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SCHOOL OF SCIENCE AND TECHNOLOGY

COURSE CODE: BIO 304

COURSE TITLE: GENERAL ECOLOGY

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MODULE I: THE STUDY OF ECOSYSTEMS

UNIT I: THE CONCEPT OF ECOSYSTEM

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1.0 INTRODUCTION

A community is made up of populations of different organisms living together in a unit environment. The manner in which these organisms relate together for sustenance and survival from producers to the various levels of consumers will be discussed in this unit on ecosystem. The ecosystem in different environments will also be looked into.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- understand the concept of ecosystem
- know the fundamental steps in the operations of ecosystem
- have a knowledge of some different types of ecosystems
- know the difference between a habitat and a niche
- understand the concept of food chain and food web.

3.0 DEFINITION OF ECOSYSTEM

Ecosystem is a term used to represent a whole community of organisms and its environment as a unit. In other words, it consists of the community of organisms (biotic factors) plus the associated physical environment (abiotic factors). It is usually self sufficient and can be permanent or temporary.

3.1 COMPONENTS OF ECOSYSTEM

Essentially, the fundamental steps in the operation of the ecosystem are:

- Reception of energy
- Production of organic materials by producers
- Consumption of these materials by consumers and its further elaboration.
- Decomposition to inorganic compounds
- Transformation to forms suitable for the nutrition of the producers.

How the above relate are shown in Fig 1.1

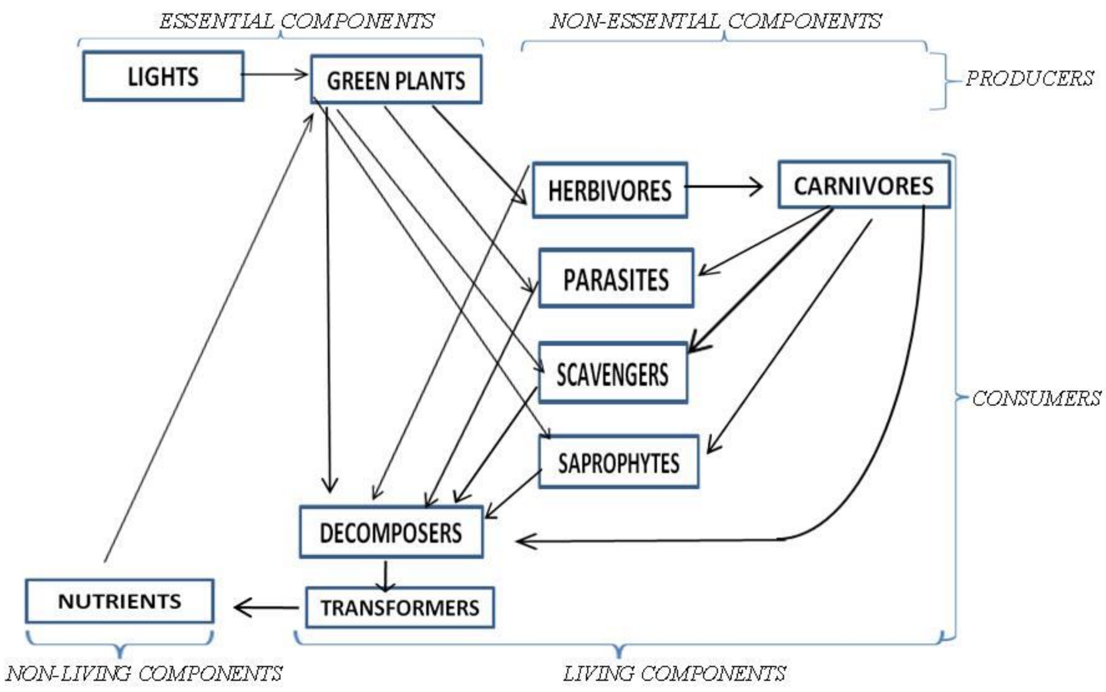

FIG 1.1: Principal Steps and Components in a Self - Sufficient Ecosystem (From Clarke, GL 1965)

The non-living components that must be present are light energy and organic nutrients for the growth of photosynthetic plants. The living components of the ecosystem consist of producers and consumers.

3.2 TYPES OF ECOSYSTEMS

Ecosystems can broadly be divided into Terrestrial Ecosystems and Aquatic Ecosystems.

These are found in the various terrestrial habitats of the earth as illustrated by the biomes e.g. tropical rainforest, temperate rainforest, savannah, temperate grassland, Hot and Cold deserts etc. The producers here are represented primarily by green plants but also include synthetic bacteria which may be of quantitative importance in specialized situations. The consumers include all the other types of organisms in the community. The principal herbivores or primary consumers which feed directly on the green plants are insects, rodents and ruminants. The herbivores serve as food for primary carnivores (secondary consumers) which may in turn fall prey to secondary carnivores, and several stages of dependency may exist. As animal life is ordinarily present in most natural communities, they sometimes hold a controlling position or take a prominent part in the operation of the ecosystem.

3.2.2 AQUATIC ECOSYSTEMS

Aquatic ecosystems are found in marine habitats, brackish estuaries, rivers, streams, lakes and ponds.

The producers here are represented by phytoplankton (drifting organisms) like algae. Primary consumers in aquatic ecosystems include molluscs, annelids and aquatic arthropods.

The secondary consumers (primary carnivores) are fish, aquatic birds. Like in the terrestrial ecosystem these may in turn fall prey to secondary carnivores and other stages of predation may occur.

3.2.3 HABITATS AND NICHES

In an ecosystem, the habitat is used to describe the environment or range of environments where an organism lives. The natural place of growth or occurrence of a species. Some species have definite habitat, for instance the lowland gorilla (*Gorilla gorilla)* has as its habitat low land tropical secondary forests while the mangrove plant's habitat is mangrove swamps. But some other species have several habitats. A good example is the tiger (*Panthera tigris*) whose habitats include tropical rain forest, snow-covered coniferous and deciduous forests and mangrove swamps.

Smaller organisms which live in a very restricted area such as on a particular plant or animal or in a specific region of the soil have where they live more precisely described as microhabitat. We can thus have a microhabitat for fleas or lice.

Niche

Unlike the habitat where an organism is found, the niche is a complete description of how the organism relates to its physical and biological environment. That is, the role of an organism within a community, its behaviour and the way in which the behaviour changes at different seasons and different times of the day. It can be seen as a method of 'making' a living within each functional category in the operation of the ecosystem. The factors that make up an organism's niche determine whether it can exist in a given ecosystem and also with how many species it can exist together.

A niche can either be a realised niche when the organism is competing with others in an ecosystem or a fundamental niche which is the niche an organism occupies if competitors were not present. Under a competing situation it has been realised that no two species of organisms occupy the same niche thus supporting the idea of competitive exclusion. One species will displace the other which may find another niche or go to extinction.

3.3 THE CONCEPT OF FOOD CHAIN

Green plants, the primary producers in an ecosystem capture energy from sunlight that fall on their leaves and convert it to food energy. When these plants are consumed by other organisms, a percentage of the plant's accumulated energy is actually converted into the bodies of the organisms that consume them. Several levels may be recognized among these consumers. The herbivores (primary consumers) feed directly on the green plants and serve as food for primary carnivores (secondary consumers). These in turn may fall prey to secondary carnivore and in some cases other stages of nutritional dependency. The tissues of the various plants and animals in the community may also be eaten by parasites and after the organisms are dead, by scavengers and saprophytes of many sorts. The organisms (plants and animals) from each of these levels feeding on one another make up a food chain. Simply speaking, it describes a one line eating relationships between species within an ecosystem (Fig 2.1).

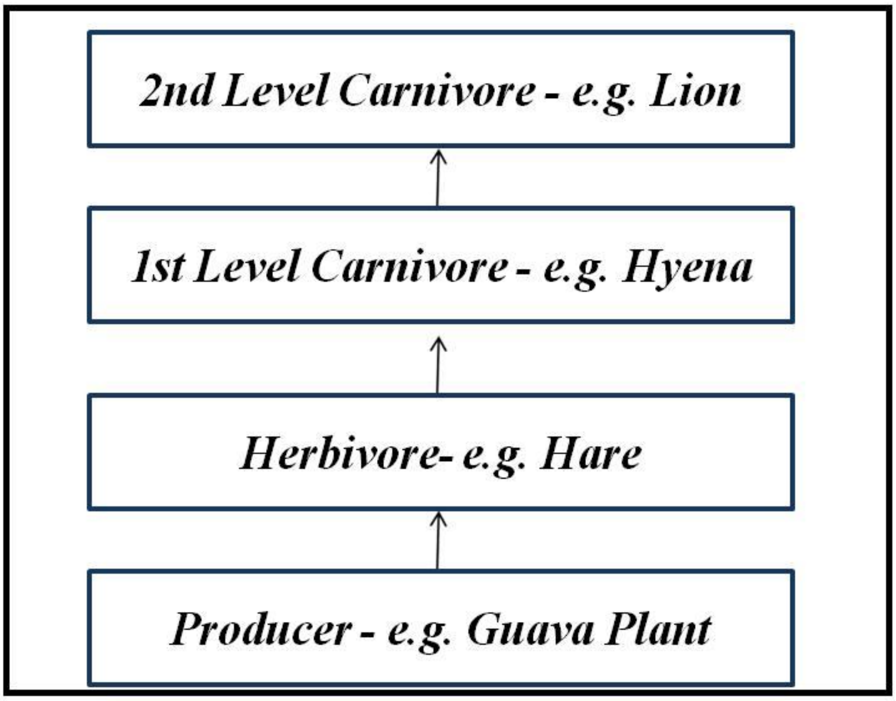

FIG 2.1: A HYPOTHETICAL FOOD CHAIN TYPICAL OF NIGERIAN SITUATION.

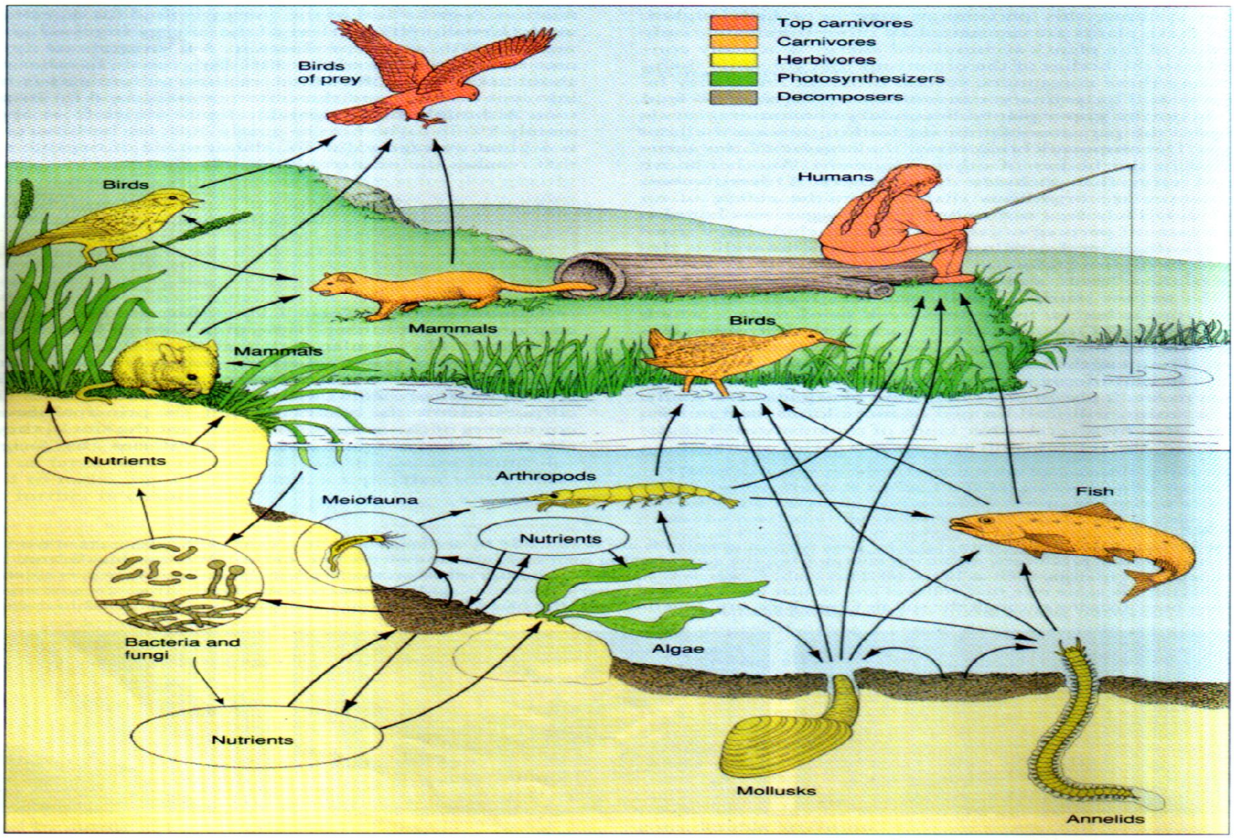

Fig 3.1: **The food web in a salt marsh, showing the complex interrelationship among organisims. The meiofauna consist of very small animals that live between the grains of sand. (From Raven and Johnson, 1996).**

3.3.1 **FOOD WEB**

In real life, it is rather rare for a given kind of organism to feed on only one kind of organism. Usually, each will feed on two or more other kinds and in turn will be fed on by several other kinds of organisms. When diagrammed, the relationship appears as a series of branching lines rather than as one straight line. This is called a food web (Fig

3.1). It is really a set of interconnected food chains by which energy and materials circulate within an ecosystem.

3.4 TROPHIC LEVELS AND PYRAMIDAL RELATIONS

Each successive level of nourishment as represented by the links of the food chain is known as a Tropical Level. It shows what organisms feed on and what feeds on them. The plant producers within an ecosystem constitute the first tropic level, the herbivores form the second and the primary carnivores form the third level and so on. Taking Fig 2.1 as an example, the guava plant is the first trophic level, the hare the second, the hyena third and the lion fourth.

Pyramidal relations may be found among the organisms at different trophic levels in the ecosystem.

3.4.1 Pyramid of numbers

Among the animals of a community the herbivores are typically the most numerous. They take in food materials synthesized by the plant producers and pass it on to the subsequent consumers. Primary carnivores that prey on the herbivores are less abundant and secondary and tertiary carnivores generally exist in still fewer numbers. This numerical relation with the more abundant species near the base of the food chain and the less abundant species near the top is known as the pyramid of numbers (Fig 4.1). The existence of parasites frequently leads to inverted pyramid of numbers when many parasites much smaller are attached to the host.

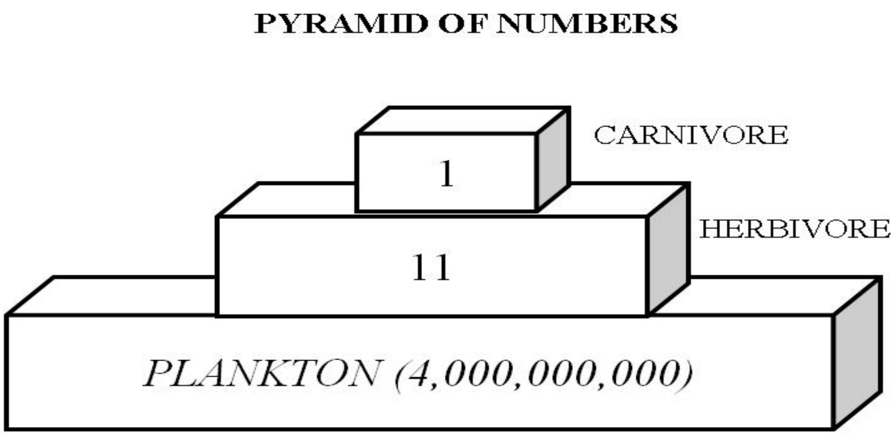

FIG 4.1: TYPICAL PYRAMID OF NUMBERS FROM A MARINE ENVIRONMENT. (RAVEN & JOHNSON, 1996).

Among producers, an inverted pyramid of numbers may result when a single tree support many much smaller organism (Fig 5.1).

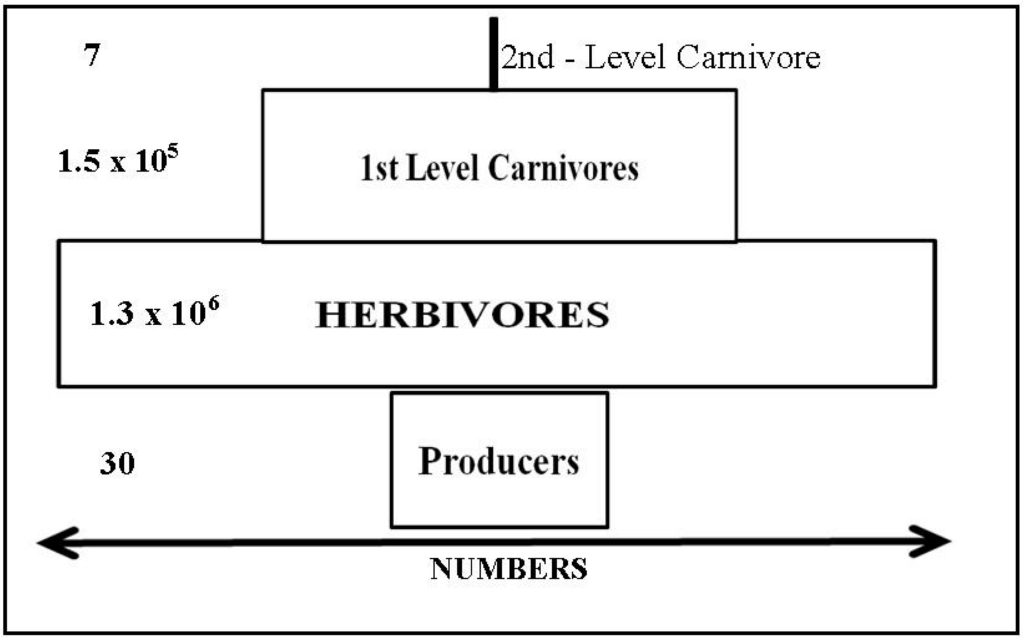

FIG 5.1: Inverted Pyramid of Numbers From a Terrestrial Environment in Wytham Oak Woods, Oxford. Only Oaks were counted as Producers. (From Chapman & Reiss, 1995).

3.4.2 **Pyramid of biomass**

The size growth rate and longevity of species making up a particular ecosystem are such that the living weight or biomass of the members of the food chain present at any one time form a type of pyramid. In a land biotope, the biomass of the vegetation existing at the moment of observation is commonly the greatest and the biomass of herbivores carnivores and further links in the food chain are progressively smaller (Fig 6.1).

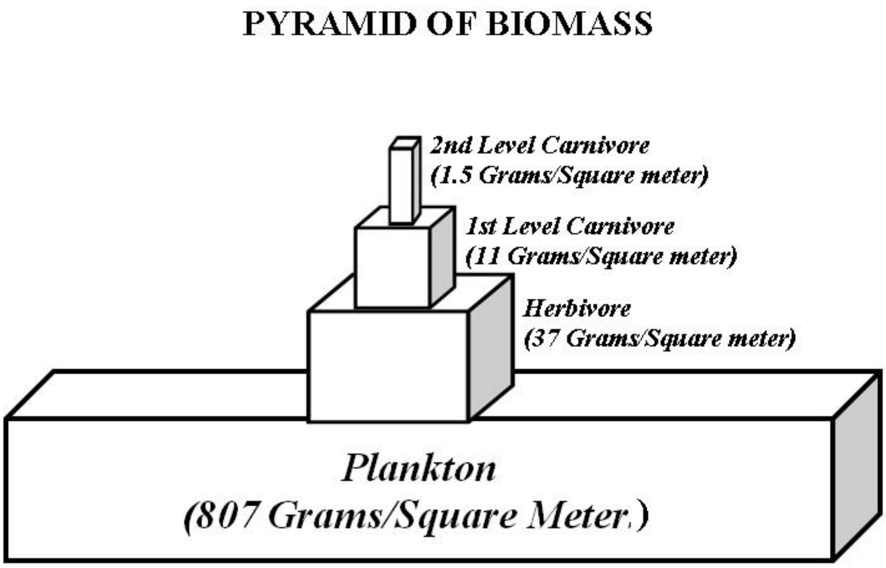

FIG 6.1: TYPICAL PYRAMID OF BIOMASS FROM A MARINE ENVIRONMENT. (RAVEN & JOHNSON, 1996).

