UNIT 25

MAN AND HIS ENVIRONMENT

Major Concept

25.1 Biogeochemical Cycles
25.2 The Flow of Energy
25.3 Ecological Succession
25.4 Population Dynamics
25.5 Human Impact on Environment
25.6 Environmental Resources and their Depletion

Learning Outcomes

Students will be able to:

- Define biogeochemical cycles and locate the primary reservoirs of the chemicals in these cycles.
- Describe water cycle in detail.
- Define the terms aquifers and water table.
- Describe nitrogen cycle in detail.
- Define the terms of nitrogen-fixation, nitrification, de-nitrification and ammonification.
- Describe productivity in terms of gross primary productivity and net primary productivity.
- Explain the flow of energy in successive trophic levels.
- Interpret the pyramids of number, biomass and energy.
- Define ecological succession as the process through which ecosystems change from simple to complex.
- Describe primary and secondary succession.
- Differentiate between xerarch and hydrarch succession.
- Explain the xerarch succession on a bare rock starting from the small pockets of lichens to the vegetation of flowering plants.
- Describe characteristics of a population, such as growth, density, distribution, carrying capacity, minimum/viable size.
- Explain, using demographic principles, problems related to the rapid growth of human populations and the effects of that growth on future generations (*e.g.* relate the carrying capacity of the Earth to the growth of populations and their consumption of resources).
- Analyze the role of the department of population welfare, government of Pakistan in controlling the growing population of Pakistan.
- Relate the need of the nuclear power to the scarcity of fossil fuels.
- State the problems of using nuclear power (surety of safe operation and safe disposal of the wastes).

- Describe the causes of the increasing concentration of carbon dioxide in the world's atmosphere.
- Correlate the increasing CO_2 concentration with the global warming and describe its long term effects.
- Explain the causes and effects of acid rain.
- Describe the composition of the ozone layer and its role in protecting the life on earth.
- State the sources of chlorofluorocarbons and their role in the depletion of ozone.
- Explain the effects of Ultraviolet radiation as a serious human health concern.
- Narrate the incidence when one of the four reactors of the Chernobyl nuclear power plant blew up in 1986.
- Distinguish between renewable and non-renewable environmental resources.
- Describe how man is responsible for the depletion of environmental resources.
- Describe the conventional and non-conventional energy resources.
- Analyze the efforts of various government departments and NGOs to educate people for the protection of environmental resources.

Introduction

The purpose of study of this unit is to enhance the level of under-standing about the ecology and human interaction with his environment. This will help to understand effects of rapidly growing human population and his activities threatening the stability of ecosystem. How biogeochemical cycles are important for flow of chemical elements and compounds between living organisms and their physical environment. This unit also deals with ecological succession, utilization of **renewable** and **non-renewable environmental resources** and their conservation. However, we will begin with discussing how elements are essential for life and how these elements are recycled between living and non-living environment.

25.1 Biogeochemical Cycle

The flow of chemical elements and compounds between living organisms and their physical environment is known as **biogeochemical cycle**. Chemicals absorbed or ingested by organisms are passed through the food chain and returned to the soil, air and water by such as respiration, excretion and decomposition. As an element moves through this cycle, it often forms

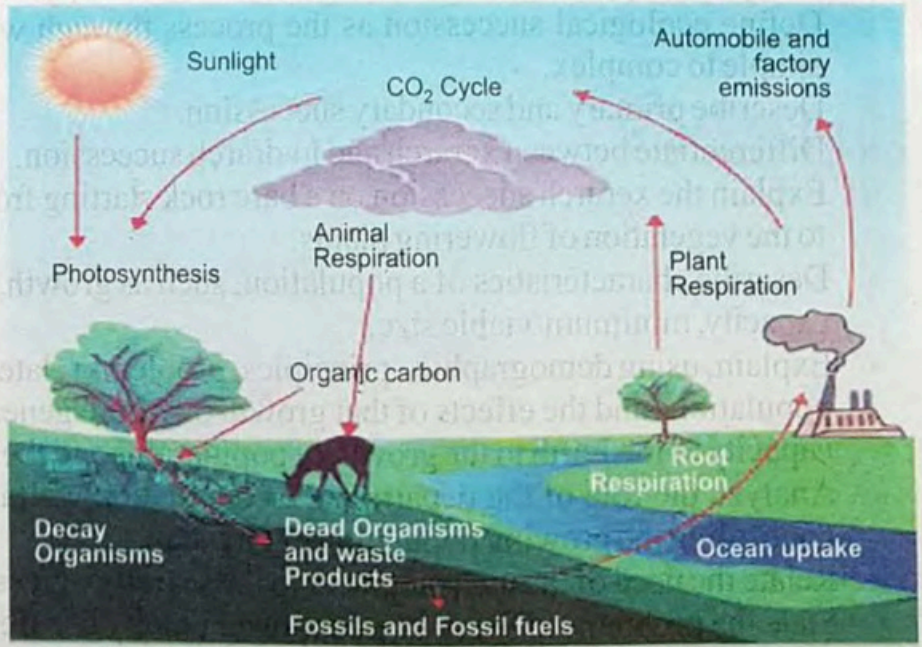


Fig. 25.1: Biogeochemical Cycles

compound with other elements as a result of metabolic processes in living tissues or by natural reactions in the atmosphere (air), hydrosphere (water) or lithosphere (outer rigid strong layer of earth). (Fig.25.1)

25.1.1 Primary Reservoirs of Nutrients

The chemicals are sometimes held for long periods of time in one place. This place is called a **reservoir** *e.g.* coal deposits that are storing carbon for a long period of time. When chemicals are held for only short period of time, they are being held in **exchange pools**. Examples of exchange pools include plants and animals.

Plants and animals utilize carbon to produce carbohydrates, fats, and proteins, which can then be used to build their internal structure or to obtain energy. Plants and animals temporarily use carbon in their systems and release it back into the air or surrounding medium. Generally, reservoirs are **abiotic factors**. Carbon is held for relatively short time in plants and animals in comparison to coal deposits. The period of time that a chemical is held in one place is called its **residence time** (the length of time a substance remains in the adsorbed, suspended, or dissolved state).

Extra Information

Two thirds of the world's population are projected to face water scarcity by 2025 according to United Nations.

