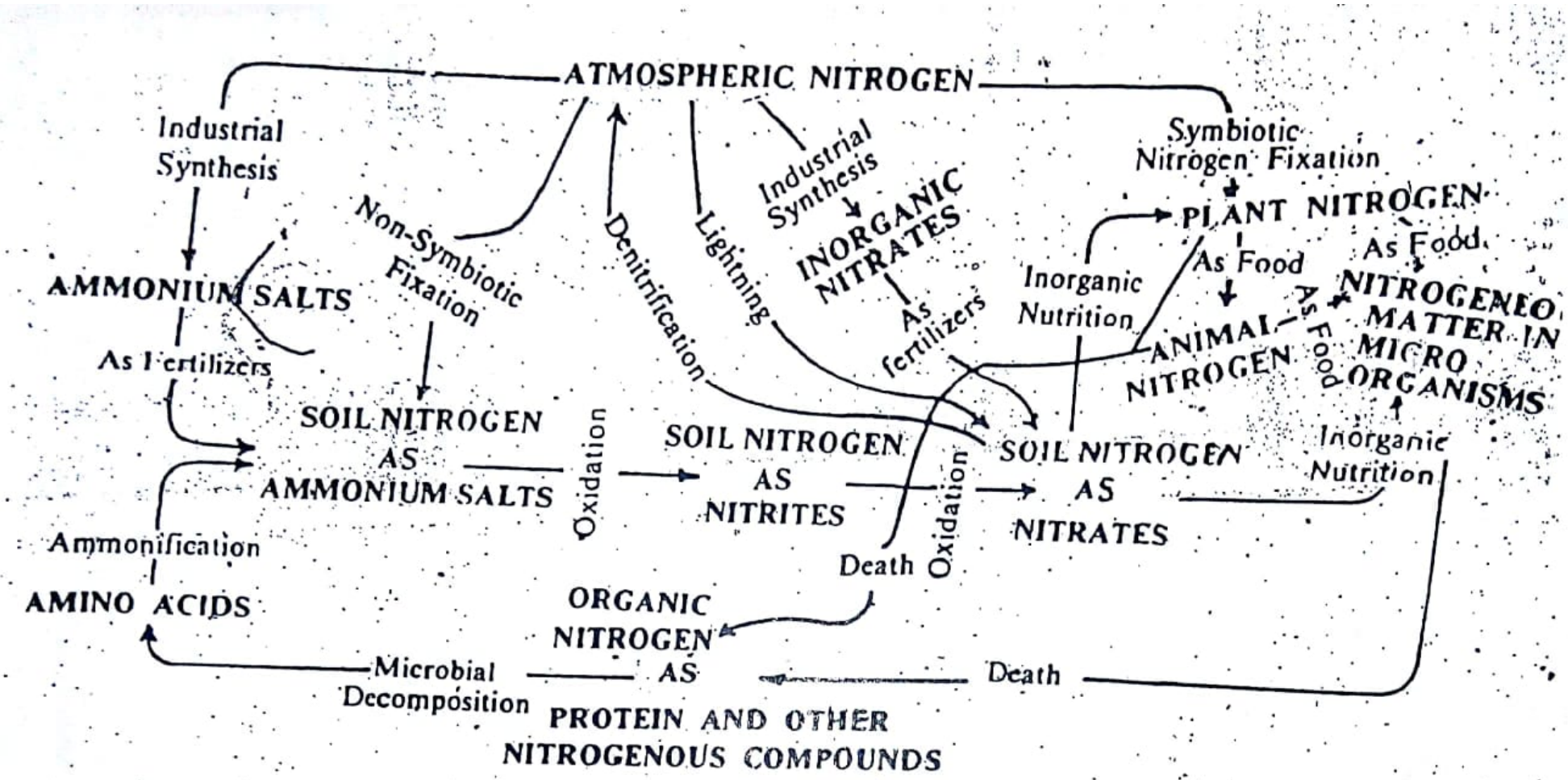


Fig. 14.4 The Nitrogen Cycle

Processes Removing Nitrogen from the Atmosphere:

(A) Biological processes:

i. **Nitrogen fixation by symbiotic bacteria** of the genus *Rhizobium*

ii. **Nitrogen fixation by some free-living micro-organisms** examples of which include some bacteria and a few species of algae. Examples of the bacteria are *Azotobacter* spp, *Clostridium* spp and *Bacillus* spp. The algae include Blue-green algae such as *Nostoc, Anabaena* and *Tolypothrix*.

(B) Non-Biological process

This involves the process of electrical discharge in the atmosphere – a process which accompanies lightning.

Some other minor processes through which nitrogen gets into the soil include:

1. Addition of artificial nitrogen-containing fertilizers
2. Washing into the soil of the nitrogen-rich organic materials suspended in the atmosphere. Examples of these materials are pollen grains, spores and bacteria.