However. pyramids of biomass can be inverted as in the oceans where a given mass of phytoplankton at certain times in the year support a larger mass of zooplankton.

SELF ASSESSMENT EXERCISE

- Identify by observations around you, two food chains of at least three trophic levels each
- Explain the following three terms:- Habitat; Niche; Ecology.
- Name the non-essential components of an ecosystem.

4.0 CONCLUSION

Ecosystems are the most complex level of biological organization. They regulate the flow of energy and cycling of the essential elements on which the lives of constituent plants, animals and other organisms depend.

5.0 SUMMARY

In this unit, we have learnt that;

- An ecosystem is a whole community of organisms (biotic factors) in an area functioning together with the physical factors (abiotic factors) of the environment.
- The components of the ecosystem are the non-living elements namely, light energy and inorganic nutrients and the living components namely, producers and consumers.
- There are various types of ecosystems including terrestrial and aquatic.
- Species within an ecosystem are known to occur in particular habitat(s) and occupy a niche.
- Food chain is a term used for one pathway eating relationships between species within an ecosystem. Where consumers feed on multiple species and are in turn fed upon by multiple species, we have a food-web.
- Each level of feeding is called a trophic level with the plant producers forming the first trophic level or the base of natural communities.
- The feeding relationship from one trophic level to another can be captured in form of pyramids thus we have pyramid of biomass and pyramid of numbers. The pyramids can occasionally be inverted.

6.0 TUTOR MARKED ASSIGNMENT

- What is your understanding of the term ecosystem?
- What are the living and non-living components of an ecosystem?
- Plants are the producers in the terrestrial ecosystem. What are the counterparts in aquatic ecosystems?
- What is the difference between a habitat and a niche?

7.0 FURTHER READING/REFERENCES

- Chapman JL and Reiss MJ (1995): ECOLOGY, principles and applications. Cambridge University Press, UK
- Raven, PH and Johnson, GB (1998): The future of the Biosphere, (611-630) In: BIOLOGY WCB/McGrow-Hill, Boston.

MODULE I: THE STUDY OF ECOSYSTEMS

UNIT II: PRODUCTIVITY OF ECOSYSTEMS

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1.0 INTRODUCTION

All living organisms require energy for metabolic activities and sustenance. This energy enters the ecosystem through the producers which are able to produce organic materials from sunlight. This unit will discuss how the energy from the sun is tapped for use of living organisms and how that energy is transferred up the spectrum from the producers to the consumers. The efficiency of this energy transfer at each level will be looked into.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- Understand the term primary productivity and recognize its significance to the ecosystem.
- Differentiate between gross primary productivity and net primary productivity.
- Understand the manner of energy flow in the ecosystem.
- Understand the efficiency of energy flow from one trophic level to the next.
- Recognise the pyramid of energy.

3.0 CONCEPT OF PRODUCTIVITY

An ecosystem includes autotrophs and heterotrophs. Autotrophs consist of plants, algae and some bacteria, while heterotrophs include animals fungi, most protists and bacteria and non-green plants. Autotrophs (plants) are able to capture light energy and manufacture their own food. However, heterotrophs must obtain organic molecules that have been synthesized by autotrophs. The energy for survival of the heterotrophs is therefore dependent on autotrophs.

3.1 PRIMARY PRODUCTIVITY

Approximately 1% to 5% of solar energy that falls on a plant is converted to food or other high quality organic materials. Primary productivity is a term used to describe the amount of organic matter produced by green plants from solar energy in a given area during a given period of time.

3.1.1 Gross Primary productivity is the total organic matter produced including that used by the photosynthetic organisms (green plants) for respiration. No subtraction is made from the total production.

3.1.2 Net primary Productivity is the total amount of energy fixed per unit of time minus the energy expended by the metabolic activities of the photosynthetic organisms in the community. It equals the gross primary productivity minus the amount of energy expended by the metabolic activities of the photosynthetic organisms.

3.1.3 SIGNIFICANCE OF PRIMARY PRODUCTIVITY

Energy enters the ecosystem from the sun as a result of photosynthesis. It is slowly released as metabolic processes proceed. The autotrophs first acquire this energy through primary productivity and provide all the energy that heterotrophs use without which they will not survive. Primary productivity therefore becomes essential to the survival of ecosystems.

3.2 ENERGY FLOW

Energy continuously flows through the biological world in one direction with new energy from the sun constantly entering the system to replace the energy that is dissipated as heat. Green plants, the primary producers of a terrestrial ecosystem, generally capture about 1% to 5% of the energy that falls on their leaves converting it to food energy. This percentage may be a little higher in especially productive ecosystems.

When these plants are consumed by herbivores or primary consumers, only a portion of the plants accumulated energy is actually converted into the bodies of the organisms that consume them. The same applies to secondary consumers, carnivores, which feed on the herbivores. Only some of the potential energy stored in the herbivore tissues is converted into the body of the carnivore. This reducing trend is sustained from one trophic level to the next.

3.2.1 Efficiency of energy transfer

The amount of energy ingested and retained at each trophic level goes toward heat production. A great deal of the energy is used for digestion and work. Usually 40% or less of energy goes toward growth and reproduction.

Raven and Johnson (1996) observed that an invertebrate typically uses about a quarter of the 40% ie 10% of the food it eats to its own body and thus into potential food for its predators. The comparable figure varies from about 5% in carnivores to nearly 20% for herbivores however, 10% is a good average value for the amount of organic matter that reaches the next trophic level. Because the energy lost at each trophic level is so great, food chains generally consist of only three or four steps. Very little energy remains in the system as usable energy after it has been incorporated successfully into the bodies at four trophic levels.

In other words, only about 10% of the energy fixed in the food is fixed in the body of the animal that eats that food. The trophic efficiency is in general related to the formula- exploitation efficiency x assimilation efficiency x production efficiency (Chapman and Reiss, 1995).

3.2.3 Pyramid of Energy

A pyramid of energy shows the flow of energy from one trophic level of a community to the next and the rate at which energy flows up a food web. The units of the pyramids of energy are energy/area/time e.g. kcal/M^2/yr i.e. (Kilocalories/Square meter/year) and are usually measured over a period of time. Following the law of conservation of energy which states that energy can neither be created nor destroyed but is always conserved, pyramids of energy can never be inverted as can be found with pyramids of numbers or of biomass. The productivity of herbivores cannot exceed the net primary productivity and that of the first level carnivores must be less than the productivity of the herbivores. The productivity of the second-level carnivores must be less than the productivity of the first-level carnivores and so on (Fig 1.2).

PYRAMID OF ENERGY

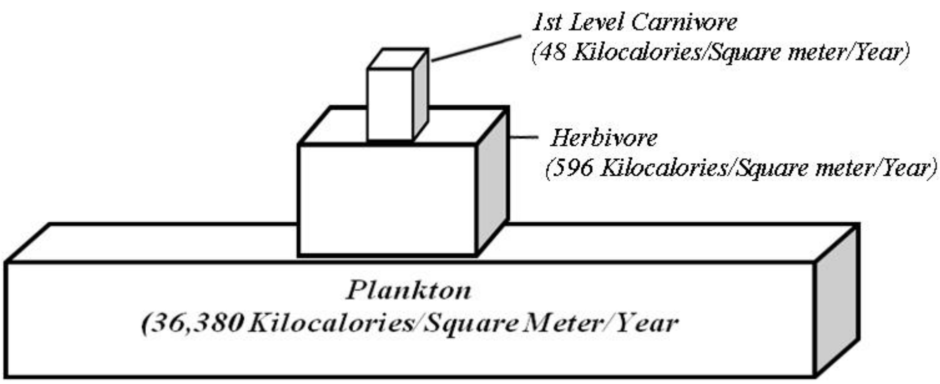

FIG 1.2: TYPICAL PYRAMID OF ENERGY FROM A MARINE ENVIRONMENT. (RAVEN & JOHNSON, 1996).

SELF ASSESSMENT EXERCISE

- What is primary productivity? Why is it important in the ecosystem?
- Describe how energy transfer occurs in the ecosystem. How efficient is the transfer?

4.0 CONCLUSION

The ecosystem acquires its energy from the producers (photosynthetic plants) which produce energy from the reception of sunlight. Through the food chain or food web, the energy becomes available to all organisms within the ecosystem.

5.0 SUMMARY

We have learnt in this unit that:

- Primary productivity is a term used to describe the amount of organic matter or energy produced by plants from sunlight (solar energy) in a given area during a given period of time.
- Gross primary productivity refers to the total organic matter (energy) produced by the photosynthetic organism (plant or algae) while net primary productivity excludes the energy expended by the metabolic activities of the organism in for example respiration.
- The energy acquired by the producers is transferred from one trophic level to the next along the food chain.
- The length of food chain is limited to 3 or rarely 4 levels because too much energy is lost at each transfer point.
- Following the law of conservation of energy, the pyramid of energy cannot be inverted.

6.0 TUTOR MARK ASSIGNMENT

- Differentiate between autotrophs and heterotrophs
- Why are photosynthetic plants of importance in the ecosystem?
- Explain the differences between gross primary productivity and net primary productivity.

7.0 FURTHER READING/REFERENCES

- Chapman J. L. and Reiss M. J. (1995) ECOLOGY, principles and application. Cambridge University Press, UK.
- Raven PH and Johnson, GB (1996) Dynamics of Ecosystems (569 – 582) In “BIOLOGY” WMC C. Brown/McGrow-Hill. Boston

MODULE I: THE STUDY OF ECOSYSTEMS

UNIT III: THE CYCLING OF NUTRIENTS IN ECOSYSTEMS

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1.0 INTRODUCTION

Elements which are critical to the survival of organisms cycle within ecosystems between organisms and reservoirs that are either liquid or gas (oxygen, water, carbon and nitrogen) or solid (phosphorus). It begins when they are incorporated from the atmosphere or from weathered rock into the bodies of organisms. The elements are unalterable in natural conditions on earth so they remain in circulation when molecules pass from one trophic level to another. They can be recycled over and over again as they operate on a closed system.

This unit will look at some of these elements and study how they are recycled.

2.0 OBJECTIVES

At the end of this unit you should be able to

- Know the major nutrients in an ecosystem that are cycled and recycled by living organisms.
- Understand how the nutrient cycles include both the living biosphere and the nonliving lithosphere, atmosphere and hydrosphere.
- Know the process of recycling of water and some of the important nutrients within the ecosystem.
- Explain the processes of Ammonification, Nitrification, Nitrogen Fixation and Dentrification.
- Understand how the phosphorus cycle differs from other nutrient cycles
- Know how the various nutrient cycles interact.

- Understand the importance of the nutrient cycles to organisms within an ecosystem.

3.0 NUTRIENT CYCLES

All of the substances that occur in organisms cycle through ecosystems in a cyclic path involving both biological and chemical processes termed biogeochemical cycle (Fig 1.3). Generally, the bulk of these substances are not contained within the bodies of organisms but rather exist in the atmosphere, water or in rocks. Carbon (in form of carbon dioxide), nitrogen and oxygen primarily enter bodies of organisms from the atmosphere while phosphorus potassium, sulfur, magnesium, calcium, sodium, iron and cobalt all of which are required for plant growth come from rocks.

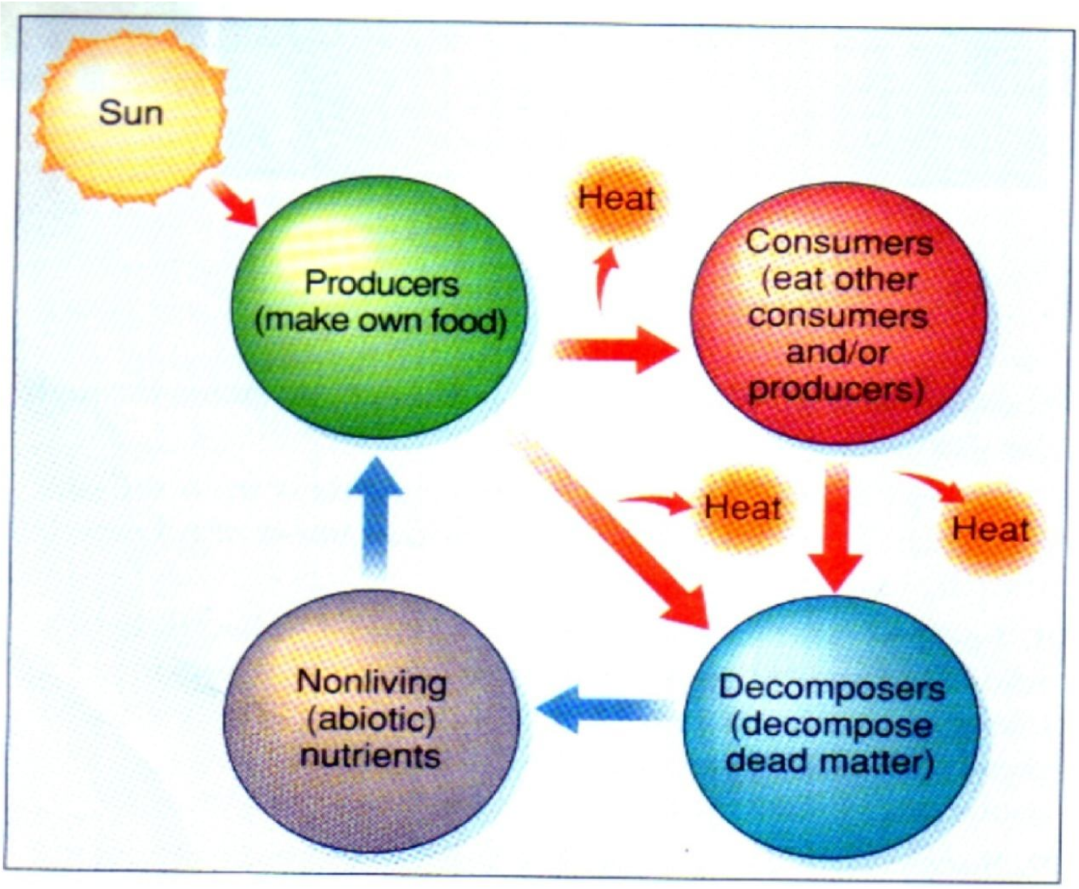

Fig 1.3 Cycling within an ecosystem (Biogeochemical cycle). (From Raven and Johnson, 1996).

The cycling of materials in ecosystems begins when they are incorporated from the atmosphere or from weathered rock into the bodies of organisms. Some times, they pass from these organisms into the bodies of other organisms that feed on them and ultimately through decomposition, they are returned to the non-living world. After this occurs, the nutrients may begin the cycle again by being incorporated into bodies of other organisms. This process goes on over and over again.

There are many nutrient cycles, but the well known and important cycles include the water cycle, the carbon cycle, the nitrogen cycle, the oxygen cycle, the phosphorus cycle and the sulphur cycle.

3.1 WATER CYCLE

Water cycles continuously from the atmosphere to the earth to the oceans and back to the atmosphere again (Fig 2.3).

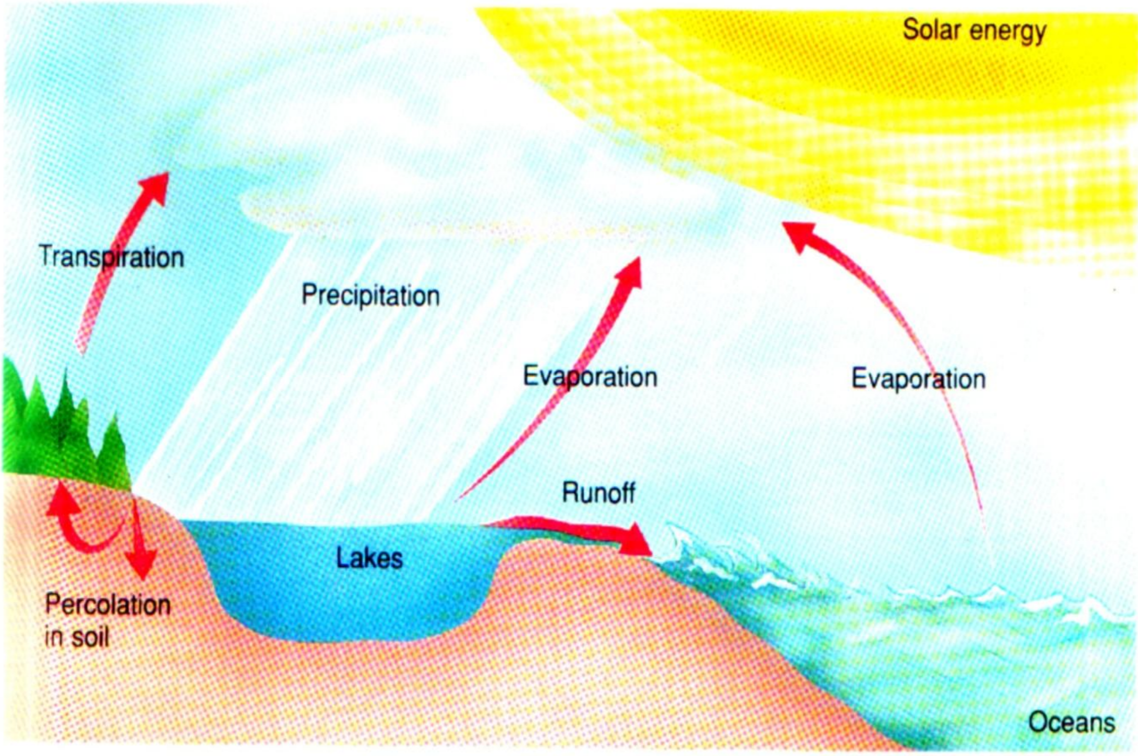

Fig 2.3 The water cycle. Transpiration is the process by which water evaporates from the surface of plants. (From Raven and Johnson, 1996).

Water is indispensable to the functioning of living organisms which live or die on the basis of their ability to capture water and incorporate it into their bodies. Water evaporates from the oceans which cover ¾ of the earth's surface into the atmosphere a process powered by energy from the sun. Over land areas, approximately 90% of the water that reaches the atmosphere comes from plants via transpiration. Following condensation, most precipitation from the atmosphere falls clean and fresh directly into the oceans but, some fall on land where it passes into the surface or subsurface bodies of fresh water. Only about 2% of all the water on earth is fixed in any form – frozen, held in the soil or incorporated into the body of organisms. This cycle of evaporation/transpiration and precipitation goes on over and over again.

3.2 THE CARBON CYCLE

The carbon cycle is based on carbon dioxide which makes up only about 0.03% of the atmosphere. Carbon is used to make carbohydrates, fats and proteins, the major sources of food energy. These compounds are oxidized to release carbon dioxide, which can be captured by plants, algae and photosynthetic bacterial to make organic compounds. The chemical reaction is powered by the light energy of the sun. This results in the fixation of about 10% of the roughly 700 billion metric tons of carbon dioxide in the atmosphere each year (Fig 3.3).

All heterotrophic organisms including non-photosynthetic bacteria, fungi, animals and few plants that have lost the ability to photosynthesize, obtain their carbon indirectly from the organisms that fix it. When their bodies decompose, organisms release carbon dioxide to the atmosphere. Once there, it can be reincorporated into the bodies of other animals.