Water Cycle

Do you know there is as much water today as there was 1000's of years ago? This is possible due to amazing water cycle. Ocean is the major source of water, which contains about 97% of the total water. The water cycle is driven by solar energy which evaporates water and by gravity which draws the water back to earth in the form of precipitation *i.e.* rain, snow, dew, or hail. (Fig.25.2)

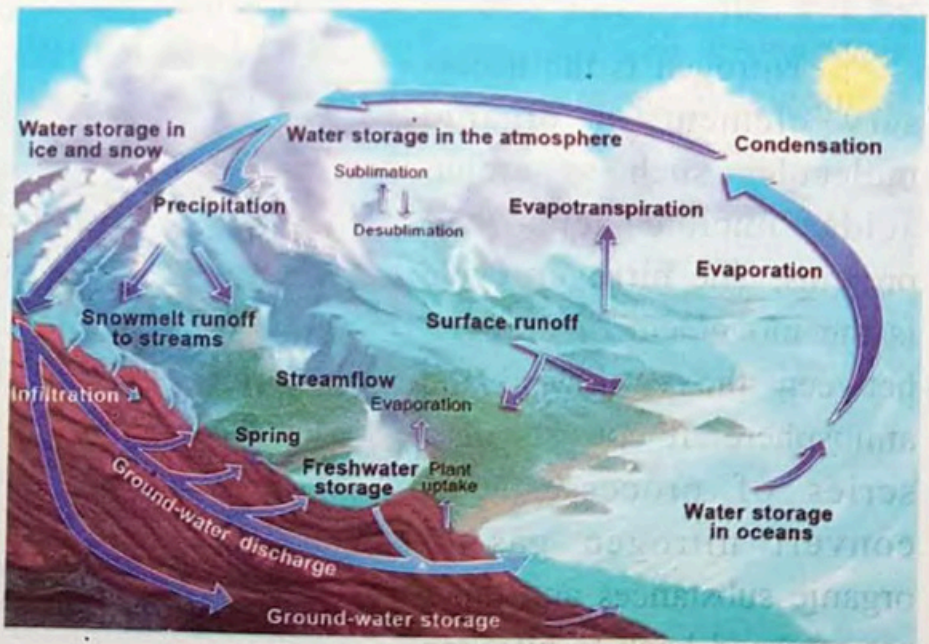


Fig. 25.2: Water Cycle

Water in Environment

Water falling on land takes different paths. Some water is evaporated from the soil, lakes and streams. A portion of water runs off the land back to the oceans.

When rain water falls, some of the **water sinks** or **percolates** into the ground and saturates the earth to a certain level. The top of the saturation zone is called **water table**. Wherever the earth contains **basin** or **channels**, water will appear to the level of the water table. The water within the basins is called **lakes** and **ponds** and water within the channels is called **streams** or **rivers**. Sometimes ground water is also located in underground rivers called **aquifers**. An aquifer is an underground layer where the material contains water, that supplies the water for wells, springs, *etc.*

Abiotic and Biotic Factors

Abiotic factors are the non-living part of environment. These include light temperature, water, wind, soil, etc. Biotic factors are living parts of an environment such as plants animals and micro-organisms.

Water in living bodies

The bodies of living things contain roughly 70% water, some of the water in the water cycle enters the **living communities** of ecosystems. It is absorbed by the roots of plants and much of this is evaporated back to the atmosphere from their leaves. A small amount is combined with carbon dioxide during photosynthesis to produce **high-energy molecules**. Eventually these are broken down during **cellular respiration**, releasing back to the environment. Heterotrophs get water from their food or by drinking. Some of this water is released back to environment by **vaporization**.

25.1.2 Nitrogen Cycle

Nitrogen is the necessary element of organic molecules such as amino acids, nucleic acids and proteins. The **nitrogen cycle** is the movement of nitrogen between the earth and the atmosphere. It consists of a series of processes that convert nitrogen gas to organic substances and these are returned back to nitrogen in atmosphere. It is a continuous cycle maintained by the decomposers and other bacteria. The nitrogen cycle can be explained in four types of reactions *i.e.* decomposition. Nitrogen fixation, assimilation and de-nitrification. (Fig.25.3)

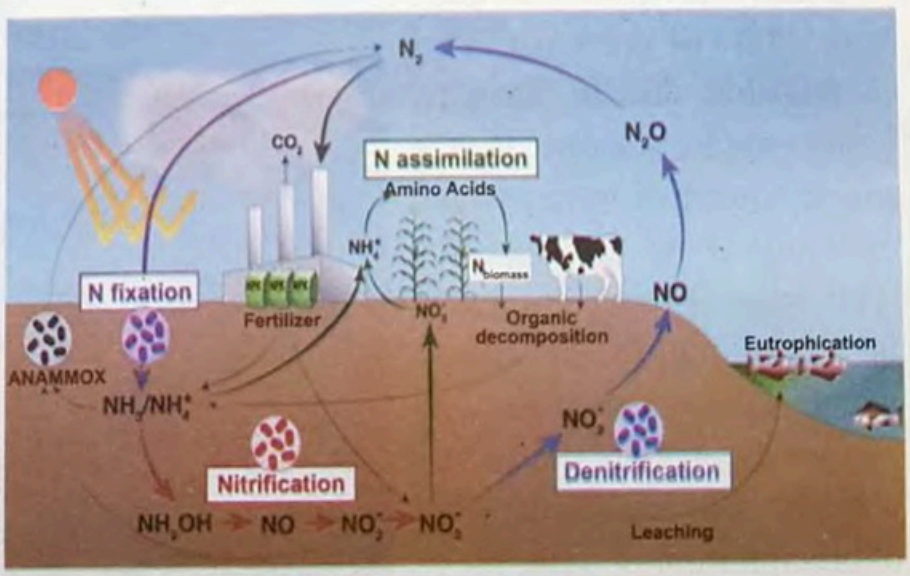


Fig. 25.3: Nitrogen Cycle

1. Decomposition

Decomposition is the process of breakdown of complex substance into its components. Decomposition of organic nitrogen compounds is the first source of soil nitrates. It occurs in two steps: (i) ammonification (ii) nitrification

a) Ammonification

The nitrogenous wastes of animals and nitrogenous compounds of dead organisms are decomposed by **saprophytic soil bacteria** and **fungi** to form simple substances like water, carbon dioxide, amino acid and energy. The amino acids are converted into ammonia or ammonium ions. Production of ammonia or ammonium compounds during the decomposition of organic matter by microorganisms (**ammonifying bacteria**) is called **ammonification**.

b) Nitrification

Some ammonia escapes into the soil but much of it and ammonium ions are converted into nitrates by **nitrifying bacteria**. It is accomplished by two groups of nitrifying bacteria. The first group of bacteria *e.g.* ***Nitrosomonas*** converts ammonia to nitrites and the second group of bacteria *e.g.* ***Nitrobacter*** converts nitrites to nitrates. This process is called **nitrification**. Nitrification takes place only in well aerated soils because the bacteria are aerobic in nature.