Processes Releasing Nitrogen into the Atmosphere:

1. **Denitrification** due to soil microorganisms such as *Psuedomonas denitrificans.*

Useful soil nitrogen may also be lost through other processes listed below:

2. **Burning** of plant materials
3. **Volatilization** from animal wastes.

Useful soil nitrogen is also lost through burning, leaching, erosion and runoff. Nitrogen is also lost from an ecosystem through harvesting of the woody elements in the ecosystem, crop harvesting in agro-ecosystems and migration of the large herbivores such as elephants.

APPENDIX

Review Essay Questions on Tropical Ecology

Basic Terms and Concepts of Ecology

Write an essay that will explain the concept of ecosystem to High School Students.

Write briefly on

i. Habitat
ii. Environment
iii. Ecological Niche
iv. Topography
v. Biome
vi. Territory
vii. Tolerance
viii. Physiography

Explain briefly the difference between the following pairs of terms

(a) Autecology and Synecology
(b) Habitat and Environment
(c) Ecology and Agriculture
(d) Population and Community
(e) Geography and Biogeography
(f) Adaptation and Tolerance
(g) Species and Population
(h) Atmosphere and Biosphere

(a) What is meant by 'dispersal'?
(b) How is dispersal effected in plants and animals?

Discuss the main ecological factors in tropical environments.

(a) What are 'indicator species'?
(b) Describe some examples of indicator species in tropical ecosystems.

Discuss briefly the main features used in characterising tropical environments.

Adaptation of Organisms

Describe the various ways in which plants and animals living on land, survive unfavourable seasons in the tropics.

Write briefly on the "The Phenomenon of Adaptation."

"The flowering plants are the most highly adapted of the plants, while the mammals are the most highly adapted of the animals." Justify this assertion by outlining their peculiar

adaptive characteristics which are not found in other organisms.

4. Evolution of organisms involves migration of organisms from water to land. The flowering plants and mammals are known to be equipped with numerous adaptations for water conservation.

Discuss the various mechanisms by which the flowering plants (among plants) and the mammals (among animals), are adapted for water conservation on land.

5. Survey the various forms of adaptation plants and animals display for successful reproduction in their natural environments.
6. "Plants are well adapted for survival in their various habitats" By reference to (a) forest grasses, (b) rock plants and (c) plants growing along road sides and paths, discuss features which you regard as adaptations to life under the various ecological conditions existing in the named habitats.

III. Tropical Climate

1. (a) Distinguish between weather and climate
   (b) Describe in outline the main features of the tropical climate
2. Describe in outline the main climatic factors in tropical environments.
3. (a) What are the weather instruments?
   (b) Make a list of the different types of the common types of weather instruments often used by ecologists in tropical environments.
   (c) Describe how any two of these instruments are used.
4. (a) What are the main types of precipitation in the tropics?
   (b) Discuss the importance of rainfall in tropical environments.
5. Give a general account of the effects of light on plants or animals.
6. Discuss the relative importance of water in the life of plants and animals.

IV. Tropical Soils

1. (a) How would you measure the following in a soil sample: water, humus and calcium carbonate, and soil hydrogen ion concentrations?
   (b) In what ways do the humus and carbonate content of a soil influence its properties?

1. BASIC TERMS AND CONCEPTS OF ECOLOGY

1.1 Introductory Remarks

The word **ecology** is coined from the Greek words 'oikos' which means home, and 'logos' which means study of, or science of. Based on these Greek roots, the word ecology can be interpreted to mean the study of organisms in their home. A lot of definitions based on the interpretation above, have been proposed by different ecologists. A useful definition of ecology is "The study of organisms in relation to their environment."

Ecology is a branch of biology in which attempts are made to study the places where organisms live, their distribution and abundance in these places, their interactions with each other and with the non-living components of these places. Ecology was in the past studied as plant ecology and animal ecology. However, the approach in modern times is to study it as an integrated biological discipline.

Ecology as a biological discipline, has a number of unique features. It not only overlaps many other branches of biology, but also involves the application of many other physical and natural sciences. Its experiences are also acquired both inside the laboratory and in the field. Some of the main branches of ecology include the following:

Autecology

Autecology is concerned with the study of individual plants or animals in relation to their environments. It is also known as **Species Ecology.**

Synecology

Synecology is concerned with the study of different groups of organisms in relation to their environments. In synecology, the studies may be on groups of individuals all of which are of the same type. This aspect of synecology is often described as **population ecology.** The studies may be on different groups of organisms belonging to different species. Such studies are often carried out in **community ecology.**

Other branches of ecology are **production ecology, biogeography** and **human ecology. Production ecology** deals with the study of energy and material relations of organisms in their environments. **Biogeography** is interested in