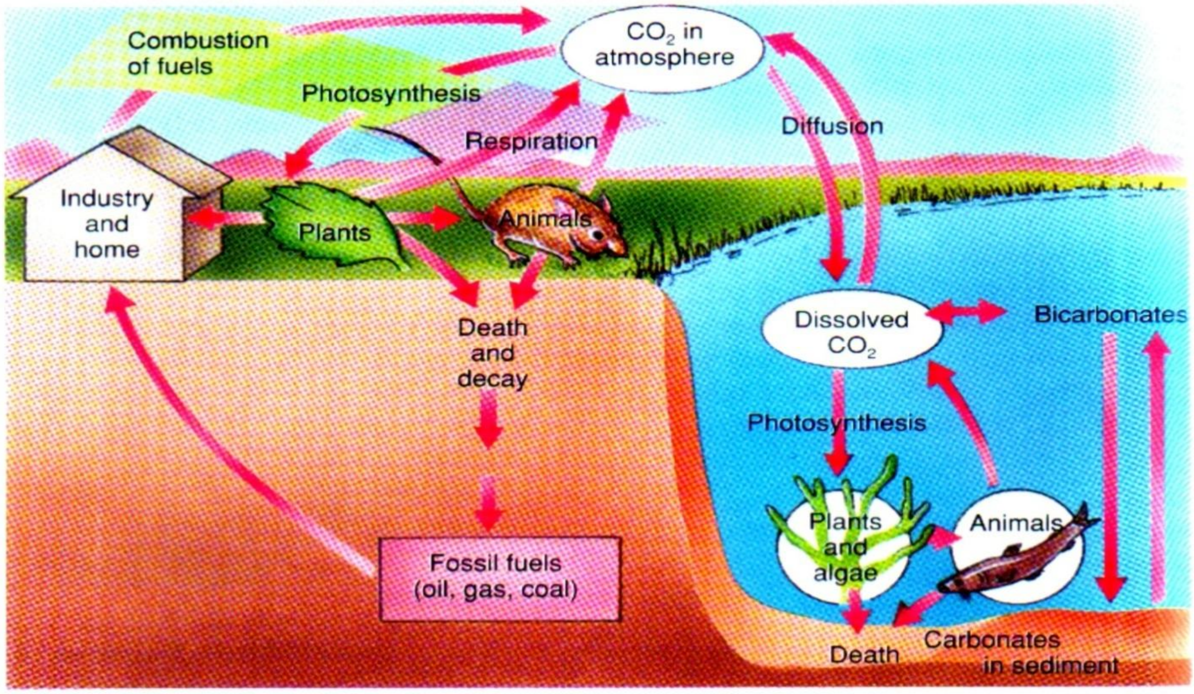

Fig 3.3 The carbon cycle (From Raven & Johnson, 1996).

The carbon cycle is unusual among nutrient cycles because it need not involve decomposers. Most of the organic compounds that are formed as a result of carbon dioxide fixation in the bodies of photosynthetic organisms are ultimately broken done and released back into the atmosphere or water. However, certain carbon containing compounds like cellulose are more resistant to breakdown.

The carbon in this cellulose may eventually be incorporated into fossil fuels, such as oil or coal.

In global terms, photosynthesis and respiration are approximately balanced, but the balance has been shifted recently because of the consumption of fossil fuels by man. The combustion of coal, oil and gas has released large stores of carbon into the atmosphere as carbon dioxide. This increase of carbon dioxide in the atmosphere appears to be changing global climate making it warmer.

3.3 THE NITROGEN CYCLE

The primary inorganic reservoir of Nitrogen is the atmosphere. Nitrogen gas constitutes 78% of the earths atmosphere but the total amount of fixed nitrogen in the soil, oceans and the bodies of organisms is only 0.03% of that figure.

Nitrogen cycles between organisms and reservoirs via the nitrogen cycle (Fig 4.3). This cycle can be broken down into a number of stages.

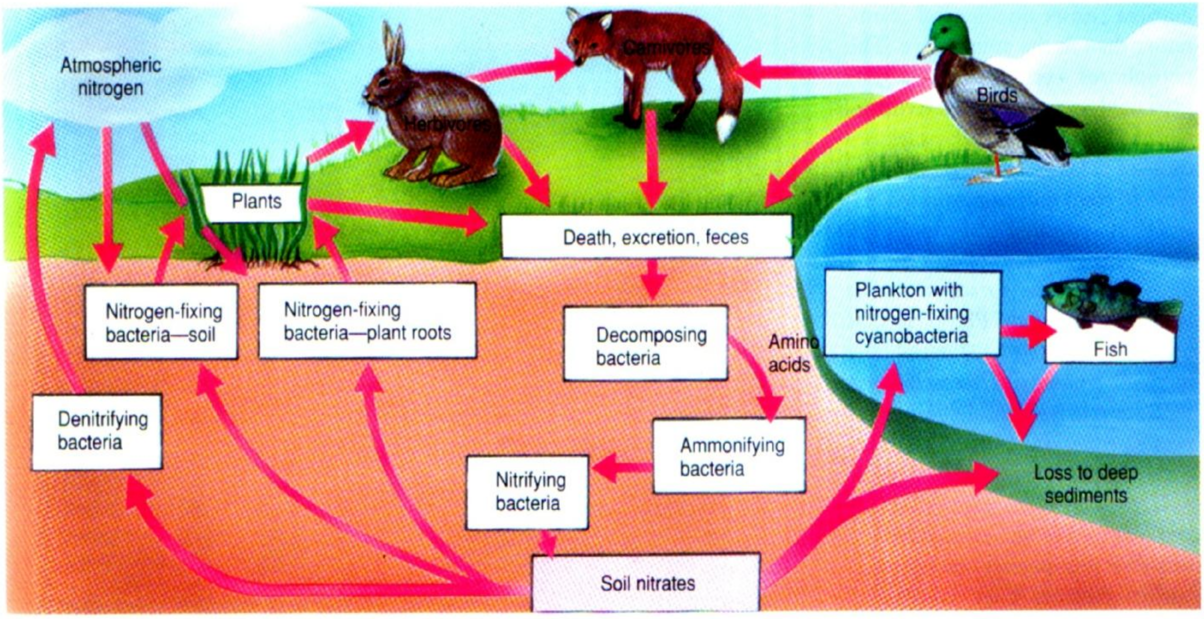

Fig 4.3 The nitrogen cycle. (From Raven & Johnson, 1996).

3.3.1 **Ammonification**

When organisms excrete nitrogenous waste or die, their nitrogen is converted to ammonium ions by the action of saprotrophic fungi and bacteria. This process is known as ammonification.

3.3.2 **Nitrification**

In warm, moist soils with a pH near 7, ammonium ions are oxidized within a few days of their formation or their addition as fertilizer (Salisbury and Ross, 1985). The oxidation benefits the bacteria performing the reactions by releasing energy which the bacteria can use for synthesis of ATP. The process takes place in two stages. First, ammonium is oxidised to nitrite, by bacteria of the genera

Nitrosomonas, Nitrosospira, Nitrosococcus and *Nitrosolobus* (Hamilton, 1988). Next, nitrite is oxidised to nitrate by bacteria of the genera *Nitrobacter, Nitrospira* and *Nitrococus.*

3.3.3 **Uptake of Nitrogen by plants.**

Most plants absorb the majority of their nitrogen as nitrate. However many plants also absorb ammonium like in forests on acidic soils where conversion of ammonium to nitrate is slow.

3.3.4 **Nitrogen Fixation**

Nitrogen fixation is the reduction of atmospheric nitrogen to Ammonium ion. It is of great importance to organisms. Together with Lightning, it is the natural way in which organisms gain access to the huge reserves of nitrogen in the atmosphere. Nitrogen fixation can only be carried out by certain species of bacteria and *Cyanobacteria* (Postgate, 1988).

Some of these species are free-living, occurring in soil or in water. Others exist in symbiotic relationships with higher plants. The most well-known of the nitrogen fixing bacteria are in the genus *Rhizobium*. These bacteria form symbiotic associations in root nodules of many plants in the family Leguminosae which includes some important crops as peas, groundnuts, beans and clovers.

3.3.5 **Denitrification**

Certain proportion of the fixed nitrogen in the soil is steadily lost. Under anaerobic conditions, nitrate is often converted to nitrogen gas and nitrous oxide both of which return to the atmosphere. This process which several genera of anaerobic bacteria carry out is called Denitrification. In its absence, all nitrogen would eventually become fixed, converted into nitrate and washed into the oceans. Life would thus be possible only in marine and littoral habitats as all living organisms depend on the results of nitrogen fixation to synthesize proteins, nucleic acid and other necessary nitrogen – containing compounds. Denitrification and nitrogen fixation together constitute the mechanism for returning nitrogen from the oceans to the land.

3.4 **PHOSPHORUS CYCLE**

The phosphorus cycle unlike those of carbon and nitrogen lacks an atmospheric component. Phosphorus enters ecosystems through the weathering of rocks. Plants obtain their phosphorus from the soil either as dihydrogen phosphate or more slowly as hydrogen phosphate. Once in an organism, though, phosphorus does not undergo reduction; it remains as phosphate. In this form it is found in a number of compounds including nucleic acids, phosphorylated carbohydrates and fats. Herbivores obtain their phosphorus from plants while carnivores obtain theirs from herbivores. Decomposers return phosphorus to the soil as phosphate ion.

In most soils and waters, phosphorus is in short supply and limits plant growth. This is because they are relatively insoluble and are present only in certain kinds of rock. Crushed phosphate-rich rocks found in certain regions are used as fertilizer and added to agricultural lands in form of superphosphate in the belief that it becomes fixed to and enriches the soil. The absorption of phosphate along with ammonium, nitrate and the potassium ion is though, greatly aided by the presence of *mycorrhizae* (fungus plants).

3.5 INTERACTIONS BETWEEN THE NUTRIENT CYCLES

The various nutrient cycles are interconnected and depend on one another to a great extent. The burning of fossil fuels for example not only puts large amount of carbon into the atmosphere, it also increases the amount of atmospheric nitrogen, phosphorus and sulphur. The interdependence of the nutrient cycles is obvious when one considers nutrient cycling through organisms. When a herbivore eats a plant or a carnivore an animal, it ingests at one go not just carbon, nitrogen and phosphorus but oxygen, calcium, potassium, chlorine and all other elements which are found in organisms.

SELF ASSESSMENT EXERCISE

- What is nitrogen fixation? Explain the role played by some species of bacteria and leguminous plants in nitrogen fixation.
- Explain how the phosphorous cycle differs from other nutrient cycles.

4.0 CONCLUSION

In an ecosystem which is an assemblage of organisms along with the non-living factors of the environment, nutrients circulate over and over again among organisms within the system.

5.0 SUMMARY

In this unit we have learnt that

- Important nutrients which are critical to the lives of organisms within an ecosystem include, water, carbon, nitrogen, oxygen and phosphorus.
- Unlike the flow of energy among the living organisms of an ecosystem which occurs on an open system, all the nutrients used in an ecosystem by living organisms operate on a closed system. That is they are recycled within organisms in the system over and over again.
- Carbon, nitrogen and oxygen have gaseous or liquid reservoirs as does water. All the other nutrients, such as phosphorus have solid reservoirs.
- The carbon cycle is unusual among nutrient cycles because it need not involve decomposers.
- The nitrogen cycle is a complex process involving the activities of many genera of bacteria.
- Phosphates are relatively insoluble and are present in most soils only in small amounts. They often are so scarce that their absence limits plant growth, hence the use of fertilizer like superphosphate in agriculture to boost crop production.
- There is an interconnection between the various types of nutrient cycles.

6.0 TUTOR MARKED ASSIGNMENT

- What are biogeochemical cycles? What are the primary reservoirs for the chemicals in these cycles?
- From what source does most of the water over land reach the atmosphere? How does transpiration differ from evaporation?

7.0 FURTHER READING/REFERENCES

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MODULE I: THE STUDY OF ECOSYSTEMS

UNIT IV: INTERACTIONS WITHIN ECOSYSTEMS

CONTENTS **PAGE**

1.0 INTRODUCTION

Populations of different organisms live together in a community which together with the nonliving factors of the environment forms an ecosystem. The organisms interact among themselves in various ways for survival. Earlier in unit one, we had observed that in a trophic level, a carnivore would feed on a herbivore. That is an example of a predator/prey interaction. Various other forms of interactions between organisms within the same community will be looked into in this unit.

2.0 OBJECTIVES:

By the end of this unit, you should be able to:

- Enumerate the major types of interactions that occur among organisms of a community within an ecosystem.
- Indicate some mechanisms employed by organisms to ward off predators.
- Know what symbiotic interactions are and differentiate between the negative and positive interactions.
- Explain the differences between commensalism, matualism and parasitism.
- Describe how interspecific competition differs from intraspecific competition.

3.0 TYPES OF INTERACTIONS

Interactions between organisms that characterize particular communities have risen as a result of their evolutionary trend. The plants, animals, protists, fungi and bacteria that live together in communities have changed and adjusted to one another continually over a period of millions of years. Many communities are very similar in their species composition and appearance over wide areas. For example, the open savanna that stretches across much of Africa includes many plant and animal species that coexist over thousands of square kilometers. Interactions between these organisms, some of which have evolved over millions of years, occur in a similar manner throughout these grassland communities. Some of these interactions include:

- Predator/Prey interaction
- Symbiosis
- Commensalism
- Parasitism
- Competition (Interspecific and Intraspecific)

While mutualism and commensalism are positive interactions others, like parasitism, predation and competition are negative interactions.

3.1 PREDATOR-PREY INTERACTION

Predator-prey interactions are interactions between organisms in which one organism feeds on the other. A good example is a lion hunting a gazelle in an open Savanna of Africa. The predators have natural characteristics and developed recognizable strategies that help them hunt and capture their prey. The strategies that prey use to avoid being eaten are not so obvious. Some animals however, employ chemical defences to ward off predators. Venomous snakes, lizards and fishes are well known examples. Also, bees, wasps, predatory bugs, scorpions, spiders and many other arthropods have chemicals that they use to defend themselves and to kill their prey. The dart-poison frogs of the family Denrobatidae produce toxic alkaloids in the mucus that covers their skin so powerful that a few micrograms will kill a person if injected into the bloodstream.

Among plants¸ obvious structures are developed such as thorns, spikes, prickles to discourage browsers like vertebrate herbivores from feeding on them. Some grass deposit silica in their leaves to make them too tough to eat. Plants like in the potato and tomato family (Solanacea) are rich in alkaloids and steroids, while some others like in the milk weed family (Asclepiadeceae) tend to produce a milky sap that deters herbivores from eating them.

3.2 SYMBIOTIC INTERACTIONS (SYMBIOSIS)

Symbiotic relationships are those in which two or more kinds of organisms live together in often elaborate and more or less permanent relationship. Examples of symbiosis include lichens, which are associations of certain fungi with green algae or *Cyanobacteria*, and *Mycorrhizae* formed from the association between fungi and the roots of most kinds of plants. Here the fungi expedite the absorption of certain nutrients by the plants and the plants provide the fungi with carbohydrates.

The major kinds of symbiotic relationships include:

- Commensalism

- Mutualism
- Parasitism

3.2.1 **Commensalism**

In nature, the individuals of one species are often physically attached to those of another. For example, epiphytes are plants that grow on the branches of other plants. In general, the host plant is unharmed while the organism that grows on it benefits.

Marine barnacles grow on other often actively moving sea animals and are thus carried passively from place to place. The barnacles gain protection from predation and by the free movement, reach new sources of food.

On land commensal interactions occur between certain birds called Oxpeckers and grazing animals, such as cattle or Rhinoceros. The birds spend most of their time clinging to the animals, picking off parasites and other insects and carry out their entire life cycles in close association with the host animal. Cattle egrets in association with Fulani cattle provide a good example of this type of relationship in Nigeria.

3.2.2 **Mutualism**

In mutualism, each organism involved in the symbiotic relationship benefits. Leafcutter ants in the tropics are known to remove a quarter or more of the total surface of the plants in a given area. They do not eat the leaves but take them to their underground nests where they chew them up and inoculate them with the spores of particular fungi. These fungi are cultivated by the ants and brought from one specially prepared bed to another where they grow and reproduce. In turn, the fungi constitute the primary food of the ants and their larvae.

Ants and aphids provide another example. Aphids are small insects that suck fluids from the phloem of living plants with their piercing mouthparts. They extract a certain amount of sucrose and other nutrients from this fluid but much is excreted in an altered form through their anus as honeydew. The ants carry the aphids to new plants where they come in contact with new sources of food and then use the honeydew as food.

3.2.3 Parasitism

Parasitism is a symbiotic relationship which is harmful to the prey organism and beneficial to the parasite. The parasite is much smaller than the prey and remains closely associated to it.

Both vertebrates and invertebrates are parasitized by members of many different phyla of animals and protists.

Parasites can be internal or external. Internal parasites of humans include tapeworm, roundworm and hookworm. The internal parasites are generally marked by much more extreme specialization than the external ones. The more closely the life of the parasite is linked to that of its host, the more its morphology and behavior are likely to have been modified during the course of its evolution. Consequently, the structure of an internal parasite is often simplified and unnecessary armaments and structures are lost as it evolves.

External parasites live on the bodies of vertebrates mainly birds and mammals. They include lice and fleas. They have developed adequate structures to attach themselves to the hairs or feathers of mammals and birds. Invertebrates are also parasitized. Many fungi and some flowering plants are parasitic on other plants and a few are pests of crops. A heavy infection of parasites called the "parasite load" may eventually cause the death of the host, directly or indirectly, by weakening it so that it succumbs to a predator or disease.

3.4 COMPETITION

Competition as an interaction occurs among organisms within a community of an ecosystem when they require the same resource that is in short supply called resource competition, or when the organisms seeking a resource harm one another in the process even if the resource is not in short supply. This is called interference competition. Competition can be interspecific or intraspecific.

3.4.1 Interspecific Competition

Interspecific competition refers to the interactions between individuals of different species, both of which require the same resources that is in short supply. Interspecific competition is often greatest between organisms that obtain their food in similar ways. We find as a result that green plants compete with other green plants for sunlight, nutrient and water, herbivores with other herbivores and carnivores with carnivores. In addition, competition is more acute between similar organisms than between ones that are less similar.

3.4.2 Intraspecific Competition

Intraspecific competition occurs when individuals of a single species or of the same species compete for a resource in short supply. Food and mating partners provide examples of causes for intraspecific competition. Competition for space may occur in some animals such as for nesting sites, wintering sites or sites safe from predators.

SELF ASSESSMENT EXERCISE

- Differentiate between interspecific and intraspecific competition.
- Explain what is meant by predator-prey interaction.

4.0 CONCLUSION

Organisms within ecosystems interact among themselves at both interspecific and intraspecific levels. The interactions can either be negative or positive. Interactions occur over resources especially when in short supply.

5.0 SUMMARY

In this unit we have learnt that

- Interactions among organisms of communities have evolved over years of species co-existence.
- Interactions can be interspecific (between species) or intraspecific (among same species).
- Some interactions are negative eg predation and parasitism while some others are positive eg mutualism and commensalism.
- Some organisms have developed various means to ward off predators.
- Competition among organisms at interspecific or intraspecific levels occurs over resources especially when in short supply.

6.0 TUTOR MARKED ASSIGNMENT

- Name some defence methods used by organisms to protect themselves against predation..
- What symbiotic relationship will you give to the following?
    - Ants and aphids
    - Lice and birds
    - Fleas and humans
    - Cats and rats
    - Cattle egret and cattle

7.0 FURTHER READING/REFERENCES

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MODULE I: THE STUDY OF ECOSYSTEMS

UNIT V: SUCCESSION IN ECOSYSTEM

CONTENTS **PAGE**

1.0 INTRODUCTION

Ecosystems have a tendency to change from very simple to complex in a process known as succession even when the climate of a given area remains stable year after year. A vacant open space or cleared woods slowly become occupied with an increasing number of larger and larger plants. A pond becomes filled with vegetation that encroaches from the sides and gradually turns it to dry land with vegetation. This progressive change in vegetation with time will be studied in this unit under succession.