2. Nitrogen Fixation

Any process of combining atmospheric nitrogen with other elements, either by chemical means or by bacterial action is called **nitrogen fixation**.

Nitrogen gas (N_2) is composed of two atoms of nitrogen linked by a very strong triple bond (N≡N). This makes it chemically unreactive and large amount of energy is required to break the bond. Nitrogen gas can be fixed in three ways.

a) Atmospheric Fixation

The nitrogen fixation that occurs spontaneously by lightning is called atmospheric fixation; a small amount (5-8%) is fixed in this way. **Lightning** allows nitrogen and oxygen to combine and produce various oxides of nitrogen. These are carried by the rain into the soil where they can be used by plants.

Extra Information

Nitrogen is the basic element for many fertilizers. Ammonia (46%) remains the most important fertilizer till date since it was first manufactured artificially.

b) Industrial Fixation

The synthesis of nitrogen containing **fertilizers** is called industrial fixation.

c) Biological Fixation

Nitrogen-fixing bacteria fix about 60% of nitrogen gas in the atmosphere. The reduction of nitrogen gas to ammonia is energy intensive. It requires 16

molecules of ATP and a complex set of enzymes to break the bonds so that the nitrogen can combine with hydrogen. Its reduction can be written as:

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

Only a relatively few bacteria (the nitrogen-fixing bacteria) are able to carry out this reaction. Fixed nitrogen is made available to plants by the death and lysis of free living nitrogen fixing bacteria *e.g.* ***Azotobacter*** (aerobic) and ***Clostridium*** (anaerobic) or from the symbiotic association of some nitrogen fixing bacteria with plants *e.g.* ***Rhizobium.***

3. Assimilation

The formation of organic nitrogen compounds like amino acid from inorganic nitrogen compounds present in the environment is called **nitrogen assimilation**. Many microorganisms are able to utilize free nitrogen directly from atmosphere but plants obtain nitrogen in the form of inorganic nitrogenous compounds like ammonia and nitrates from the soil, whereas animals take their nitrogen from the eating of plants or other animals.

4. Denitrification

The process in which a nitrate becomes molecular nitrogen, especially by the action of bacteria. Such bacteria are called de-nitrifying bacteria *e.g.* ***Pseudomonas*** reduces nitrates in the soil to gaseous state.

$$\underset{\text{(Nitrate)}}{NO_3} \longrightarrow \underset{\text{(Nitrite)}}{NO_2} \longrightarrow \underset{\text{(Nitrogen Oxide)}}{NO} \longrightarrow N_2O \longrightarrow \underset{\text{(Nitrogen Gas)}}{N_2}$$

25.2 The Flow of Energy in Ecosystem

Energy moves life. The cycle of energy is based on the flow of energy through different trophic levels in an ecosystem. Species are classified to trophic levels on the basis of their main source of nutrition and energy.

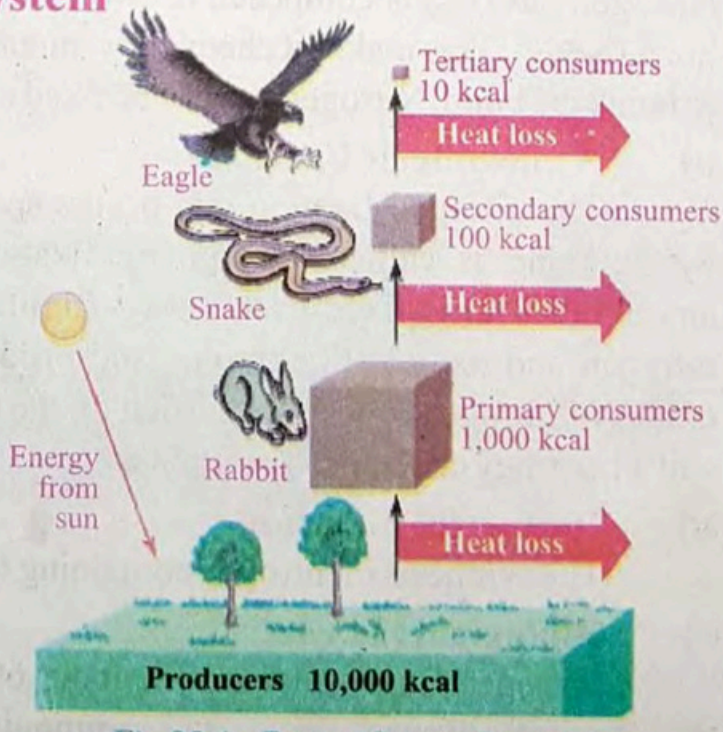


Fig.25.4: Energy flow in Ecosystem

25.2.1 Concept of Trophic Levels

In an ecosystem the organisms are arranged in different feeding groups, each is known as trophic level. There are following trophic levels.

First Trophic Level

At the first trophic level (T_1), **primary producers** (plants, algae and

some bacteria) use solar energy to produce organic plant material through photosynthesis.

Second Trophic Level: Herbivores or primary consumers make up the second trophic level (T_2).

Third Trophic Level

Predators, the **secondary consumers** that eat herbivores comprise the third trophic level (T_3); If larger predator *i.e.* tertiary consumers are present; they represent still higher trophic levels.

Fourth Trophic Level

Organisms that feed at several trophic levels or predator (Carnivore eat another carnivore) and (**omnivores**) are classified at the highest of the trophic levels (T_4), at which they feed.