2.0 OBJECTIVES:

By the end of this unit, you should be able to understand fully the;

- Meaning of succession
- Difference between primary succession and secondary succession
- Process of primary succession
- The influence of man on succession.

3.0 Ecological Succession

Succession is a process of ecological change over time in a given area of an ecosystem from simple to complex. This change occurs even when the climate remains stable year after year. Succession is continuous and worldwide in scope. If for example a wooded area is cleared and left alone, plants will slowly reclaim the area. Eventually traces of the clearing will disappear and the area will again be woods.

Succession is a natural change. As such, changes caused by the direct influence of humans in clearing and replanting land cannot be defined as succession.

Succession can either be primary or secondary.

3.1 Primary Succession

Primary succession occurs on bare, lifeless substrate like a rock or un-colonised ground which has never had any vegetation growing on it before or in open water like newly formed lakes. It may also occur on sand dunes, lava flows of volcanoes, new volcanic islands, landslips or lakes left behind after the retreat of glaciers. On a bare rock, the process may start with the growth of pioneer species like lichens, forming small pockets of soil. Acidic secretions from the lichens and from the plants, that grow on the rocks, later help to break down the substrate and add to the accumulation of soil. Mosses may then colonise these pockets of soil, eventually followed by ferns, horsetails and the seedlings of flowering plants. Over many thousands of years or even longer, the rocks may be completely broken down and the vegetation over an area where there was once a rock outcrop may be just like that of the surrounding grassland or forest. This type of primary succession on a rock is called lithosere while when on bare ground is called a xerosere. In contrast primary succession which develops in aquatic environment is called hydrosere. A new lake, poor in nutrients may gradually accumulate organic matter and become rich in nutrients. Plants standing along the edges of the lake like cattails and rushes, and those growing submerged such as pondweeds together with other organisms like algae plants whose spores are carried by air to the lake may contribute to the formation of a rich organic soil. As this process continues, and the build-up increases, the pond may become shallower and vegetation will increase. Slowly, terrestrial vegetation will encroach from the sides and fill the pond.

Eventually, the area where the pond once stood may become an indistinguishable part of the surrounding vegetation.

The process of succession on the rock or lake referred to above may over a very long term make them feature the same kind of vegetation characteristic of the region as a whole. This made the American ecologist Clements many years ago propose the concept of “Climax Vegetation”. He felt that succession represented a unidirectional series of changes which could not be reversed. But now, with an increasing realization that;

i. The climate keeps changing
ii. The process of succession is often very slow
iii. The nature of a regions vegetation is being determined to a greater extent by human activities, ecologists do not consider the concepts of climax vegetation to be as useful as they once did. Clements ideas are thought to be too precise and rigidly organized to reflect the realities of ecosystem change.

3.2 Secondary Succession

If a wooded area is cleared and left alone, plants will slowly reclaim the area. Eventually, traces of the clearing will disappear and the area will again be woods. The sequences of vegetation developing on these previously vegetated and cleared areas are called secondary succession. The changes that occur on abandoned cultivated land or that take place when a fire has burned off an area are also secondary succession. Humans are often responsible for initiating secondary succession.

3.3 Human Influence on Succession

A large amount of the terrestrial surface of the earth carries vegetation which is no longer in natural succession. Human interference for agricultural production has halted vegetation change or completely destroyed the natural vegetation. The most obvious effects of farming practices are found on arable land where the natural vegetation has been cleared and monocultures of crops are grown instead. Such plants are only grown for a few months before they are harvested, the soil turned over and new crop planted. The only wild plants able to survive such practices are quick growing annual weeds which can flower and set seed before the crop is harvested. Another major managed vegetation type is grassland. Grazing by sheep, cattle or other domestic animals or mowing either for short turf or once a year for hay, all maintain grassland and prevent succession to scrub. The effects of human land management on preventing and diverting succession are obviously seen around the world today. Large areas of natural vegetation have been cleared the most controversial perhaps being the clearance of tropical rainforest for the creation of grassland for cattle.

Such large scale clearance usually alters the ecosystem involved.

SELF ASSESSMENT EXERCISE

- Explain the following terms:- Lithosere, Xerosere and Hydrosere
- What do you understand by ecological succession?

4.0 Conclusion

Primary succession starts from the scratch in areas that are originally bare like rocks or open water. Secondary succession takes place in areas where the communities or organisms that existed initially had been disturbed. Both types of succession lead ultimately to the formation of climax communities if left undisturbed.

5.0 Summary

In this unit, we have learnt that;

- Succession is a process of ecological change from simple to complex that occurs over time in a given area of an ecosystem
- Succession can be primary or secondary.
- Primary succession starts from a bare surface either of rock, san dunes, volcanic eruption or open water.
- Secondary succession takes place after a disturbance on a community of organisms that had existed initially.
- Primary succession occurring on a rock is called lithosere, on a bare ground xerosere and on open water (lake or pond) hydrosere.

- Humans by their agricultural activities have disrupted the process of succession in many parts of the world.

6.0 Tutor Mark Assignment

- What is primary succession?
  Name three locations where primary succession can take place.
- What types of organisms are often associated with early stages of primary succession?
- Explain in details why humans are considered to initiate secondary succession.

7.0 Further Reading/References

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MODULE II: POPULATION DYNAMICS

UNIT I: THE STUDY OF POPULATIONS

CONTENTS **PAGE**

1.0 INTRODUCTION

Organisms do not live solitary lives in isolation from other members of their species. Usually, they live in groups or if normally single, they interact with other members of their species at various times in their lives. Some characteristics of such organisms of the same species living and interacting together in one place at the same time will be studied under this unit.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- Understand what makes a population
- Know some attributes of populations.
- Determine the types of dispersion found in populations.
- Know what exponential growth is and how it is affected by the environment.
- Calculate the growth rate of a population
- Know how to undertake a population estimate
- Know some ways to determine the age of organisms.

3.0 CONCEPT OF POPULATION

A group of individuals or organisms of the same species which live together in one geographical area at the same time is called a population. The individuals may be evenly spaced or randomly dispersed, clumped distribution pattern are the most frequent in nature. This is so because individuals of animals, plants or microorganisms tend to group in particular preferred local micro-habitats that are not uniformly distributed.

All populations have characteristic features like size, density, dispersion and demography.

3.1 POPULATION ATTRIBUTES

The attributes to be considered are size, density, growth, structure.

3.1.1 Population size

Size is an important feature of a population since it has a direct bearing on the ability of a given population to survive. Very small populations are the ones most likely to become extinct. Random events or natural disturbances are more likely to endanger a population if it contains only a few individuals. In- breeding can also be a negative factor in the survival of a small population. It can lower the vigor by direct genetic effects and can also reduce the level of variability which is likely to detract from the population's ability to adjust to changing conditions. An entire species that consists of only one or few small populations is likely to become extinct especially if it occurs in areas that have been or are undergoing radical changes.

3.1.2 Population density

We have earlier indicated how a population can evenly or randomly spread or may have a clumped distribution. Density is extremely important in a population. If the individuals that make up a population are widely spaced, they may rarely, if ever, encounter one another. The reproductive capabilities and therefore the future of the population may be very limited even if the absolute numbers of individuals over a wide area are relatively high. Population density is a measurement of the number of individuals per square kilometer of land area.

3.1.3 **Population growth**

An important characteristic of any population is its capacity to grow. Most populations tend to remain a relatively constant size regardless of how many offspring are produced. However under certain circumstances, a population size can increase rapidly. The innate capacity of growth, that is, the biotic potentials for any population is exponential. This can be expressed by the curve in (Fig 1.6). The rate of increase remains constant but actual increase in number of individuals accelerates rapidly as the size of the population grows. Real populations seldom show this exponential growth rate for many generations. No matter how rapidly populations grow under such circumstances, they eventually reach some environmental limit imposed by shortages of an important factor such as space, light, water or nutrients. The population ultimately stabilizes at a certain size called the carrying capacity of the particular place where it lives.

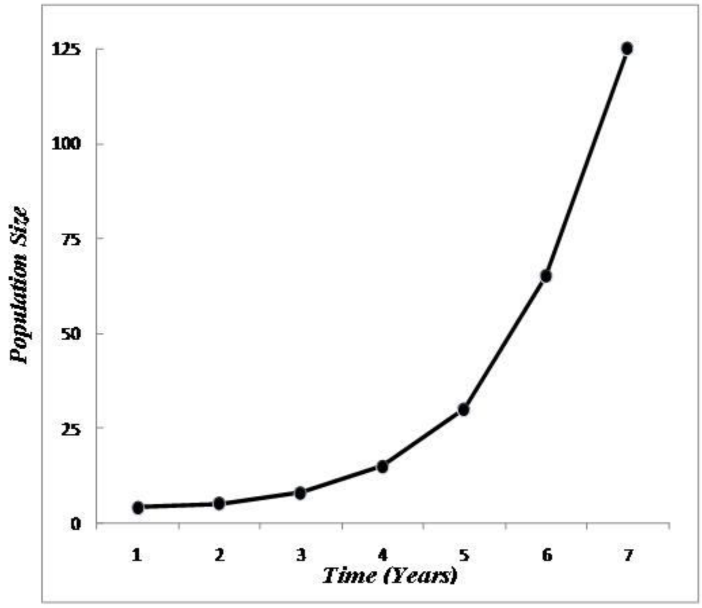

Fig 1.6: Hypothetical Population through time which shows exponential growth.

3.1.4 **Population Growth Rate**

Population growth rate (PGR) is the fractional rate at which the number of individuals in a population increases.

It specifically refers to the change in population over a unit time period, often expressed as a percentage of the number of individuals in the population at the beginning of that period. This can be written as the formula:

Population growth rate (PGR) =

$$\frac{\text{Population at end of period} - \text{Population at beginning of period}}{\text{Population at beginning of period}}$$

From the above, assuming that an hypothetical country with a population of 60 million people increased to 80 million in 10 years, the growth rate will be:

$$\frac{80m - 60m}{60m} = \frac{20}{60} = \frac{1}{3} \text{ or } .33$$

Growth rate = **.**33 over 10 year period.

The most common way to express population growth is as a ratio. The change in population over a unit time period is expressed as a percentage of the population at the beginning of the time period. That is: Growth ratio = Growth rate x 100%.

Thus for our hypothetical country, the growth ratio is **.**33 x 100% = 33%. A positive growth ratio (or rate) indicates that the population is increasing while a negative growth ratio (or rate) indicates population decline. A growth rate of zero indicates that there were the same number of people at the two periods.

3.1.5 **Age structure and population estimate**

Age structure is important for the study of populations along with knowing the size of the population. The number of individuals is easiest to estimate where the organisms are large or stationary like trees. For small and mobile organisms like insects and small mammals, then, it will not be possible to count the population exactly. Under such circumstances, a method is used to estimate populations called mark, release and recapture method. First, several individuals are captured from the population and marked in such a way they can be recognized again. The marked individuals are released back to the population and given time to mix with the unmarked ones. Then more are captured which hopefully will include some of the marked individuals. The proportion of marked to unmarked individuals captured this time around can be used to calculate the proportion of individuals in the whole population which were originally marked, and hence the population size. There is an assumption here that the marked individuals released after the first capture, mix in with the population after release and have the same chance of being recaptured as any unmarked individual.

Age of some organisms can be determined accurately like the annual growth rings in temperate trees, annual growth rings in the teeth of some animals, in fish scales, in shells of molluscs and in the otoliths (small calcareous grain found in the inner ear used for balancing) of mammals. It is difficult to determine the exact age of organism studied either because they do not have a structure which records yearly cycles or because study of such structure can only be done by killing or harming the organism. The age of such individuals are usually estimated and only give approximate ages.

Age structure and population size at each age group are valuable information to construct the survivorship curves or population pyramids.

SELF ASSESSMENT EXERCISE

- Name the ways in which the age of some organisms can be determined accurately.
- Name the three ways of population dispersion or spread. Which is most frequent and why?

4.0 CONCLUSION

Organisms or individuals of the same species which live together in an area at the same time as a population have characteristic features of size, density dispersion, growth, age and structure.

5.0 SUMMARY

In this unit we have learnt that:

- Population refers to organisms or individuals of same species living together in an area at the same time.
- Populations have attributes with which they can be studied and analysed.
- Very small populations are the ones most likely to be extinct from random events, natural disturbances or even inbreeding.
- Populations can be evenly or randomly spread or have a clumped distribution.
- Exponential growth of populations is not a common phenomenon as the carrying capacity of the environment imposes limits on growth.
- Population size of some organisms can be estimated by mark, release and recapture method.
- Some features can be used to fairly determine the age of some organisms.

6.0 TUTOR MARKED ASSIGNMENT

- Which is more likely to become extinct; a small population or a large population? Why?

- Describe the status of a population with more deaths than births and more emigration than immigration within a given time frame.

7.0 FURTHER READING/REFERENCES

- Raven, P.H. and Johnson G.B. (1998) Population Dynamics (532 – 551) In BIOLOGY WCB/McGrow-Hill, Boston.
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MODULE II: POPULATION DYNAMICS

UNIT II: PATTERNS IN POPULATION DYNAMICS

CONTENTS **PAGE**

1.0 INTRODUCTION

In the study of populations of organisms various patterns are employed to understand their characteristic features. Analysis of acquired data over time provides opportunities for understanding and interpreting some of the characteristic features. This unit will study some ways of interpreting population data for better understanding of populations.

2.0 OBJECTIVES

By the end of this unit you should be able to

- Know and be able to construct a population Life Table
- Know and interpret population pyramids
- Know what is meant by survivorship curves
- Interpret the 3 types of survivorship curves
- Understand the evolutionary strategies of populations

3.0 PRESENTATION OF DEMOGRAPHIC DATA

The numerical data collected during a population study can be presented in various ways for the purpose of clarity. Some of the ways of analyzing the data will be considered in this unit.

3.1 POPULATION LIFE TABLES

Numerical data collected during a population study and presented as a table of figures is known as a Life Table. Life tables usually represent data for a cohort but can also be produced using age structure data. A cohort is a group of organisms from one population which are roughly the same age. A life table data for a cohort follows one group of individuals from the beginning of their life through to their death. The number alive at a given time is shown to the death of the last individual. Cohort studies are therefore not suitable for very long-lived species as they would take too long to complete. A mixture of age structure and cohort is best for long life species. An example of an age structure life table is shown with the case of the black berry plant (*Prunus serotina*) Fig I.7.

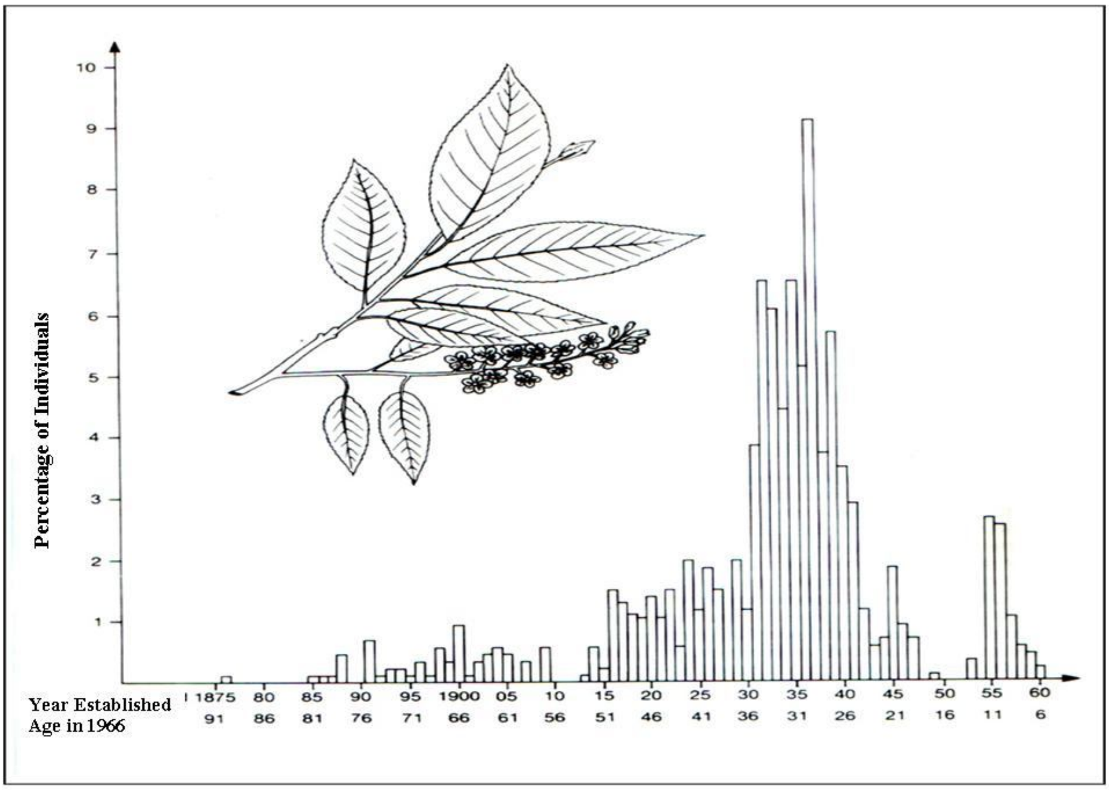

Fig 1.7 : The age structure of black cherry *(Prunus serotina)* populations found in oak forests, Wisconsin, USA. (From Chapman & Reiss, 1995).

3.2 POPULATION PYRAMID

Another way of representing population data is as population pyramids. These are often used in human demography as they have the advantage of showing males and females separately on the same graph. The pyramid is really two bar graphs back to back with males conventionally shown to the left and females to the right of a central vertical age axis. A population pyramid shows the composition of a population by age and sex. For humans, where population pyramids usually represent numbers for a whole country, the shape of the pyramid reflects birth and death rates. Bottom-heavy pyramids show increasing annual birth rates or high birth rates and high infant mortality e.g. Kenya (Fig 2.7). Top heavy pyramids with more old people than expected show a decreasing birth rate and good adult survival e.g. Austria (Fig 2.7a). In most human population pyramids, the number of female will be disproportionately large as compared with the number of males. Females in most regions have a longer life expectancy than males.

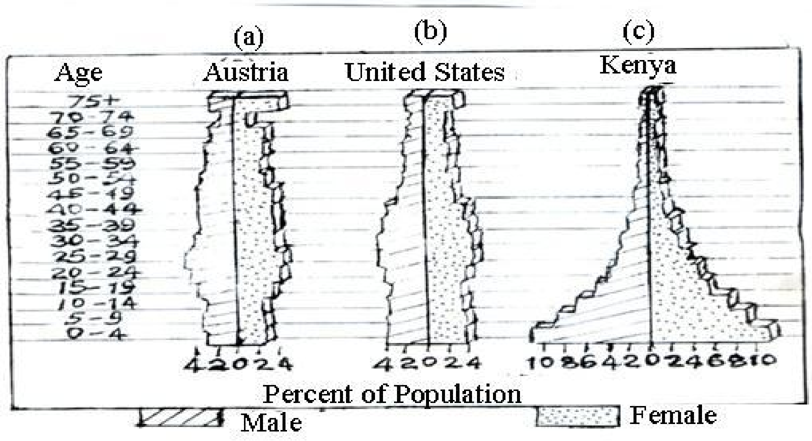

Fig 2.7: Three 1990 Population Pyramids
(a) Austria (b) United States (c) Kenya
(From Raven & Johnson, 1996)

3.3 POPULATION SURVIVORSHIP CURVES

One way to express the characteristic of populations with respect to age distribution is the survivorship curve. This is a graph showing the number of individuals which survive per thousand of population through each phase of life. Even where the population is less than a thousand, it is standardized to a thousand so that life tables can easily be compared. Besides using numbers, survivorship curves can also be presented using a semi-log plot.

Three major samples of survivorship curves are shown in Fig 3.7

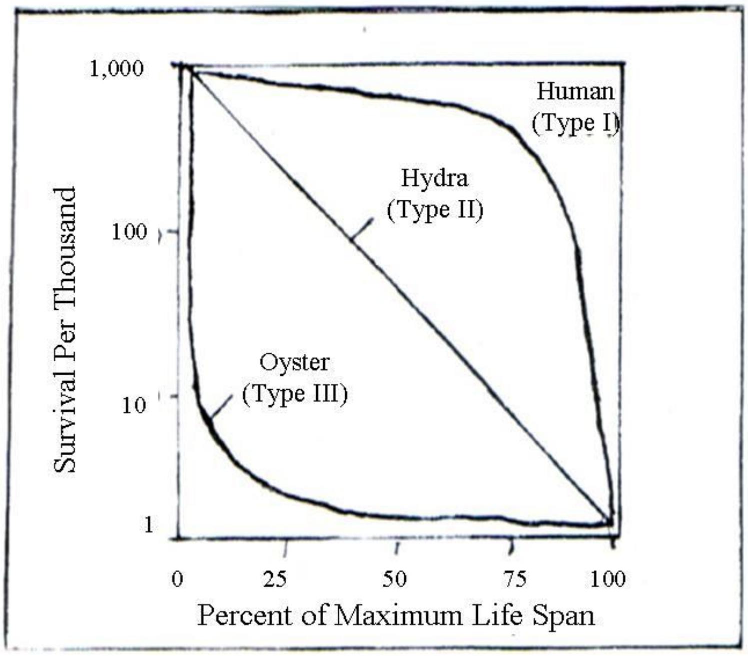

Fig 3.7:
Survivorship curves for Oyster, for Hydra (a microscopic fresh water animal) and humans. (From Raven & Johnson, 1996)

In hydra, individuals are equally likely to die at any age; as indicated by the straight survivorship curve (type II) Fig 3.7 Oysters on the other hand produce vast numbers of offspring, only a few of which live to reproduce. However, once they become established and grow into reproductive individuals their mortality is extremely low (type III survivorship curve) Fig 3.7. Even though human babies are susceptible to death at relative high rates the highest mortality in people occurs later in life in their post reproductive years (type I survivorship curve) Fig 3.7. Many animal and protist populations in nature probably have survivorship curves that lie somewhere between those characteristic of type II and type III. Plant populations with high mortality at the seed and seedling stages are probably closer to type III. The shape of survivorship curves can be used to tell at a glance what critical periods in the lives of individual organisms are. For example, where the curve becomes steeper, there is an increase in mortality which indicates some environmental or developmental effect on the population.

3.4 EVOLUTIONARY STRATEGIES

The general forms of survivorship curves can indicate what evolutionary strategy a species has and how population numbers are maintained. Individuals in populations with type 1 curves usually have few offspring. These offspring are well cared for so that their chance of survival is high. Such strategies occur in birds and large animals, including humans. Species with type lll curves usually have large numbers of offspring, most of which die before they reach maturity. Most plants, fungi, fish, amphibian and invertebrates have this strategy.

3.4.1 r- and k - strategies

No matter how rapidly populations grow under certain circumstances, they eventually reach some environmental limit imposed by shortage of an important factor such a space, light, water or nutrients. A population ultimately stabilizes at a certain size called the carrying capacity of the particular place where it lives. The growth curve of a specific population which is always limited by one or more factors in the environment can be approximated by the following equation.

Growth rate (R) = $dN/dt = r N (K - N/K)$

In other words, the growth rate of the population under consideration (dN) equals its rate of increase (r) multiplied by N the number of individuals present at any one time and then multiplied by an expression equal to K, the carrying capacity of the environment, minus N divided by K. As N increases (the population grows in size), the fraction by which r is multiplied becomes smaller and smaller, and the rate of increase of the population declines. It follows therefore that as N approaches K, the rate of population growth dN/dt begins to slow until it reaches O, when N =K.

Graphically the relationship gives an S shaped curve called the Sigmoid growth curve (Fig 4.7).

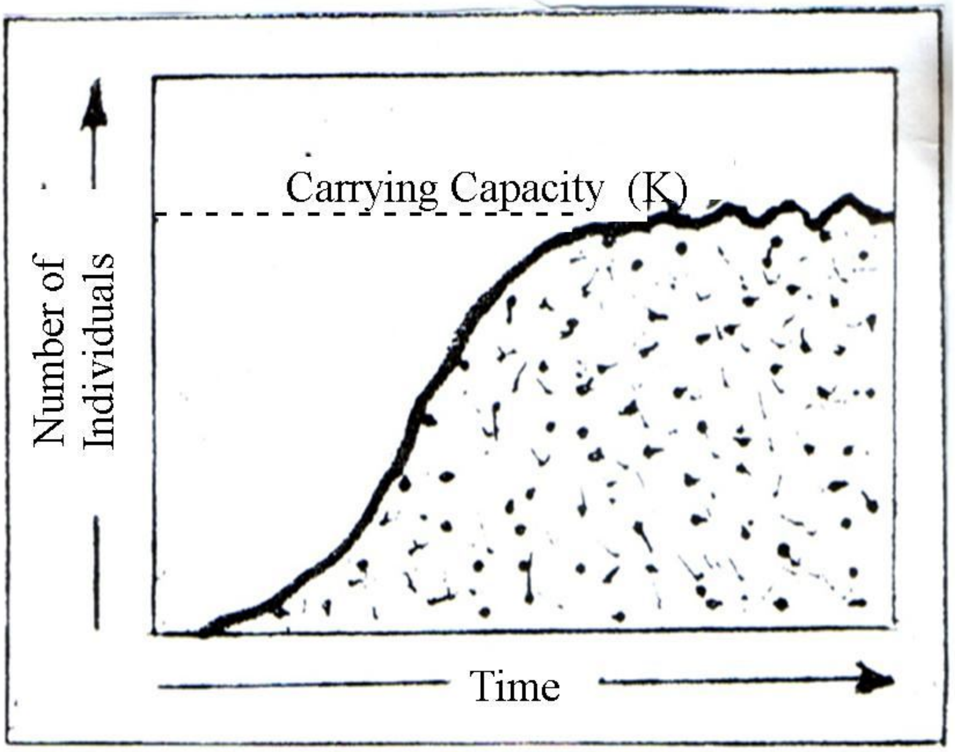

Fig 4.7:
The Sigmoid growth curve (From Raven & Johnson, 1996)

The curve is called sigmoid because it resembles the Greek letter sigma (s). As the size of population stabilizes, its rate of growth slows down and eventually it does not increase further.

r- and k– strategies are another way of classifying evolutionary strategies suggested by MacArthur and Wilson (1967). The initials r- and k- come from the logistic equation for describing the actual rate of growth of population R or dN/dt. From the equation it can be seen that an r - selected population is one in which the maximum rate of increase (r) is important. An r – selected population can take advantage of a favourable situation by having the ability to increase population size rapidly. This means having many offspring which under normal circumstances die before reaching maturity but which may survive if circumstances changed. Hence r– selection is associated with type III survivorship curve of Fig 3.7. On the other hand, a K- selected population is associated with a steady carrying capacity (K).

K-selected populations are less able to take advantage of particular opportunities to expand than are r-selected populations. They are in general, more stable and less likely to suffer high mortality rates of immature individuals. Usually, K-selected organisms have few, well cared for young and tend to be associated with type I survivorship curve as indicated in Fig 3.7.

SELF ASSESSMENT EXERCISE

- Describe the components of a human population pyramid

- Explain the characteristics of (a) Top heavy population pyramids and (b) Bottom heavy population pyramids.

4.0 CONCLUSION

Through the analysis of demographic data, adequate information can be provided on the growth, sustenance and survival of populations of organisms.

5.0 SUMMARY

In this unit we have learnt that

- Population life tables either for age structure or cohort show the number surviving or dying in a population in a given time for various age classes.
- Population pyramid shows the composition of a population by age and sex usually for a whole country and reflects birth and death rates.
- There are 3 types of survivorship curves used to describe the characteristics of mortality in different kinds of populations.
- The survivorship curves as affect organisms have evolutionary tendencies which are also reflected by the r – and k – strategies.

6.0 TUTOR MARKED ASSIGNMENT

- What is the difference between an age structure life table and a cohort life table?
- Define survivorship curve. Describe the three types of survivorship curves and give an example of each.
- Compare and contrast k-strategies and r-strategies.
  What type of growth curve do they exhibit?
  What are the relative number and size of their offspring?

7.0 FURTHER READING/REFERENCES

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- Chapman, JL and Reiss MJ (1995): Population Dynamics (26-39) In ECOLOGY, principles and applications. Cambridge University Press. UK.
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MODULE II: POPULATION DYNAMICS

UNIT III: POPULATION REGULATION

CONTENTS **PAGE**

1.0 INTRODUCTION

We have known how a population of an organism can undergo an exponential growth increase until the environment imposes a limit at the carrying capacity level. Various other factors come into play to regulate the populations of organisms. Some of these regulatory factors will be studied in this unit.

2.0 OBJECTIVES

By the end of this unit, you should be able to;

- Explain what is meant by population regulation
- Know the difference between density dependent factors and density – independent factors of population regulation.
- Know the roles played by space, nutrient, water and territory on population regulation
- Describe how predator-prey interactions regulate population.
- Name some density-independent factors that regulate population.

3.0 POPULATION REGULATION

Often a population invading a new area where food and space are plentiful will undergo exponential growth to begin with. Soon however, the external constraints of the environment influence the rate of increase which begins to decline. Eventually, in most cases, the population stabilizes. The number in the population at the stabilized state is called the carrying capacity of the environment. The carrying capacity has imposed a check or regulation on further growth of the population. Other ways of population regulation will be looked into in this unit.

3.1 Types of Population Regulation

Population regulation can conveniently be divided into density dependent factors and density independent factors.

Factors that are dependent on the size of a population to regulate the growth of the population are said to be Density-Dependent.

Factors that operate regardless of population size, such as weather or physical disruption are said to be Density-Independent.

3.2 Density-Dependent Factors

Density dependent factors in general are those that have an increasing effect in population as population size increases. As the population grows, the individuals in the population compete with increasing intensity for limited resources. Such resources include space, water and nutrients. The more individuals there are competing for the resources, the higher the mortality will be in the population.

3.2.1 Space

Space is the most basic requirement of an organism. Because most animals are not stationary, competition for space may come under territory defence. For plants, space is important especially for plant leaves to catch the sunlight. Except a plant is isolated, at a point in growth the plant starts to interfere with or will be interfered with by neighbouring plants of the same species or different species. Thus, a mature plant will probably have displaced several others to stunted growth or death. Examples can be found in some plantations. As seedlings get larger, they begin to compete for space. Some plants are out-competed and die as others take over their space. As such, the density of plants fall in a process called self-thinning.

3.2.2 **Food and Water**

Both plants and animals require energy, nutrients and water to survive, grow and reproduce. Food for photosynthetic plants means mineral nutrients, carbon dioxide and the presence of enough light to synthesise organic molecules.

We have learnt earlier in this unit that plants, when clustered together, their leaves struggle for space to catch the light and fix energy from the sun. The vital nutrients for plant growth especially, nitrogen, potassium and phosphorus are often in short supply in soils. Soil nutrient content may limit population size of certain plant species. In fact, not to be overgrown by the bush foliage of the larger plants that grow well in the fertile soil, some low-growing plants favour growing in poor soil. Invariably when plants cluster together for nutrient and water, some outgrow others to bring about stunted growth or death.

Food and water have direct effect on the health of animals and on their reproductive potential. The lack of sufficient food to maximize reproductive potential may be the most important regulator of population size in animals. Thus, where the preferred source of food of an organism is available in abundance the population of the organism rises. At a period of scarcity, it falls. The life style of some herbivores in temperate regions is affected by this situation. In summer and autumn food abound as young shoots and fruits but, come winter, foliage becomes rare and of low quality. Herbivores then alter their life style to migrate, hibernate or live as best they can, often with considerable loss of life. At such periods also, carnivores have difficulties which often would lead to higher mortality because of lack of herbivore prey to feed on. Some animals react to overcrowding by hormonal changes. When the migratory locusts (short horned grasshoppers) are crowded, they produce hormones that cause them to enter a migratory phase in which the locusts take off as a swarm and fly long distances to new habitats.

3.2.3 **Territories**

While plants struggle for space to get enough light, nutrient and water, animals struggle to acquire territories. Such a territory is an area which contains a resource of sufficient value to an animal that it defends. The animal holds or defends the territory by marking the boundaries in some way and challenging strangers if they approach too closely.

Many species including mammals, birds, reptiles, amphibians, fish insects and crustaceans are known to hold territories. Territories can be small or large and can be held by solitary animals e.g. tiger or whole social groups of animals like the meerkats (*Suricata suricatta*) where a few individuals keep watch for danger or strangers and the whole adult troop goes to defend the area if necessary. Small territories are usually for breeding sites as used by birds. The size and number of territories in an area affects how many breeding individuals can live in the area and so influences population size.

In a territory defended for food, the amount the animal needs and the amount and quality of the food in the defended area will affect territory size and regulate population size.

3.2.4 **Predator-Prey Relation**

Predators obviously affect the population size of their prey by limiting the population. A low population of the prey species usually provides inadequate food for the predators and the predator population decreases. As this occurs, the prey population can recover. In this situation, the predator and prey populations follow a cyclical pattern. However, if numbers of prey are influenced by food availability, then the predator may not be regulating the population at all. Only if predators are very efficient, or the prey population is slow to reproduce is predation likely to regulate the prey population.

3.3 **Density Independent Factors**

Density independent factors are those factors such as weather, fire, volcanic eruption and other catastrophes or physical disruption of the habitat that operate regardless of population size. These unpredictable factors tend to alter population size in a fairly haphazard way. A fire, flood, hurricane or volcanic eruption may wipe out many species in the vicinity of the disaster. New populations may then be established by immigrants from neighbouring populations. A huge meteor which crashed unto earth some 65 million years ago is thought to have caused the extinction of the dinosaurs and many other species at the end of the Cretaceous period. New populations are believed to have re-established at the affected sites.

SELF ASSESSMENT EXERCISE

- Explain the roles played by nutrients, space and territory in population regulation.
- Explain how a cyclical pattern is developed in predator-prey relations.

4.0 Conclusion

In the populations of organisms, many factors come into play to regulate and put populations into check thus preventing over-population.

5.0 Summary

In this unit, we have learnt that;

- Population regulation provides the means of putting a check on population growth.
- Population regulation can be density dependent which describes a situation where population growth is curtailed by crowding, predators and competition.

- Population regulation can also be density-independent where factors such as weather or environmental conditions operate to affect populations regardless of population size,
- Predator-prey relations also play a role in population regulation.

6.0 Tutor Marked Assignment

- Differentiate between Density-Dependent and Density Independent factors of population regulation.
- Explain how the population growth of an organism can be affected by density dependent and density independent factors.

7.0 Further Reading/References

- Raven,P.H. and Johnson GB (1998): Population Dynamics (532-551) In BIOLOGY. WCB/McGrow-Hill, Boston
- Chapman JL and Reiss MJ (1995): Population regulation (40-53): In ECOLOGY; principles and applications. Cambridge University Press UK.
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1.0 INTRODUCTION

The longest detailed record of population changes is for humans. The recent rapid increases in growth of human population threaten the sustainability of many regions and of the planet itself. This unit will study the trend in human population growth from early times, analyse the causes and consider the consequences of over population.

2.0 OBJECTIVES

By the end of the unit you should be able to:

- Understand the meaning of population as used for humans.
- Learn the trend in human population growth from ancient times.
- Know about the pattern of human population distribution.
- Know the implications of an increasing human population on the available natural resources in the world and the subsequent impact on the environment.
- Learn about the ways of solving problems of the environment and earth's resources arising from the activities of a rising human population.

3.0 THE HUMAN POPULATION

The term population is used rather differently in human demography from its strict ecological definition. It is usually used to represent the number of people in a country or sometimes in the world. With the social structure of humans, the patterns of world trade and the rate of travel, to apply the ecological definition of population on humans becomes difficult.

3.1 HUMAN POPULATION GROWTH

Estimates of world population are most accurate for the last few hundred years because detailed documentation exists. For the earlier periods, estimates had to be based on the interpretation of fragments of evidence. Before written records, estimates could only be made by demographers from archaeology and recent anthropology. For example, the study of recent hunter – gatherer and settler agricultural societies can be used to give an indication of the density of population which was likely to have occurred in such societies in the past. The general trend in world population from lower Paleolithic times seems to have been a slow increase in numbers. The growth rate for the population has been estimated as only about 0.001% up to about 10,000 years ago. The number of people in the world at the period was approximately 10 million. By the Neolithic period, there seems to have been a rapid increase in the population up to about 50 million. This increase in population growth rate up to 0.1% coincides with a change over from hunter-gatherer societies to more stable agricultural societies. With more dependable source of food where agriculture was practised, towns and cities developed and such settlements were widespread by 3,000B.C. At the time of Christ, there were an estimated 130 million people on earth about half the population of the United States today.

The ability to live together on a long-term basis in relatively large settlements made possible the specialization of professions which provided the necessary condition for the development of modern culture and of metal tools and utensils.

Three main periods of human population increase are recognized

The first is the suggested increase in population caused by the development of tools by Palaeolithic humans.

The second increase in population growth rate corresponds with the change from hunter-gatherer societies to settled agriculture (the Neolithic agricultural revolution).

The third burst in population growth is well documented as it is associated with the recent industrial revolution of the eighteenth and nineteenth centuries. A growth curve of human population is shown in Fig 1.9.

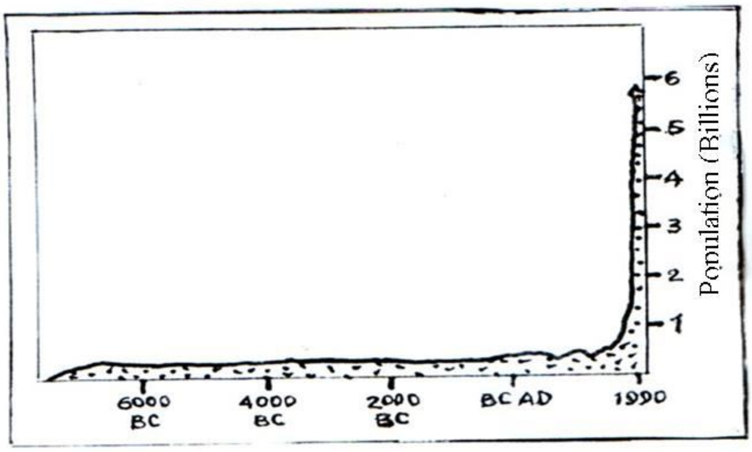

Fig 1.9: Growth curve of human population (Raven & Johnson, 1996)

In 1996, the human population on earth was found to have reached the staggering total of 5.8 billion from 2.5 billion as recently as 1950. The present current world population is about 6 billion people and increases at an annual world-wide rate of approximately 1.6%. At this rate which may seem relatively small, nearly 250,000 people are added to the world population each day. This will double the present population in only 43 years. Even where birth rate has reduced with the advocacy of birth control, death rate is also reducing due to better sanitation and improved medical techniques. The implications of a continuous rise in world population are numerous as will be observed later.

3.2 HUMAN POPULATION DISTRIBUTION

The distribution of human population around the world is not even just as the spread of resources is not. Clump distribution is common especially in industrialized countries. One fifth of the world's population which lives in these industrialized countries consumed 85% of the world's resources. Population growth is most rapid in the tropics and subtropics than in industrialized countries of the world.