Fifth Trophic Level

Decomposers, which include **bacteria, fungi, molds**, and **detritivores** such as worms, and insects, break down wastes and dead organisms and return nutrients to the soil, occupy the fifth trophic level (T_5). (Fig.25.5)

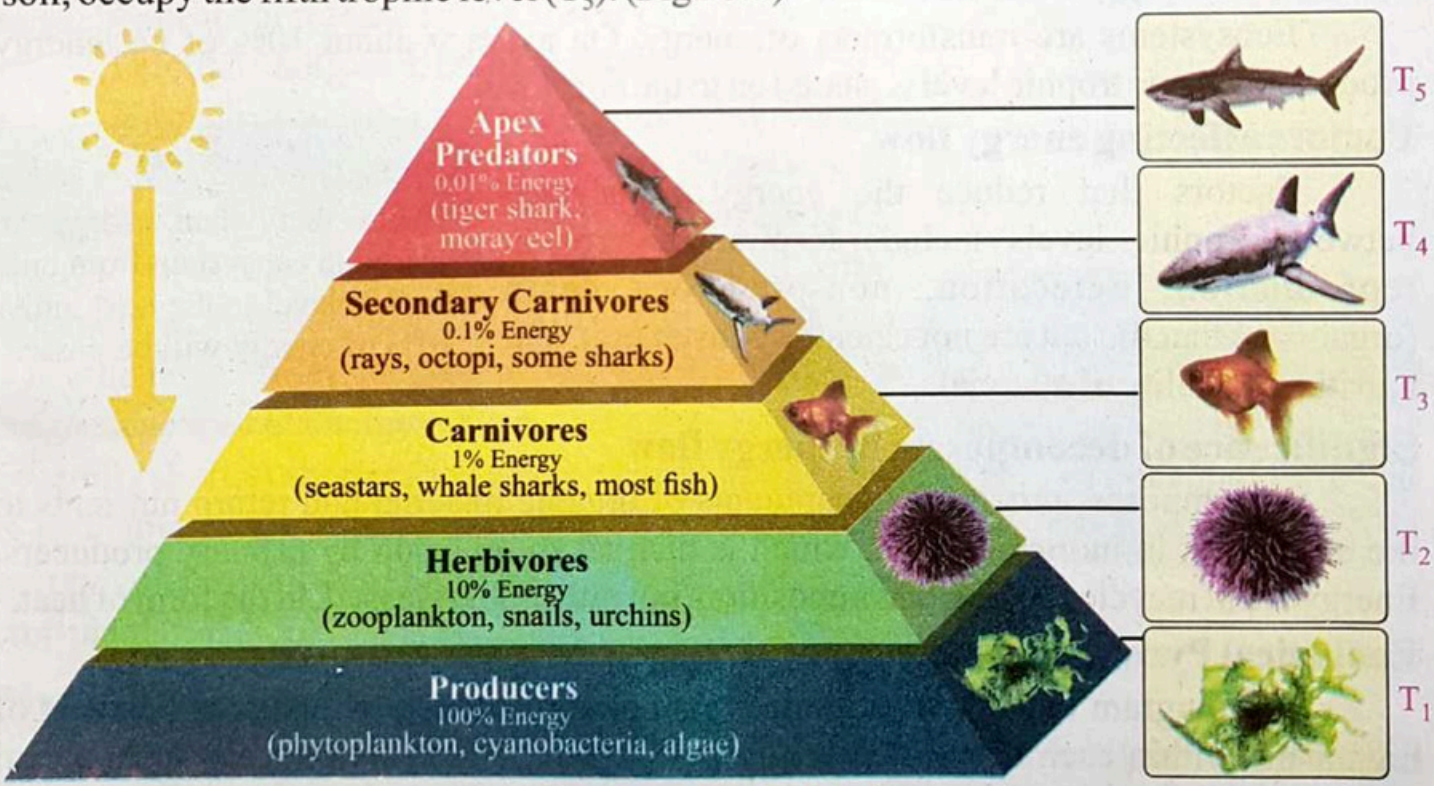


Fig. 25.5: Trophic Levels

25.2.2 Concept of Productivity

The **ultimate source of energy** for ecosystems is sun (solar energy). Only 1% of solar energy is incorporated into the ecosystem. The total amount of solar energy which is fixed by the producers during photosynthesis is called **gross primary productivity**

(GPP). On the other hand, the amount of energy that remains available for plant growth after subtracting the fraction that plants use for respiration is termed as **Net primary productivity (NPP)** or **biomass**.

Productivity in Land Ecosystems

Productivity in ecosystem depends on Temperature and moisture. It generally rises with temperature up to about 30°C, after which it declines and is positively correlated with moisture. On land primary productivity thus is highest in warm, wet zones in the tropics where tropical forest biomes are located. In contrast, desert shrub ecosystems have the lowest productivity because their climates are extremely hot and dry.

Productivity in Aquatic Ecosystems

Light and nutrients are important controlling factors for productivity in aquatic ecosystems. In oceans, light penetrates only up to **500m** of the oceans. Marine primary productivity is high near coastlines. Among aquatic ecosystems, **algal beds and coral reefs** have the highest net primary production while the lowest rates occur in the open due to a lack of nutrients in the illuminated surface layers.

25.2.3 Energy Flow between the Trophic Levels

Ecosystems are transformers of energy. On average about 10% of net energy production at one trophic level is passed on to the next level.

Factors affecting energy flow

Factors that reduce the energy transferred between trophic levels include respiration, growth, reproduction, defecation, non-predatory death (organisms that die but are not eaten by consumers), and nutritional quality of material.

10% Rule

Means that when energy is passed in ecosystem from one trophic level to the next, only 10% of energy will be passed on.

Significance of decomposers in energy flow

Decomposers process large amounts of organic material and return nutrients to the ecosystem in inorganic form, which is then taken up again by primary producers. Energy is not recycled during decomposition, but rather it is released, in the form of heat.

Ecological Pyramids

The diagram that shows the relative amount of energy or matter or numbers of organisms within each trophic level in a food chain or food web is called ecological pyramids. **Ecological pyramids** are, therefore, graphical representation of ecological data.