The world is filled up with rapidly growing cities and mega cities like New York each of which contains more than 10 million inhabitants. Cities like Mexico City, Tokyo, Sao Paulo and Seoul have even higher populations than New York.

Although about 60% of the people in the world live in tropical or subtropical regions, city dwellers are fewer in these regions where many people live in absolute poverty and many others malnourished. The population growth, which is most rapid in the tropics and subtropics and leads to the modern day emergence of cities in these regions might create environmental hazard since they have less potential to solve the problems that arise in a crowded city.

3.3 RESOURCE CONSUMPTION

A large population of people will consume a lot of food and water, use a great deal of energy and raw materials and produce a great deal of waste and pollution. The present human population of about 6 billion people puts a lot of pressure on the environment as it consumes wastes or diverts an estimated 40% of the total global net photosynthetic productivity on land. One of the greatest and most immediate challenges facing today's world is to produce enough food to feed its expanding population. There is need to improve the productivity of crops that are already being grown. Much of this improvement must take place in the tropics and subtropics where the rapidly growing majority of the world's population lives.

Realising that the world's available resources are limited, there is need to learn how to manage the resources by stabilizing the human population. The facts virtually demand restraint in population growth which many countries e.g. China are already practising.

3.4 ENVIRONMENTAL IMPACTS OF RISING HUMAN POPULATIONS

Not only is the human population size which is still increasing a problem, but the level of consumption, the corresponding use of technology, the great deal of waste produced are among the present environmental challenges the earth faces.

The use of technology to sustain global prosperity has resulted in pollution of various types that are harmful to the environment. These include:

i. Acid rain**:** when sulphur introduced into the upper atmosphere combines with water vapour to produce sulphuric acid and the water later falls down as rain or snow.

ii. Global warming which occurs following increase concentration of carbon dioxide in the atmosphere.

iii. The Ozone hole caused by the thinning of the ozone layer in the stratosphere as a result of pollution from Chloroflourocarbons (CFCs) and other chemicals.

In addition to the above, with the rising population, forests especially tropical rain forests are being destroyed for agricultural purposes and burning for fuel. Such practices lead to increase deforestation and if undertaken in an area of fragile vegetation, desertification.

3.5 PROSPECTS FOR FUTURE

Most of the problems enumerated so far with regards to the threat on the earth's environment can be related to the rising human population. To reduce the threat, most countries are now devoting considerable attention to slowing the growth rate of their populations and there are genuine signs of progress. For now, the growth rate is higher in the tropical and subtropical countries which are less developed than the industrialised countries of Europe and the United states which enjoy a standard of living at least 20 times higher than in many developing countries. If the developing countries sustain the effort to slow down their growth rate, it is estimated that the world population might stabilize at some point in this century.

One of the greatest and most immediate challenges facing the world today is to produce enough food to its expanding population. The most promising strategy to achieve this is to improve the productivity of crops that are already being grown. Much of this improvement must take place in the tropics and subtropics where the rapidly growing majority of the world's population lives, including most of those enduring a life of extreme poverty.

New types of crops need also be identified especially ones that will do well in the tropics and subtropics. Improved cost effective agricultural techniques need also to be put in place in these areas.

The world needs to take action to reduce or eliminate the pollutants responsible for the formation of acid rain, the ozone hole, global warming and cancer. These global threats are the result of human activities.

SELF ASSESSMENT EXERCISE

- Name the three major periods of human population increase from earliest times to date. What circumstances caused the increase?
- Name some ways in which the explosive growth of human population affect the environment.

4.0 CONCLUSION

The human population is increasing beyond what the earth's present resources or technology can sustain. This is already having adverse effect on the environment and can threaten the lives of organisms. There is need for humans to take measures to reverse the trend.

5.0 SUMMARY

In this unit, we have learnt that:

- The term population as used in human demography differs from the strict ecological use of the word.
- Human population has been growing at an alarming rate following the industrial revolution and today about 250,000 births occur daily.
- The explosively growing population is placing considerable stress on the environment to the extent of being harmful to organisms.
- Among the challenges to the environment posed by human activities are releases of harmful materials into the environment found responsible for causing acid rain, global warming and ozone hole.
- Increased deforestation especially in the tropical rainforests, a consequence of human population growth, also contributes towards harming the environment To halt the problems, urgent steps need be taken to slow down human population growth, produce more food through improved technology, develop new technology that are less harmful to the environment, and ban the production and use of toxic chemicals.

TUTOR MARKED ASSIGNMENT

- In what part of the world is population growth most rapid and what are the consequences?

- Compare the distribution patterns of human population in the tropical and subtropical regions with those of the industrialized countries.
- Name some necessary actions to be undertaken to reverse the negative effects of human activities on the environment.

7.0 FURTHER READING/REFERENCES

- Chapman JL and Reiss MJ (1995): Human Population Dynamic (18): In: - ECOLOGY, principles and applications
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- Raven, PH and Johnson, GB (1998): The future of the Biosphere, (611-630): In: Biology WCB/McGrow-Hill, Boston.

MODULE III: BIOLOGICAL COMMUNITIES

UNIT I: THE CONCEPT OF COMMUNITIES AND COMMUNITY INTERACTIONS

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1.0 INTRODUCTION

Communities are populations of many species of organisms living together in the same habitat or environment. The habitats vary from terrestrial to aquatic and so, influence the types of communities living in them. We shall learn in this unit what make up communities, the types and how they are structured.

2.0 OBJECTIVES

By the end of this unit, you should able to;

- Define what a community is
- Name and understand the major types of communities
- Understand the influence of co-evolution on communities
- Explain the role played by biotic and abiotic factors on communities.
- Determine what influence the species richness of a community.

3.0 THE CONCEPT OF COMMUNITIES

A community is a grouping of populations of many species that live in the same place. The community is dynamic and reflects the variability and evolution of its components. It also involves vast interactions between very discrete groups.

3.1 COEVOLUTION OF SPECIES WITHIN COMMUNITIES

Interactions between organisms that characterize particular communities have arisen as a result of their evolutionary history. The plants, animals, protists, fungi and bacteria that live together in communities have changed and adjusted to one another continually over a period of millions of years. For example, many features of flowering plants have evolved in relation to the dispersal of the plants' gametes by animals, especially insects. These animals in turn have evolved a number of special traits that enable them to obtain food or other resources efficiently from the plants they visit, often from their flowers. In predator-prey interactions, carnivores eg lion have evolved strategies to help them capture their prey while the prey e.g. gazelle on their part evolved strategies for escape from predation. These are common features which have evolved over millions of years in, for example, the grassland communities of Africa.

The long-term evolutionary adjustment of two or more groups of organism that facilitate the organisms living together is termed coevolution. It is a process by which different kinds of organisms adjust to one another by genetic change over long periods of time.

The stepwise process ultimately involves adjustment of both groups of organisms. Defence mechanisms plants adopt like possession of thorns, spines and prickles or of chemical compound to prevent being eaten by herbivores, and various chemical defences of animals eg venomous snakes, lizards and fishes as well as stings from bees, wasps, predatory bugs, scorpions and spiders are various strategies evolved over time for survival within communities.

Coevolution can also be identified in the various types of symbiotic relations in which organisms have coevolved to the point of dependence.

3.2 TYPES OF COMMUNITIES

Biological communities are named according to their locations on land or water. Three major communities can therefore be identified as follows.

i. Terrestrial communities

ii. Ocean communities

iii. Freshwater communities

Some communities however take their names from physical features for example, rock pools, lakes and sand dunes. Specialized communities do also occur e.g. the mammalian gut communities.

3.2.1 Terrestrial Communities

The major terrestrial communities of organisms are structured largely by climate, particularly temperature and rainfall which is in turn influenced by the geographical location on the planet. Terrestrial communities are called biomes and are easily recognized by their overall appearance and characteristic climates Each biome, classified primarily by the general features of the vegetation, is similar in its structure and appearance wherever it occurs on earth and differs significantly from other kinds of biomes.

Biomes are classified in a number of different ways one of which will be adopted later in this unit.

3.2.2 Ocean or Marine Communities

Nearly three quarters of the earth surface is covered by ocean. A great wealth of nutrients and biomass are present in the world's oceans particularly in warm coastal regions and the planktonic stratum of the surface zone. About 40% of the world's photosynthetic productivity is estimated to occur in the oceans. Notwithstanding, an estimated 90% of living species of organisms are terrestrial although representatives of almost every phylum occur in the sea. Brackish water habitats usually occur between freshwater and marine.

3.2.3 Freshwater Communities

Very little of the earths water is stored as fresh water in ponds, rivers and lakes. Freshwater habitats are distinct from both marine and terrestrial ones but they are limited in area. Inland lakes cover about 1.8% of the earth's surface and running water covers about 0.3%. All freshwater habitats are strongly connected with terrestrial ones with marshes and swamps constituting intermediate habitats. Ponds and lakes have three zones in which organisms occur. The littoral zone is the shallow area along the shore. The limnetic zone is the well illuminated surface water away from the shore inhabited by plankton and other organisms that live in open water. The profundal zone is the area below the limits of effective light penetration.

3.3 THE STRUCTURE OF COMMUNITIES

Communities are affected by both the abiotic and biotic features of where they occupy. One of the abiotic features is the water situation, whether the physical environment is marine, fresh water, marsh, drained soil or desert. Also important are the mineral nutrients, geology and topography of the environment.

The abiotic features help to describe the overall form of communities which is usually determined by vegetation in terrestrial communities. Plants can have various growth forms including :-

Trees which create forest or woodland communities; bushes which dominate scrub; herbs and grasses which are the major types in grasslands like savannah or prairie and wet mosses which build up bogs.

This physical structure is not so obvious in aquatic habitats except where calcareous reefs occur.

The overall structure of a community is determined by a combination of features such as the physical environment, community size and longevity of species present. A recently developed community may contain only a few species and the number will increase as more species invade and establish. The species richness of a community is also influenced by features of the community including the age of the community, its primary productivity, the form of the organisms present and their competitive ability. A community may be stable or unstable, with high or low primary productivity and may change seasonally or even daily.

SELF ASSESSMENT EXERCISE

- What factors are responsible for the differences found in terrestrial communities?
- Where between the land and the oceans do we have a greater variety of species? Why are there more species in your area of choice?

4.0 **Conclusion**

Communities are indeed integrated groups of species which occur together in a common environment or habitat. Communities are influenced by co-evolution and are continually evolving and change dynamically through time.

5.0 **Summary**

In this unit we have learnt that;

- A community is a grouping of populations of many species that live in the same place, an environment or habitat.
- Many different organisms interact to determine the structure of the community.
- Interactions between organisms within a community have arisen out of their evolutionary history under what is termed co-evolution.
- The major types of communities are terrestrial, ocean or marine and freshwater. Specialized communities can also occur eg mammalian gut communities.
- Community structures are determined by biotic and abiotc factors.
- The species richness of a community is influenced by its age, its primary productivity, the form of the organisms present and their competitive ability.

6.0 **Tutor Marked Assignment**

- Explain in details how a community differs from a population.

- What is coevolution? What are examples of the advantages of coevolution?
- What are the abiotic and biotic features which affect the structure of communities?

7.0 Further Reading/References

- Raven PH and Johnson GB (1996): Biological Communities (585 – 609): In: BIOLOGY WCB/McGraw-Hill, Boston
- Chapman JL and Reiss MJ (1995): Communities (167-184)
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MODULE III: BIOLOGICAL COMMUNITIES

UNIT II: TERRESTRIAL BIOMES I

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1.0 INTRODUCTION

Many ecologists have tried to classify the principal terrestrial vegetation types into which the world is divided. These world vegetation types have come to be known as biomes. Aquatic biomes are also recognized. The biomes are many and the various types will be studied in this and subsequent units.

2.0 OBJECTIVES

BY the end of this unit you should be able to:

- Define accurately what biomes are
- Determine the major factors that influence the distribution of terrestrial biomes
- Have a knowledge of the characteristics of the following biomes
  - Tropical Rain Forest
  - Tropical Seasonal Forest
  - Savannah
  - Desert

3.0 DEFINITION OF BIOMES

Biomes are climatically and geographically defined areas of ecologically similar characteristic appearance of communities of plants, animals and soil organisms. Biomes are defined by factors such as plant structures (trees, shrubs, grasses), leaf types (such as broadleaf, needle leaf) plant spacing (forest, woodland, savanna) and climate. Climate is a major factor determining the distribution of terrestrial biomes. Among the important climatic factors are:

- Latitude**:** Arctic, boreal, temperate, subtropical, tropical
- Humidity**:** humid, semi-humid, semi-arid, arid
- Seasonal Variation**:** Rainfall may be distributed throughout the year or be marked by seasonal variation.
- Dry summer, wet winter: Most regions of the earth receive most of their rainfall during the summer months. Mediterranean climate regions receive their rainfall during winter months.
- Elevation**:** Increasing elevation causes a distribution of habitat types similar to that of increasing latitude.

3.1 CLASSIFICATION OF BIOMES

In general, biome classification schemes seek to define biomes using climatic measurements in particular latitude (or temperature zoning) and humidity.

However, no two taxonomists or ecologists seem to agree on a system of classification so, it is hardly surprising that a definitive list of biomes cannot be produced.

For the purpose of this study, the following major classification of biomes will be looked into

- Tropical rain forest
- Tropical seasonal forest
- Savannah
- Desert
- Temperate grassland
- Temperate deciduous forest
- Temperate shrubland (Mediterranean)

- Taiga
- Tundra

3.1.1 **TROPICAL RAIN FOREST**

Tropical rainforests occur near the equator where the rainfall is abundant and occurs throughout the year. They are found in South and Central America particularly in and around the Amazon basin, West and Equatorial Africa, South-East Asia, Indonesia and North-east Australia as in Fig 1.11. This continual combination of warmth and moisture allows continuous plant growth to occur. The tropical rainforest is the richest biome in terms of number of species probably containing at least half of the species of terrestrial organisms. Contrary to popular belief, undisturbed tropical rainforest is not impenetrable. This is because so little light is able to get through to the forest floor that relatively few plants can grow there. Many trees in the canopy are covered by epiphytes (plants growing on other plants) and some other trees produce aerial roots which absorb nutrients just as roots in the soil do. Much of the animal life is confined for most of the time to the canopy. Fruits are found throughout the year and specialized fruit eaters have evolved among the insects, the birds and the primates. Some other animals concentrate on feeding on leaves for example, the species of sloth in tropical South American forests.

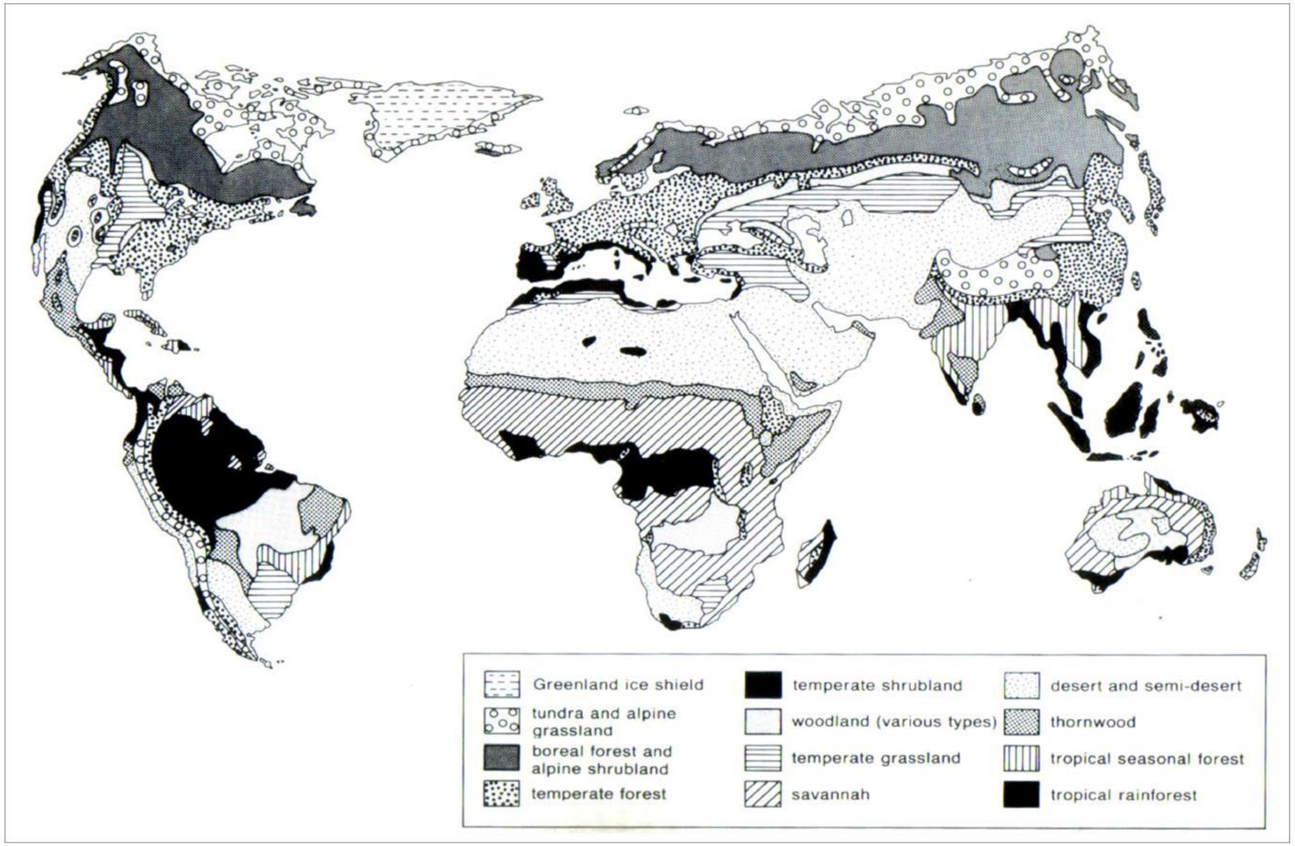

Fig 1.11 **The world's major terrestrial vegetation types. (From Friday and Ingram, 1985)**

3.1.2 **TROPICAL SEASONAL FOREST**

Close to tropical rain forests are tropical seasonal forests which occur in humid tropical climates with a clear dry season during which period trees lose their leaves. They are found in India, South-east Asia, West and East Africa, South and Central America and Northern Australia. The seasonality makes their habitat less diverse than the rain forests. Tropical seasonal forests are often found also where monsoons occur e.g. India. The monsoons provide seasonal rains as well.

3.1.3 **SAVANNAH**

Savannahs are tropical grasslands often with scattered trees. They are most extensive in Africa but are also found in Australia, South America and Southern Asia. Savannah is subjected to fire either from lightning or started by humans. Much of the African Savannah is burnt each year which has made savannah trees have thick bark which insulates the living cambium from the heat of the fire. The savannah or grassland of Africa is famed for its abundance of wildlife being inhabited by herds of grazing animal and their associated predators. The numerous herbivores including Zebra, Buffalo, gazelle and Giraffe support large numbers of mammalian carnivores like lion, Leopard, Cheetah and Spotted Hyena among others.

On a global scale, the savannah biome is transitional between tropical rainforest and desert. Generally, it records rainfall of between 90 - 150 cm annually. Temperatures annually fluctuate more in this biome than in the tropical rain forest and there is seasonal drought.

Savannahs have often been converted to agricultural purposes throughout the world and provide most of the agricultural products for many tropical and subtropical countries.

3.1.4 **DESERT**

Deserts are found throughout the world, mostly in the subtropical zone between 15 and 40^0 north and south of the equator.

Deserts usually receive less than 50mm of rain a year and the rain is unpredictable. Because vegetation is sparse and the skies are usually clear, deserts radiate heat rapidly at night. This leads to large daily changes in temperature, sometimes exceeding 30^0c between day and night.

Summer day time temperatures in deserts are extremely hot frequently exceeding 40^0c but nights are cool or cold. For most desert organisms the key to survival is being able to make use of the occasional heavy rainfalls.

Some ephemeral plants use the occasion to germinate, grow flower and produce seeds within the space of 20 – 30 days. Others survive as perennials as underground bulbs or corns with the above ground parts shooting out after heavy rain. Others like cacti are succulent with thick cuticles and sunken stomata which only open at night to minimize transpiration losses. Trees and shrubs that live in deserts often have deep roots that reach sources of water far below the surface of the ground.

Animals in the desert face a formidable array of problems. A wide variety of mechanisms have evolved to deal with the problems. To avoid high temperatures, most desert vertebrates live in deep, cool and sometimes even somewhat moist burrows. Active ones only emerge at night when the temperatures are relatively cool. Camels can drink large quantity of water when it is available and can then safely withstand the loss of much of it as they can tolerate a 30% loss of their total water content. Most mammals die if 14% of their water is lost.

Among the great deserts of the world are Namid and Kalahari deserts in the south of Africa, the Sahara desert in the north, the Arabian desert, the Gobi to the north of Himalayas and perhaps the driest of them all, the coastal Atacama desert of Peru and Chile in South America.

SELF ASSESSMENT EXERCISE

- Compare the tropical rain forest and the savannah in terms of rainfall, animal types, vegetation and burning by fire.
- Name some special adaptations desert plants and animals have developed.

4.0 CONCLUSION

Biomes are assemblages of organisms that have a characteristic appearance in such a way that makes one biome different from another. These differences in biomes are so unique in the four different biomes looked into in this unit.

5.0 **SUMMARY**

In this unit we have learnt that:

- The natural assemblages of organisms in the world can be divided into biomes.
- Terrestrial biomes are traditionally defined mainly in terms of their vegetation which is influenced by climatic factors of latitude and humidity.
- Tropical rain forests occur near the equator and is the richest biome in terms of number of species.
- Much of animal life in the tropical rain forest is for most part confined to the tree canopy.
- The tropical seasonal forest experience clear dry season during which trees lose their leaves.
- Savannahs are for the most part grasslands with a large wild life population of herbivores and their associated carnivores.
- Desserts are found all over the world and are the hottest and driest habitats on earth. Organisms that live in deserts develop special adaptations to help them cope with the harsh desert conditions.

6.0 TUTOR MARKED ASSIGNMENT

- What are the major factors that influence the formation of terrestrial biomes?
- What are the characteristics of the desert biome? How do the daily temperatures of the desert compare with those of the Tropical rain forest?

- Why do trees lose their leaves in tropical seasonal forest? In what parts of the world will you find this biome?

7.0 Further Reading/References

- Chapman JL and Reiss MJ (1995): Biomes (P 214 – 227)
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MODULE III: BIOLOGICAL COMMUNITIES

UNIT III: TERRESTRIAL BIOMES II

CONTENTS **PAGE**

1.0 INTRODUCTION

In unit 2 of this module, you will recall that we discussed terrestrial biomes I of the biological communities.

This unit will continue with the study of biomes with emphasis on biomes found in the temperate regions of the earth surface, areas cooler than the tropical regions already treated in the earlier unit.

2.0 OBJECTIVES

By the end of this unit you should be able to:

- Know the characteristics and locations of the following biomes
- Temperate rainforest
- Temperate deciduous forest
- Temperate grass land
- Boreal forest (Taiga)
- Tundra

3.0 TEMPERATE RAINFOREST

Temperate rainforests occur along the pacific coast of North America, New Zealand, Australia and Chile. Their climate is cool and maritime, lacking great variation in temperature and with abundant summer rain and much cloudiness and fog. Like with the tropical rainforest, they have rain throughout the year. Though at sometimes of the year, the so called rain is condensed fog. The trees in the temperate rainforests are the tallest in the world. In Australia, the dominant tree of these forests is the mountain ash (*Eucalyptus regnans*) which can grow to over 90m in height. In North America, the dominant tree is redwood (*Sequoia sempervirens*) which may be as high as 100m.

3.1 TEMPERATE DECIDUOUS FOREST

Temperate deciduous forests grow in continental climates of Northern hemisphere in areas with relatively warm summers and cold or severe winters. The biome covers large areas including much of Asia (Eurasia), eastern United States and Canada. Annual precipitation is generally from 750 to about 2500mm and is well distributed throughout the year but water is generally unavailable during the winter because it is frozen. Trees are the dominant life form and the most abundant species are the oaks.

Where there is less precipitation, temperate deciduous forests are replaced by temperate grassland.

3.2 TEMPERATE GRASSLAND

Temperate grasslands are found across large areas of eastern Europe and Asia (Eurasia) where they are called steppe; Central North America where they are called prairie and Argentina where they are called pampas.

The summers are hot and the winters cold with the continental climate moderately dry having between 200 to 750mm of rain each year. The flora of these temperate grasslands is dominated by perennial grasses.

The Eurasian steppes lie between the forests to the north and the deserts to the south. Most of the steppe has now been devoted to the production of wheat. Much wheat is also produced in the prairies of North America as temperate grasslands are suited to agriculture when they receive enough precipitation.

3.3 BOREAL FOREST (TAIGA)

Boreal forest is also known as taiga. It extends from north-eastern Europe across Russia to the Pacific Ocean and right across North America from Alaska to Newfound land. To the North it merges into tundra; and to the south, it grades into temperate deciduous forest or grassland. It can be very cold in the taiga. In winter, taiga receives a deep blanket of snow and for much of the year, snow lies on the ground. Eastern Siberia is the coldest area in the northern hemisphere with a January temperature of – 50 to -60^{o}c . Because of the latitude where boreal forest occurs the days are short in winter (as little as 6 hours) and correspondingly long in summer.

The vegetation of boreal forest is dominated by coniferous trees primarily, spruce, hemlock and fir. Most trees tend to occur in dense stands of one or a few species. During summer, plants may grow rapidly and crops often attain a large size in a surprisingly short time.

With the harsh winters, the taiga poses severe problems for the animals found in it. Some of the birds and mammals migrate, some remain active during the long dark winter, like the community of rodents and other animals beneath the thick cover of snow where they are completely protected from most predators and some of the mammals hibernate. Large animals that live here include herbivores like moose, deer and carnivores such as wolves, bear and lynx. This region is traditionally known for fur trapping and lumber producing.

3.4 Tundra

Farthest north in Eurasia, North America and their associated Islands between the taiga and the permanent ice, occurs the open often boggy low treeless vegetation known as tundra. It is an enormous biome, extremely uniform in appearance that covers a fifth of the earths land surface. The growing season is too short, the winters too cold and dry and the soil too unstable to support trees. The trees present are small and are mostly confined to the margins of streams and lakes. In general, tundra is dominated by scattered patches of grasses and sedges (grass like plants) heathers, lichens and dwarf willows. The growing season is so short that few plants are annuals. When the short growing season does arrive, plant growth and flowering may be spectacular with enormous areas bathed in colour. The rapid growth of plants is with food stored underground by the plants. Tremendous numbers of insects suddenly appear and for a few weeks productivity is high before winter sets in again for most of the year. Large grazing animals including musk-oxen, caribou, reindeer and carnivores such as wolves, foxes and lynx live in the tundra which teems with life in the short summer.

3.5 TEMPERATE SHRUBLAND (MEDITERRANEAN)

This biome is noted for winter rainy season and summer drought. It has what is often called Mediterranean climate and is found around the Mediterranean area itself; California, central Chile, the Cape region of South Africa and Southwestern Australia. The annual rainfall is about 300 – 800mm and during the summer there is usually no rain for about four months. The vegetation is very similar in these separated regions even though the individual plant species differ greatly between the regions. This biome called Chaparral in California and Maquis in the Mediterranean region consists of evergreen often spiny shrubs and low trees between 1 - 5m high with small thick drought resistant leaves. Because of its relatively dry conditions, these shrubland are greatly affected by fire. California Chaparral is highly inflammable. Fires are often started by lightning. In recent times bush fires in this biome have caused so much havoc in both California and Australia.

SELF ASSESSMENT EXERCISE

- Indicate what is unique about the temperate shrubland (Mediterranean) with regard to rainfall, vegetation, and natural hazard.
- In what areas of the world will you find the temperate rainforests?

4.0 CONCLUSION

In concluding studies on the terrestrial biomes, so many differences have been found among the biomes to recognize the uniqueness of each biome with regards to community composition and structure.

5.0 SUMMARY

In this unit we have learnt

- That temperature is the major difference between the tropical biomes and the temperate biomes.
- Of the locations and characteristics of the major biomes in the temperate regions of the earth.
- That temperate rainforests produce the tallest trees in the world.
- That the temperate grassland is called prairie in North America, steppe in Eurasia and pampas in Argentina. It is a wheat producing area in the steppe and prairie.
- That coniferous trees are dominant in boreal forest and animals have to adapt to the conditions on this biome because of the harsh winters.
- That the boreal or taiga is a lumber producing and fur trapping region.
- That the tundra has long, cold winters and short summers yet it teems up with activities of plants and animals during the short summers.
- That the vegetation in areas with Mediterranean climate are very similar even though they are in separated far apart regions and that the biome is naturally inflammable.

6.0 TUTOR MARKED ASSIGNMENT

- (a) What are the key characteristics of the temperate grasslands with respect to productivity, seasonal temperature and rainfall?
  (b) In what respect do they resemble the Savannahs?
- Compare and contrast the characteristics of the taiga and the tundra.
- Name the biomes known for the following:
  - wheat production
  - lumbering
  - fur trapping
  - tallest trees in the world
  - easily flammable plants

7.0 Further Reading/References

- Chapman JL and Reiss MJ (1995): Biomes (P 214 – 227)
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- Wikipedia, the free encyclopedia Biome (Pp 1 – 9).

MODULE III: BIOLOGICAL COMMUNITIES

UNIT IV: ALPINE AND AQUATIC BIOMES

CONTENTS **PAGE**

1.0 INTRODUCTION

Our study of the terrestrial biomes in units 2 and 3 of this module show a lot of diversity in the composition and characteristics of organisms (flora and fauna) within the various biomes which appear to be well defined. The biomes are determined mainly by latitude and temperature. Alpine biomes however are influenced by altitude while aquatic biomes have their uniqueness. Both alpine and aquatic biomes will be studied in this unit.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- Understand the influence of altitude on the formation of biomes
- Know about biomes in bogs and freshwater swamps within the tropical and temperate zones.
- Understand the types of communities found in lakes and ponds and in streams and rivers.
- Have some knowledge of coastal and marine biomes.

3.0 ALPINE BIOMES

Increasing altitude produced many of the same changes in temperature and moisture as increasing latitude. The tops of the mountains, therefore, have a typical windswept vegetation similar in many respects to tundra. The difference between altitude and latitude however is that day length remains constant up a mountain while it changes with increasing latitude as you approach the poles. Among the biomes influenced by altitude are the following.

3.0.1 **ALPINE SHRUBLAND**

Alpine shrublands are sometimes found above the tree line on mountains. They occur in South America, Africa, the Himalaya and New Zealand. Above about 300m, frosts occur at night and the altitude marks the limit of the mountain forest or tree line. The vegetation in this high location is like that on the mountain of East Africa described as Afro-alpine of low growing treeless alpine type.

The giant rosette plants (giant lobelias) *Lobelia telekii* up to 5-8m in height dominate the landscape. Hyrax, rat and mice abound in this alpine biome.

3.0.2 **ALPINE GRASSLAND**

High up the mountain, the climate might be thought to be similar to the climate near the poles. However, with longer day length on the mountain than the poles and the fact that the mountain often receives more rain and snow than the poles, mountain vegetation differs significantly from the vegetation of the tundra. Alpine plants on the mountain are small and tend to grow slowly with beautiful delicate brightly coloured flowers. The alpine marmot (*Marmota marmota*) occurs throughout the Alps of central Europe. Marmots hibernate at least half the year when their heartbeats slow down and body temperature falls to enable them conserve energy.

3.1 FRESHWATER BIOMES

Freshwater biomes are found in bogs, swamps, marshes, lakes, ponds, rivers and streams. Bogs are wetlands that only receive water from rainfall. Swamps and marshes form where water runs off the surrounding land and collects as a result of impeded drainage or where ground water lies close to the surface. In some cases, rivers and streams may also feed into the areas. It becomes a swamp if the dominant vegetation are trees and a marsh if the vegetation is mainly of grasses and reeds.

3.1.1 COOL TEMPERATE BOG

Bogs tend to be nutrient poor as they receive water only from the rain which has very little nutrient content. They are dominated by mosses the dominant species being of the genus *Sphagnum*. Bogs occur mainly in the temperate and boreal regions. Bog community is slow growing and short. Primary productivity is slow with only small populations of herbivores such as insects, hares and bog lemmings and few predators such as spiders and owls. Larger herbivores and predators like deer, caribou and bears roam over large areas and occasionally enter bogs.

3.1.2 TROPICAL FRESHWATER SWAMP FOREST

The best developed tropical fresh water swamp forests are those of the Amazon basin in South America. They are dominated by trees.

Minerals in the waters and accompanying soils tend to be scarce so that primary production is low. As such, there are few animals in the biome.

3.1.3 TEMPERATE FRESH WATER SWAMP FOREST

The most famous swamp area of this biome is found in Florida (USA) called the Everglades. Here the very low-lying land is often flooded. Dominant tree species include the swamp cypress and water tupelo. With the floor of the forest under water most of the time several plant species have knee roots which may act as pneumatophores. Animals are abundant in this swamp forest. In the Everglades, there are about 250 species of birds, 240 of fish, 57 of reptiles 25 of mammals and 17 species of amphibians. Alligators are quite common in the swamp forest. Marshes which are dominated by grasses, sedges and reeds are common in temperate zones. The same genera of plants are common in marshes found in North America and Eurasia both in the northern hemisphere.

3.1.4 LAKES AND PONDS

The factors that influence the biome of lake or pond is the extent to which the water is present all the year round. A pond for example can be ephemeral or not. The nutrient abundance or lack of it is also important.

Large lakes like the North American Great Lakes drain a huge area which in the past consisted of deciduous forest to the south and conifer forest to the north. Human activities have greatly affected the forests. Salmon fishing used to be a dominant business in the lakes. However, as a result of sawdust pollution of streams used by salmon for spawning and which flowed into the lakes, fishing ceased by 1900. In the absence of pollution, the presence of plankton in a lake should encourage the presence of many other organisms in the lake and increase productivity to man's advantage.

3.1.5 STREAMS AND RIVERS

Stream and rivers vary greatly. The large Amazon river with its huge mouth cannot be compared with a steep stream just taking off from a mountain side. As a stream or river flows from its source to its mouth, the speed decreases, the volume of water increases, oxygen level falls, the bed becomes less steep and composed of smaller particles and human influences increase. Streams and rivers unlike lakes are unidirectional with relatively rapid flow of water. This characteristic may be responsible for the virtual absence of plankton in them. The communities in rivers and streams are therefore, quite different from those of even adjacent lakes.

3.2 OCEAN OR MARINE BIOMES

Marine biomes are found in the coastal and intertidal zones around the oceans of the world. The various types of marine biomes include:

- Marine rocky shore
- Marine sandy beach
- Marine mud flat
- Temperate salt marsh

- Mangrove swamp
- Coral reef
- Marine surface pelagic
- Marine deep pelagic
- Continental shelf benthos
- Deep ocean benthos

Few of these will be studied in this unit.

3.2.1 **Marine Rocky Shore**

Marine rocky shore can occur on any rocky coastline and are found in both temperate and tropical climates. They are found where waves or currents are particularly strong.

Vascular plants and mammals are totally absent here. Photosynthetic organisms found here are multi-cellular algae or seaweeds. Most of the animals are invertebrates, a few fish and occasional visit of predatory birds. No organism here is large or obvious like oak trees because the energy of the waves crashing on the rock would probably break up and wash them off.

Rock pools differ greatly from one another. A biological feature of a rock shore is zonation of organisms in littoral regions. Those low down on the shore spend almost all their time submerged by water, high up on the shore, they may be submerged only at certain times of the month remaining terrestrial at other times apart from the influence of sea spray. Besides the plants (species of seaweed), animals (sedentary barnacles and mobile periwinkles) also show characteristic zonation too.

3.2.2 **Marine Sandy Beach**

Marine sandy beaches occur around the world in the littoral belt. They look inviting to humans but pose considerable problems for the organisms living there. Sand is abrasive and constantly on the move as such, no rooted plants can establish in the intertidal region. Except for some calcareous matter from seashells, sand is nutrient poor although diatoms and other algae can be found on surface layers. In the intertidal region, plankton and detritus brought in by the waves are what small animals depend on. Such animals include bivalve, mollusc, sea cucumber, crabs, worms and other wormlike or flattened invertebrates. The rich invertebrate life supports large numbers of wading birds with specialized beaks used to remove invertebrates from various depths of the sand.

3.2.3 **Mangrove Swamp**

Mangrove swamps occur along the coastline of tropical or subtropical regions where strips of swampland are submerged every high tide with marine or brackish water. Wherever the wave action is not too strong to prevent regeneration, these coastal wetlands are densely vegetated with thickets of mangrove trees. There are about 70 species of mangrove plants around the world with *Rhizophora* and *Avicennia* being the most important genera. Mangroves are well adapted to salty conditions although they are capable of growing in fresh water. Mangrove swamps are influenced by tides as incoming tides bring in nutrients. Plant seeds are also dispersed by tides. The structure of the trees is unique and unusual as aerial roots arise quite high up on the trunk then, plunge into the mud beneath.

A variety of animals live within the mangrove including fiddler crabs, mud skippers, alligators, crocodiles and in some mangroves big cats such as tigers.

3.2.4 **Coral Reef**

Corals are coelenterates (invertebrates), relatives of the sea anemones. Most corals are colonial and secrete a limestone skeleton from which the polyps extend. The polyps have tiny tentacles which catch food and stuff it into a central mouth. At times of danger, the individual polyps pull themselves down into the skeleton out of harm's way.

A coral reef is made up of the limestone skeletons secreted by innumerable colonial coral polyps which are left behind one on top of another. Coral reefs are only found in clear seas within 50m of the surface where the temperature remains above 20^0C throughout the year. Many species of corals live together within a single reef. These corals support many other animals such as invertebrates the most well known being the crown-of-thorns star fish (*Acanthaster planci*) and many fishes. In terms of high productivity, the species diversity complexities of co-evolution and sheer beauty, coral reefs are the tropical rainforests of the ocean. They abound mainly in the pacific West Indies where we have some coral Islands.

3.2.5 **Continental Shelf**

The considerable continental shelves that surround many of the continents lie on average, 130m below sea level, so that in their shallower regions, benthic algae and plants can photosynthesise. Here are found the impressive Kelp forests of large brown algae such as *Laminaria*. Kelps are often found in areas where ocean currents and the action of waves ensure a plentiful supply of nutrients. Their productivity may be high but they enter the food web in the form of detritus as few animals feed on them. The continental shelf benthos supports large numbers of animals from a variety of phyla. These animals include polychaete worms, nemertine worms, mollusks, sea squirts, sponges, sea spiders crustaceans and echinoderms along with a number of fish.

SELF ASSESSMENT EXERCISE

- Indicate the areas where you will find a tropical freshwater swamp and a temperate freshwater swamp.
- Compare the two areas in terms of productivity and species abundance.

4.0 **CONCLUSION**

We have learnt from this unit that altitude and aquatic environments so influence the biomes within them to make them different from the characteristic biomes situated within the same area of latitude.

5.0 SUMMARY

In this unit we have learnt that:

- Alpine biomes are influenced more by altitude than by latitude.
- In the tropics, the higher up a mountain, the more is the biome similar to that found in higher latitudes. Alpine vegetation can in some way be similar to tundra.
- Freshwater biomes differ significantly from marine biomes.
- Fresh water biomes occur in tropical or temperate swamp forests, marshes lakes and ponds and stream and rivers.
- There are various types of marine biomes where we recognized marine sandy beach and mangrove swamp as common features in Nigeria.