Pyramids of Energy

A lot of energy is lost to the environment as food is transferred from one trophic level to the next. Energy may be lost to the environment in following ways. (Fig.25.6)

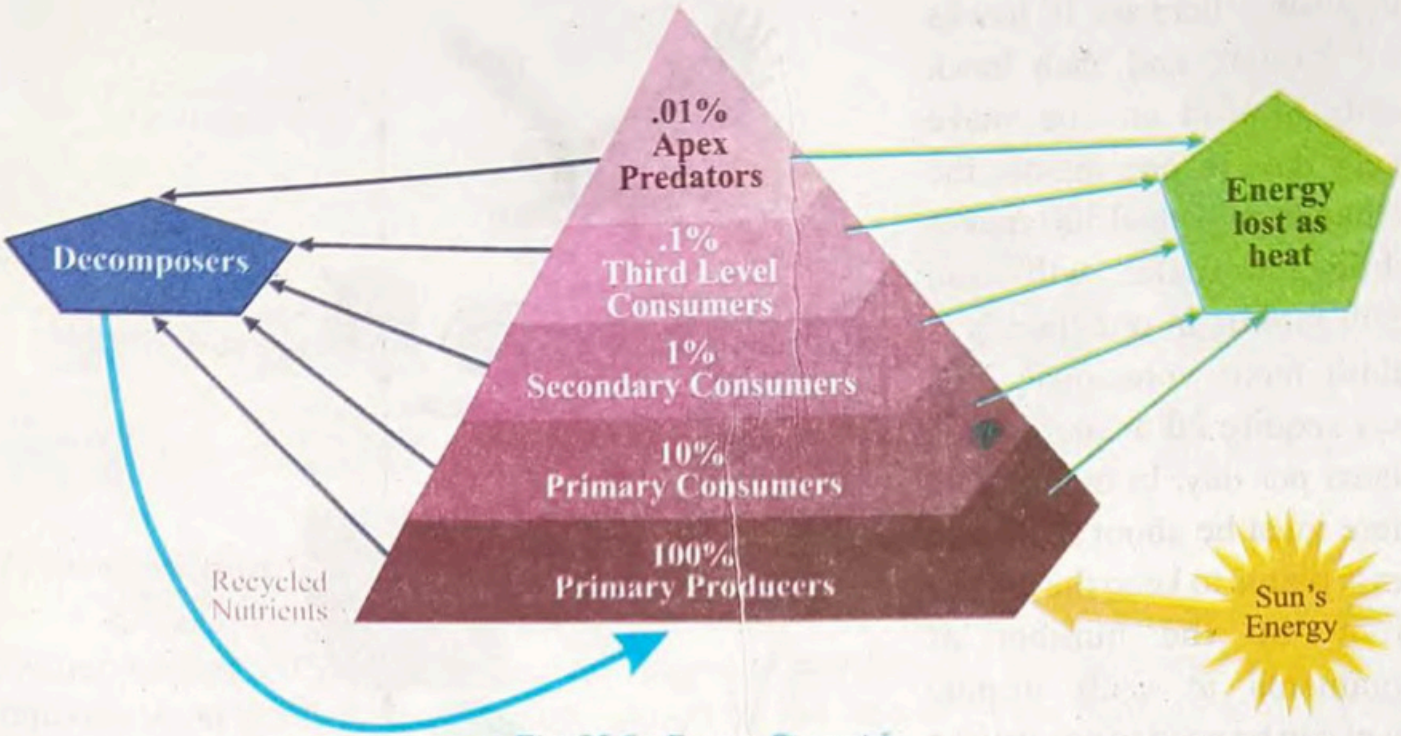


Fig. 25.6: Energy Pyramid

- As heat during respiration at every trophic level.
- Through undigested matter egested by consumers.
- Through excretory products *e.g.* urea, from consumers.

The total energy level decreases progressively along the food chain. Therefore, the pyramid of energy is always broad at the base and narrow towards the apex. Normally we can assume that 90% of energy is lost when it is transferred from one trophic level to the next. The progressive loss of energy explains why food chains are generally short. A shorter food chain means more energy is available to the **final consumer**. Therefore, more energy will be available to human if he feeds directly on crop plants rather that to eat cattle that feeds on plants.

Extra Information

It is estimated that there are more than 100,000 different types of decomposers in existence.

Pyramid of Biomass

Biomass is the total mass of living matter in each trophic level at any one time. For the food chain we have just considered, the pyramid of biomass has a similar shape to that of pyramid of number. The mass of all grasses is together having a larger biomass than the snakes. Three hundred snakes are heavier than the ten **hawks**.

Pyramid of Numbers

Consider a **simple food chain** consisting of grass, rabbits, snakes and hawks.

Supposing there are 10 hawks in a habitat, and each hawk needs to feed on one snake every day. In one month, the 10 hawks will need 300 snakes while 300 snakes will need 4500 rabbits in one month. A rabbit feeds voraciously and may require 20 or more grass plants per day. In one month, there must be about 2700,000 grass plants to keep the rabbits alive. So the number of organisms at each trophic level can be used to construct a pyramid of numbers. For this food chain, the pyramid will be **broad at the base** and **narrow towards the top**. (Fig.25.7)

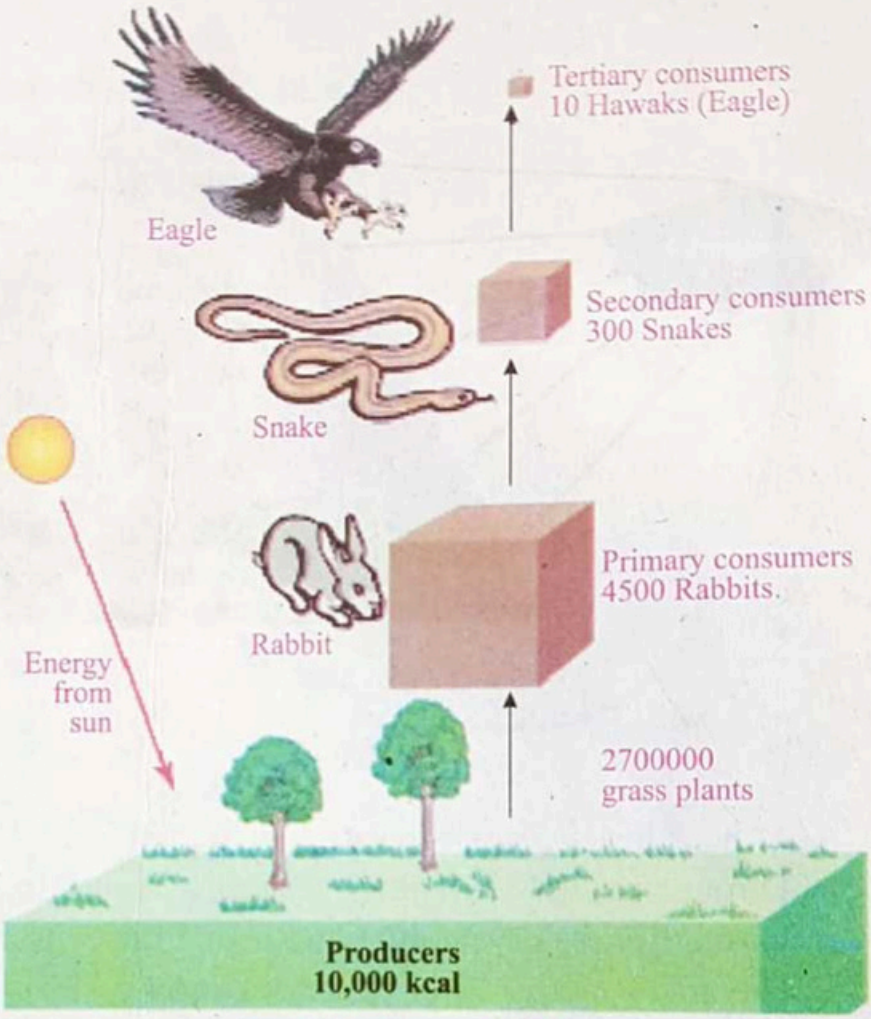


Fig. 25.7: Pyramid of Number

25.3 Ecological Succession

Ecological succession is the gradual process by which ecosystem change and develop overtime.

Kinds of Ecological Succession on the Basis of Origin

There are two main types of succession.

1- Primary Succession

2- Secondary Succession

1) Primary Succession

It is the start of vegetation on bare or newly exposed area such as land exposed as a result of soil erosion, melting of glaciers, *etc.* The newly exposed land surface is unsuitable for a large number of species; only few species are capable of growing in such areas. The **first entrants** are known as **pioneer species** or **primary invaders**.

The primary succession modifies the habitat as a reaction of the plants to environment and results in the creation of conditions suitable for the growth of other species. (Fig.25.8)

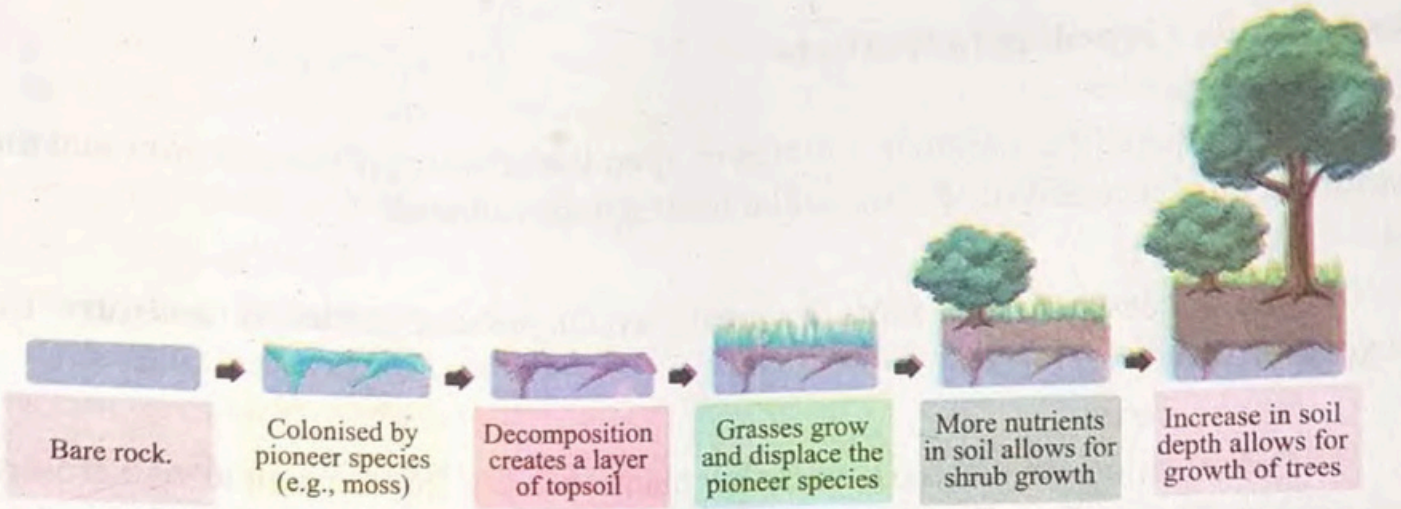


Fig. 25.8: Primary Succession

2) Secondary Succession

It takes place in the areas where the established or **normal succession** is disturbed by such factors as fire, grazing, *etc.* the degree of resemblance to the original succession depends upon the degree of damage caused by the factors. If the damage is slight the secondary succession will soon become primary like. In case of severe damage the secondary succession may remain different. (Fig.25.9)

Fig. 25.9: Comparison between Primary and Secondary Succession

Successions According to Habitats

a) Hydroseres

This type of succession is initiated in **open water** where plants can grow and the pattern of this succession is almost similar in all aquatic habitats.

b) Mesoseres

The succession, that starts in areas, which possess **sufficient moisture** for vegetation to develop.

c) Xeroseres

Colonization of the **bare rock** by plants is very good example of xerosere succession. The rock surface is extremely **xeric** except for short periods of rain when moisture is available.

Hydrach and Xerarch

Ecological succession which beings in pond, lakes, marshes or elsewhere water, are termed as hydrach and different stages are called hydrosere, while succession initiated as bare rocks, sand dunes, rocky slopes, *etc.* (dry areas) are termed as xerarch and different stages are called xerosere.