6.0 TUTOR MARKED ASSIGNMENT

- Why can forests not develop up a mountain situated in a tropical climate?
- How does a bog differ from swamps and marshes?
- Where do mangrove swamps occur? What is unique about mangrove plants? Name some animal life present in this biome.

7.0 FURTHER READING/REFERENCE

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MODULE IV: MAN AND THE ENVIRONMENT

UNIT I: INFLUENCE OF MAN ON THE ENVIRONMENT (I)

CONTENTS **PAGE**

1.0 INTRODUCTION

We have learnt in modules I and II how organisms live together in communities within an ecosystem made up of the biotic and abiotic components.

These communities when of the same characteristics over large or regional climatic areas become biomes. With the explosively growing human population, considerable stress is being placed on the environment such that the communities are being adversely affected. In this unit, you will learn the various ways in which human activities pose a threat to the environment.

2.0 OBJECTIVES

By the end of this unit you should be able to:

- Define what is meant by pollution
- Name the major chemicals responsible for chemical pollution and their side effects.
- Explain what is meant by acid rain and its harmful effects to the environment
- Explain what the ozone layer is and what causes the ozone hole.
- Tell the consequences of the thinning of ozone layer to man and other organisms.
- Explain the relationship between carbon dioxide and global warming and indicate the side effects of global warming.

3.0 MAN AND THE ENVIRONMENT

Communities thrive within the environment in which man has a dominating influence. With the increasing human population, considerable stress is placed on the environment through the ever-increasing consumption of quantities of food and water, using a great deal of energy and raw materials and producing enormous amounts of waste and pollution. Industrial pollution and deforestation add to the threat on the environment. Some effects of human activities on the environment will be looked into in this and subsequent unit.

3.1 POLLUTION

Pollution is the direct or indirect release of products harmful to organisms into the environment as a direct result of human activity. Pollution can occur in any of these ways; Chemical, Industrial or Nuclear.

3.1.1 CHEMICAL POLLUTION

To cope with an increasing human population, wide spread agriculture carried out increasingly by modern methods, causes large amounts of many new kinds of chemicals to be introduced into the global system. These include pesticides, herbicides and fertilizers. A good example is the chlorinated hydrocarbons, a class of compounds that includes DDT, chlordane, lindane and dieldrin. They are not biodegradable, may be resistant to decay and therefore accumulate in the environment.

Although, these chemicals have been banned for normal use in industrial countries like the United States and Europe they still circulate in the ecosystem. It is known that now, they are still manufactured in the United States for export and used in other countries often finding their way back to United States as contaminants on fruits and vegetables. Chlorinated hydrocarbon molecules break down slowly and accumulate in animal fat. Furthermore, as they pass through the food chain they become increasingly concentrated especially in the top trophic levels. Before the ban of DDT in United States and Europe it led to the production of thin, fragile eggshells in many predatory bird species in the United States and peregrine falcons in Britain. Some other countries had similar problems which could have caused the extinction of the species. Chlorinated compounds have other undesirable side effects and exhibit hormone-like activities in the bodies of animals.

Accidental release of toxic materials into streams and rivers by chemical industries cause a lot of water pollution. The River Rhine in Europe was highly polluted in 1986 when water used by firemen to put off fire in a Sandoz chemical company in Basel, Switzerland washed about 30 tons of mercury and pesticides into it. Flowing down river, the deadly wall of poison killed everything it passed. For hundreds of kilometers, the surface of the river was blanketed by dead fish. The plants in the river also began to die. It took about six months before the authorities could observe that life would come back again to normal on the Rhine. Pollutions like the one described on the Rhine have been known to occur in many parts of the world.

Back home in Nigeria, the spillage of oil in the Niger-delta area of the country has similar catastrophic effect on the local environment destroying plants, fishes and other aquatic creatures.

Water pollution also occurs from the diverse substances that today's enormous human population produces continuously. Despite the implementation of ever-improved methods of sewage treatment throughout the world, our lakes, streams and groundwater are becoming increasingly polluted with for example household detergents containing phosphates.

3.1.2 INDUSTRIAL POLLUTION

Industrial pollution occurs when factories or factory products release pollutants into the atmosphere that cause environmental damage. Industrial pollution can occur in any of these ways:-

3.1.2.1 Production of Acid Rain

Factories that burn coal as fuel send smoke up high into the atmosphere through their smokestacks which are usually above 65 meters tall. The smoke contains high concentrations of sulphur dioxide and other sulphates. Combustion of fossil fuels, whether petrol in vehicles, or coal, oil or gas in power stations produce similar sulphur –rich end results.

When sulphur introduced into the upper atmosphere combines with water vapour in the air, they produce sulphuric acid and when the water later falls as rain or snow, the precipitation is acid hence, it is called acid rain.

While unpolluted rain has a pH of about 5.6 due to the presence of dissolved carbon dioxide, acid rain water may have a pH of between 4.0 - 4.5 as in Britain or a lower pH of 3.8 as in northeastern United States.

Acid precipitation destroys life. Thousands of lakes in northern Sweden and Norway no longer support fish. In northeastern United States and eastern Canada, tens of thousands of lakes are dying biologically as a result of acid precipitation. At pH levels below 5.0 many fish species and other aquatic animals die, unable to reproduce under these conditions.

The flaring of gas from oil wells in the Niger-delta region will among other harmful effects, have acid rain type of effect on the environment. By having corrosive effects on the leaves of plants which are used for photosynthesis, the plants ultimately die. It is no surprise therefore that cases of dying plants and low crop production are often reported from the Niger-delta region.

With a pH of 4.5 - 6.0 of groundwater in southern Sweden, acid precipitation seems to be slowly filtering down into underground reservoirs threatening water supplies of future generations. There has been enormous forest damage in the Black Forest of Germany and in the forests of eastern United States and Canada. It has been estimated that at least 35 million hectares of forest in northern hemisphere are being affected by acid rain and the problem seem to be growing. A view of affected forests shows many trees diseased and dying as a result of acid rain. Often, the recipient of the pollution may be far away from the source as prevailing winds transfer the pollution over wide areas.

Solution to the problems of acid rain has not been easy but substantial progress has been made since the Clear Air Act revisions of 1990 addressed the problem in the United States while a number of other countries including Britain have significantly reduced their sulphur dioxide emissions over the last 20 years.

3.1.2.2 **The Ozone Layer**

Ozone is only present in concentrations of a few parts per million or less and concentrated in the earth's stratosphere 15 - 50km above the surface of the earth. During the mid-1980s British environmental scientists suddenly realized that above Antarctica, ozone levels were falling dramatically creating a gap called the ozone hole. The hole is not a permanent feature, but rather one that becomes evident each year for a few months at the onset of the Antarctic spring. It has been observed that every September from 1975 onward, the ozone hole has reappeared and the layer of ozone thinner and the hole larger. Thinning of the ozone layer in the stratosphere is a matter of serious concern. This layer protects key biological molecules especially proteins and nucleic acids from the harmful ultraviolet rays that bombard the earth continuously from the sun. Ultraviolet radiation is a serious human health concern. Every 1% drop in the atmosphere ozone content is estimated to lead to a 6% increase in the incidence of skin cancers.

At middle latitudes, the drop of approximately 3% that has occurred worldwide is estimated to have led to an increase of perhaps 20% in skin cancers. Skin cancers are one of the more lethal diseases afflicting humans who are relatively resistant to increase ultraviolet radiation. Other organisms such as photosynthetic plankton species that are so important to global productivity are apparently much more susceptible.

The substances most responsible for the sudden collapse of the ozone layer were identified as Chloroflourocarbons or CFC for short. CFCs are chemicals that have been manufactured in large amounts since they were invented in the 1920s. They are largely used in cooling systems eg refrigerators, fire extinguishers and aerosols. After much lobbying by scientists and environmentalists in the 1980s a number of measures were agreed to and signed internationally to reduce the use of CFCs and phase out production by the year 2000. However, large amounts of CFCs that were manufactured earlier are moving slowly upward through the atmosphere.

3.1.2.3 **Carbon dioxide and Global Warming**

The earth's atmosphere gives it a warmer temperature of about 15^0C at ground level than the – 18^0C of the moon which is devoid of atmosphere. Much of the incoming radiation from the sun is absorbed by the atmosphere and then re-radiated back into the earth's surface. On the moon with no atmosphere, the heat is re-radiated out into space. The atmosphere on earth acts like a gigantic greenhouse trapping the heat and surrounding the earth. Humans can only survive on the earth because of this greenhouse effect.

Carbon dioxide and water vapour are the gases in the atmosphere responsible for keeping the surface of the earth relatively warm by trapping the heat radiating from the surface of the earth. However, it is well known that each year, humans are contributing to the greenhouse effect by releasing into the atmosphere huge amounts of carbon dioxide, methane, chloroflourocarbons (CFCs), nitrous oxide and other gases. The most important of these gases in relation to the greenhouse effect is carbon dioxide. Roughly seven times as much carbon dioxide is locked up in fossil fuels. Before widespread industrialization, the concentration of carbon dioxide in the atmosphere was approximately 260 to 280 parts per million (ppm).

Since the extensive use of fossil fuels to operate industries, aircrafts and vehicles, the amount of carbon dioxide in the atmosphere has been increasing rapidly. A major proportion of carbon dioxide added to the atmosphere also comes from the destruction and burning of trees and other vegetation particularly those in the remaining tropical rainforests. Again, by destroying the rainforest, there occurs a reduction in the amount of carbon dioxide fixed each year in photosynthesis leading to further increase of the gas in the atmosphere. During the 25 year period starting from 1958, the concentration of carbon dioxide in the atmosphere increased from 315ppm to more than 340ppm. Climatologists have calculated that the actual mean global temperature has increased by 1^0C since 1900. This phenomenon of global temperature increase is known as **Global Warming** and is associated with the increasing concentration of carbon dioxide in the atmosphere. As more and more carbon dioxide is pumped into the atmosphere and no means of stopping the greenhouse effect, there is every chance that the earth will continue to get warmer. The consequences can be great. Sea levels will rise and is suspected to have risen by 2 to 5 centimeters already due to global warming.

It should be noted that Nigeria also has its own contribution towards global warming. By World Bank estimates, Nigeria has annually burned into the air 75% of the gas extracted from its wells. By some estimates, the equivalent of 40% of Africa's total natural gas consumption is flared in Nigeria. These losses are worth an estimated $2.5 billion annually and have resulted in 70million metric tons of carbon dioxide emissions a year, a substantial proportion of world-wide greenhouse gas (World Bank/United Nations Report 279/04). The pollution from car emissions in our major towns like Lagos, Portharcourt and Abuja have also their contributory effect to the global warming.

If the climate becomes warm enough to melt the polar ice caps, sea levels will rise by more than 150 meters and will flood for example, the entire Atlantic coast of North America as far as several hundred kilometers inland. The global warming may explain why the last couple of decades seem to have seen more extremes in the weather than usual.

SELF ASSESSMENT EXERCISE

- Describe how acid rain is formed?
- What are the damages caused by acid rain?

4.0 CONCLUSION

The explosive increase in human population is putting a lot of stress on the environment with negative consequences on organisms.

5.0 SUMMARY

In this unit we have learnt that:

- Pollution is the release by man of harmful products to the environment.
- Chemical pollutions occur through man's use of pesticides, herbicides, fungicides and fertilizers.
- Some of these chemicals like the chlorinated hydrocarbons do not break down easily in the environment and accumulate in animal fat tissues.
- Industrial activities of man are responsible for the production of acid rain and the ozone layer which have negative impacts on the environment.

- Global warming is a serious threat to the environment caused by the increasing concentration of carbon dioxide in the earth's atmosphere.

6.0 TUTOR MARKED ASSIGNMENT

- (a) What is global warming?
  (b) What effect does it have on the world as a whole?
  (c) How is it affected by industrialization?
- What is the Ozone layer? How is it formed? What are the harmful effects of decreasing the earth's ozone layer?

7.0 FURTHER READING/REFERENCES

- Chapman JL and Reiss MJ (1995): Nutrient Cycling and Pollution (151 – 166): In: - ECOLOGY, principles and applications Cambridge University Press, UK
- Raven, PH and Johnson, GB (1996): The future of the Biosphere, (611-630): In: Biology WCB/McGrow-Hill, Boston.
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MODULE IV: MAN AND THE ENVIRONMENT

UNIT II: INFLUENCE OF MAN ON THE ENVIRONMENT II

CONTENTS **PAGE**

1.0 INTRODUCTION

The activities of man have been shown to be threatening the well being of the earth's environment. Some of the activities have been discussed in the previous unit. Others will be raised in this unit to provide a complete picture of the effects of man's activities on the environment.

2.0 OBJECTIVES

By the end of this unit you should be able to:

- Know why the world needs nuclear energy and the main raw materials for its production.
- Indicate the dangers associated with exposure of radioactive materials into the atmosphere.
- Know how the rainforests are being destroyed and the environmental impact of such destruction.
- Know the dangers and risks of building nuclear power plants.
- Acquire knowledge of how the activities of man are a threat to the lives of other species of organisms on earth.
- Have an idea of the procedure to undertake to solve some of the enumerated problems.

3.0 NUCLEAR POLLUTION

Nuclear energy emerged from the realization that our sources of energy coal, gas and oil are becoming scarce and the cost of locating and extracting new deposits more expensive. Modern society is being forced to look elsewhere for energy. Although, nuclear power is not cheap as power plants are expensive to build and operate, using current technology, the raw materials, uranium ore is so common in the earth's crust that it is unlikely we will ever run out of it. Nuclear power therefore promises to provide an alternative source of plentiful energy which can be utilized for electricity generation.

The pollution from nuclear power is not of common occurrence but can be deadly. In April 1986, one of the four reactors of Chernobyl nuclear power plant in Ukraine blew up. The explosion and heat sent up a plume 5 kilometers high, carrying several tons of uranium dioxide fuel and fission products. It was the largest nuclear accident ever reported as 100 megacuries of radioactivity were released. The cloud spread the radioactivity in a band across central Europe from Scandinavia to Greece. Some 24,000 people received serious radiation doses while 31 individuals died as a direct result of radiation poisoning most of them firefighters preventing the fire from spreading to other reactors. The exposure of people outside the Chernobyl area to the radiation is suspected would cause from 5000 – 75,000 cancer deaths.

The world is not praying for another such accident to occur. Therefore, to safely maintain nuclear power plants, there is the need to undertake the following:

- Ensure safe operation of the world's approximately 390 nuclear reactors.
- Safely dispose of radioactive wastes produced by the plants.
- Safely decommission plants that have reached the end of their useful lives (about 25 years).

- Guard against terrorism and sabotage because the technology of nuclear power generation is closely linked to that of nuclear weapons.

These actions are necessary bearing in mind that escape of radioactive materials into the atmosphere may increase the incidence of cancer.

3.1 DEFORESTATION

When tropical evergreen forests are removed, the ecological consequences can be disastrous. Most forest destructions occur in the tropics especially in the rain forests of Brazil, Africa and Southeast Asia. More than half of the world's human population lives in the tropics and the percentage is increasing rapidly. Many people in the tropics have traditionally engaged in shifting cultivation. Such agricultural systems work well where human populations are relatively low.

As populations increase however, there will be reduced opportunities for successful growth of traditional crops. The use of firewood as a source of fuel hastens the demise of many tropical forests. About 1.5 billion people worldwide depend on firewood as a major source of fuel. Local supplies are cut faster than the trees can regenerate themselves. The situation is also peculiar to Nigeria. The controversial issue of the clearance of tropical rainforest in countries like Brazil for the creation of grassland for cattle accelerates the destruction of forests.

Tropical rainforest as noted in an earlier unit is the richest biome in terms of number of species of terrestrial organisms. The systematic destruction of the forest may lead to a tragic loss of known and unknown biodiversity and also be a contributory factor to global warming.

3.2 LOSS OF BIODIVERSITY

A most serious and rapidly accelerating of all global environmental problems caused by man is the loss of biodiversity. In the past 300 years, there has been a loss of species of well known groups of organisms including mammals, birds and plants. Scientists have calculated that as much as 20% of the world's biodiversity may be lost during the next 30 years. With man destroying the tropical rainforests under what may be termed development, and felling of trees for logs, the loss may be much greater.

The loss could affect many species of plants, mammals, birds and invertebrates. Man is killing species off at a rate that has not been approached for the past 65 million years.

There is the need to stop the trend as we might be doing so at our own peril. On moral¸ ethical or aesthetic grounds man has no right to drive to extinction his living companions in the universe. Secondly, organisms are the only means of sustainability to man. They are sources of food, medicine, clothing, biomass (for energy and other purposes) and shelter.

Thirdly, organisms occurring in communities function to preserve soils, regulate water and nutrient cycles that are essential to plants, modulate characteristics of the atmosphere and absorb pollution. There is therefore the need for man to work together and participate in sound, globally based schemes to preserve as much as possible of the biological diversity of life on earth.

3.3 SOLVING THE ENVIRONMENTAL PROBLEMS

All the environmental problems so far enumerated in this and the previous units have been created by rapid human population growth. The growth has created the following unavoidable and obvious problems.

- an increasing need for energy
- a depletion of resources
- a growing level of pollution.

Environmental scientists have considered these problems not to be insurmountable. It will however require a combination of scientific investigation and public action to be brought to bear effectively for solutions to be achieved. Solving environmental problems may require the following suggested steps to be undertaken

- **Assessment:** The first stage in addressing any environmental problem is scientific analysis, through the gathering of information. With collected data and experimentation, models can be constructed to describe the situation and to make predictions about future course of events.

- **Risk Analysis:** Using the results of scientific analysis as a tool, it is possible to analyse what could be expected to happen if a particular course of action were followed. An environmental impact statement is often prepared at this point.

- **Public Education:** When a clear choice can be made among alternative courses of action, the public must be informed.

- **Political Action:** The public, through its elected officials, makes a choice, selecting a course of action and implementing it. To implement choices can be difficult when environmental problems transcend national boundaries.

- **Follow –through:** The result of any action taken should be carefully monitored to see whether the environmental problem is being solved and more basically to evaluate and improve the initial evaluation and modeling of the problems.

It should be borne in mind that perhaps one of the ways of solving the world's environmental problems is the improvement of technology in the area of solar energy and wind energy to provide the driving force for the technological development of the future.

SELF ASSESSMENT EXERCISE

- What benefits will man and the environment derive from a reliable and effective solar energy and wind energy?

4.0 CONCLUSION

Activities of man in relation to the explosive population growth are shown to be destroying rainforests and threatening the lives of other organisms in the earth's environment. Man's desire for nuclear energy also has its consequences on the environment. The responsibility falls on man to identify and implement solutions to these environmental problems.

5.0 SUMMARY

In this unit, we have learnt that;

- Nuclear energy uses uranium as raw materials
- Nuclear accidents can cause radiation which leads to cancer formation in man.
- The tropical rainforests are gradually being destroyed by man's activities. This act is contributing to global warming.
- The environmental impact of man's activities is destroying some species off the earth's environment.
- Environmental scientists believe that these problems are not insurmountable and have suggested some procedure to be adopted to have them solved.

6.0 TUTOR MARKED ASSIGNMENT

- (a) What are the benefits of nuclear power?
  (b)What should be done to safely maintain nuclear power plants?
  (c)Why should nuclear accidents be prevented?
- Why is it important to sustain the earth's biodiversity?

- Enumerate the world's major environmental problems and make your suggestions on how they can be tackled.

7.0 FURTHER READING/REFERENCE

- Chapman JL and Reiss MJ (1995): Nutrient Cycling and Pollution (151 – 166): In: - ECOLOGY, principles and applications. Cambridge University Press, UK
- Raven, PH and Johnson, GB (1996): The future of the Biosphere, (611-630): In: Biology. WCB/McGrow-Hill, Boston.