Stages Involved in the Development of Xeroseres (Xerarch Succession)

A xerosere comprises the following stages.

i) Crusticose Lichen stage

The pioneer species are always **lichens**, *e.g. Rindodina* and *Lecidea*, *Licarnora*, which flourish during short moist periods but can withstand long periods of drought. These pioneers cause the accumulation of some organic matter and dust, thus providing a base for the growth of higher lichens.

ii) Foliose Lichen Stage

The **crusticose-lichens** are gradually replaced by **foliose lichens** such as *Parmelia*, *Umbilicaria*, *dermatocarpon, etc.* The foliose lichens absorb more and lose less water. More organic matter is accumulated and a base for the growth of mosses is provided.

iii) Moss Stage

Xerophytic mosses like *Polytrichum* and *Tortula* occupy the soil formed by the lichens of the previous stages. The mosses absorb much more water and nutrients owing to their longer rhizoids. They can also withstand desiccation. Further accumulation of organic matter results in the formation of a thick layer of humus capable of supporting other herbs and grasses.

iv) Herbaceous Stage

Annual herbs invade the area for a few generations, their growth is poor. As dead

parts of these herbs decay and form humus which riches the soil, *biennial* and **perennial herbs** appear. These plants reduce evaporation and increase temperature, thus cause increase in the moisture of the soil. Gradually a soil layer few inches thick and rich in organic contents is produced which can support the growth of shrubs.

v) Shrub Stage

Shrubs then invade the soil formed by the inhabitants of the previous stages. These over shadow the herbs. More organic matter is accumulated, soil becomes richer and its water retaining capacity is increased.

vi) Three and Climax stage

Among the first invaders are xerophytic trees, which are widely spaced. The trees increase in number and become stronger and wide spread as the soil becomes deeper. Mesophytic ones replace the xerophytic shrubs. New herbs develop in the humid air and the richer soil. The interaction between species and environment continues for generations and the result is a **climax forest** with thick growth of mesophytic trees associated with characteristic under shrubs and herbs.

25.4 Population Dynamics

Population dynamics is the branch of life sciences which deals with the studies of long term and short term changes in size, age, composition of population and biological and environmental processes influencing those changes. **Population dynamics** deal with the way populations are affected by birth and death rates and by **immigration** and **emigration**.

25.4.1 Characteristics of a Population

A population is a group of individuals of a single species, living in the specific area at a specific time. Members of a population rely on the same resources, are influenced by similar environmental factors and have a high likelihood of interacting with and breeding with one another. The characteristics of a population are: growth, density, distribution, carrying capacity and viable size.

Growth

Increase in the number of individuals of a population is called **population growth**. Consider what happens if a few individuals enter an unoccupied area. Assuming there is enough food and that predation and disease are not too severe, reproduction will occur and the number of individuals will increase. At first, there may be a **lag phase** as the individuals settle into their new environment. As reproduction gets underway, the population shows exponential growth. The population size doubles at regular intervals. During exponential phase the population is said to grow geometrically.

Density

Density is the number of individuals per unit area or volume *e.g.* the number of apple trees per square kilometer in Zairat or the number of *E. coli* bacteria per milliliter in a test tube.

Distribution

The way a population is spatially distributed across an area, is driven largely by food supply or other resources, is called **distribution**. There are three distribution patterns found in different populations like clumped (individuals aggregate in patches), uniform (individuals are evenly spaced) or random distribution (unpredictable spacing among individuals).

Carrying capacity

There is a limit to the number of individuals that can occupy a habitat. The **carrying capacity** is defined as the maximum population size that a particular environment can support. Ecosystems cannot exceed their carrying capacity for a long period of time. Otherwise species will deplete sources of food, water, *etc.*

Health Services through various programmes

The department of population welfare is providing Family Planning and Reproductive Health Services. These include:

1. Family Welfare Centres
2. Mobile Service Units
3. Reproductive Health Services (RHS)

These centres are being run by various NGOs with assistance of the Population Welfare Department.

25.5 Human Impacts on Environment

Human activity has been affecting the environment for thousands of years. Population growth leads to the loss of natural habitat. **Deforestation** causes loss of species of fauna and flora, oxygen production and carbon dioxide elimination. Ozone layer depletion, water pollution, global warming, desertification, increased erosion of land, is directly caused by human activities such as use of nuclear fuel, industrialization, urbanization, transportation, *etc.*

25.5.1 Nuclear Power

Nuclear power is the use of nuclear reaction that releases nuclear energy to generate heat. This heat is used in **steam turbines** to produce electricity in a nuclear power plant, generates heat and electricity. The scarcity of fossil fuels which is not available in all the countries is the reason for the development nuclear power stations.

Advantages of nuclear power

There are number of advantages of nuclear power *e.g.*

i) 15% of the world electricity provided by nuclear power.

ii) Nuclear power costs about the same as coal, so it's not expensive to make electricity.

iii) Does not produce smoke or carbon dioxide, so it does not contribute to the **greenhouse effect**.

iv) Produces huge amounts of energy from small amounts of fuel.

v) Produces small amounts of waste.

vi) Nuclear power is reliable and **un-exhaustible source of energy**.

Disadvantages of using nuclear power

Some disadvantages of nuclear power are as under.

i) Release **radioactive wastes** in environment, so disposal and safety is important

ii) Incurs heavy **initial cost** to construct a power plant.

iii) Threat to aquatic marine life due to the **traces of oxygen**.

iv) **Hazardous implications** on human lives and technology can be misused especially by **terrorists**.

v) Nuclear weapons can **destroy humanity**.

Chernobyl Nuclear Power Incidence

The Chernobyl disaster was a nuclear accident. It occurred on 26 April, 1986 at the **Chernobyl Nuclear Power Plant in Ukraine**. An explosion and fire released large quantities of radioactive contamination into the atmosphere which spread over much of the **Union of Soviet Socialist Republics (USSR)** and Europe. Approximately over 500,000 workers were affected apart from the 57 direct deaths in the accident itself. United Nations Scientific Committee on the Effects of Atomic Radiation predicted in 2005 that up to 4,000 additional cancer deaths related to the accident would appear among the 600,000 persons receiving more significant exposures.

What happened in Japan in 2011?

On March 11, 2011 an earthquake of magnitude of 9.00. It ruptured a 500 kilometres long fault zone off the northeast coast of Japan, killing 513 people.

25.5.2 Carbon Dioxide and Global Warming

Due to burning of fossil fuel in motor vehicles and industrial processes, the amount of CO_2 is increased in atmosphere. CO_2 absorb high energy radiations and thus result is increase the atmospheric temperature. This rise in temperature is known as **global warming**. CO_2 is also injurious to human health as it decreases the oxygen

carrying capacity of blood.

Causes of Increasing Concentration of CO_2 in Atmosphere

The main causes of CO_2 in the atmosphere are burning of fossil fuels, such as coal, oil and natural gas for industry, driving our transport, heating our homes, generating electricity, the burning of wild, forests are increasing CO_2 in the atmosphere. There has been a marked increase in the CO_2 percentage in the atmosphere since industrial revolution. In addition, **eruption of volcanoes** off and on, is another cause to increase of CO_2 in the world atmosphere.

CO_2 Concentration and the Global Warming

The amount of CO_2 in the air is increasing day by day. Itmakes up about 0.04% of the air now, compared with 0.03% in the mid-twentieth century. It is very likely that the raised atmospheric CO_2 levels are causing the average temperatures on Earth to increase, a process called global warming or green-house effect. (Fig.25.12)

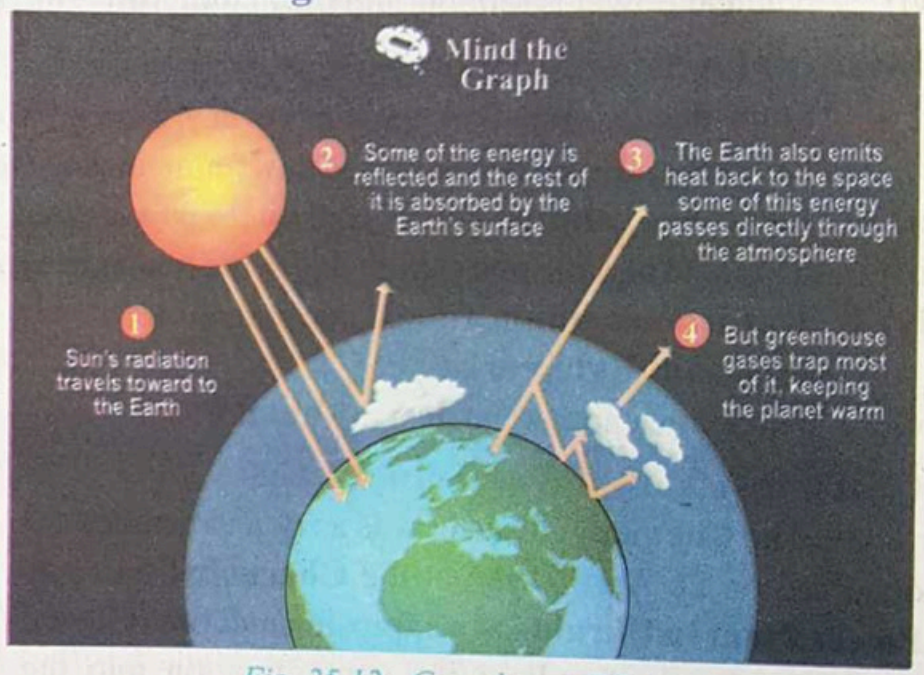


Fig. 25.12: Greenhouse Effect

Long term effects of Global Warming

CO_2 increase in atmosphere prevents reflection of infra-red radiation which warms earth. A worst-case scenario suggests that the warming would be great near the poles. The resultant melting polar ice might raise sea level by an estimated 100 m, gradually flooding areas 150 km (or more) inland from the current coastline. A warming trend would also alter the geographical distribution of precipitation, making major agricultural areas drier.

25.5.3 Acid Rain

Acid rain, or **acid deposition**, is a broad term that includes any form of precipitation that contains acidic components such as **sulphuric acid** or **nitric acid**. The precipitation is not necessarily wet or liquid; the definition includes snow, fog and hail. The type of acid rain that contains water is called wet deposition while the acid rain that contains dust or gases is called dry deposition. (Fig.25.13)

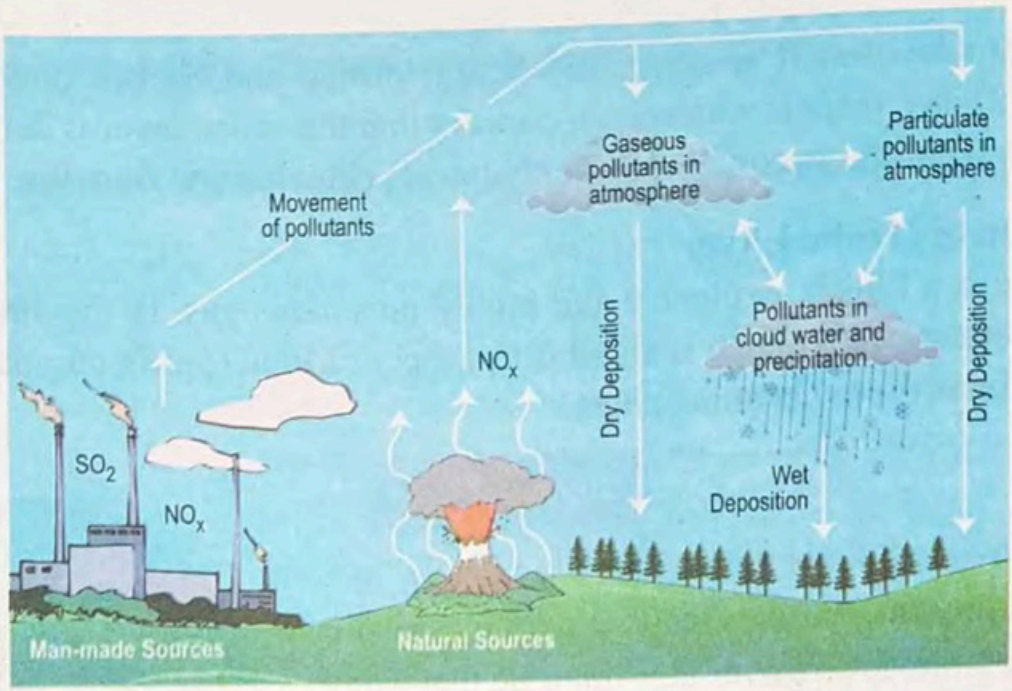


Fig. 25.13: Acid Rain

The Causes of Acid Rain

The acid rain may fall hundreds of miles away from the source of pollution. It is a natural phenomenon caused by chemicals emitted during volcanic eruption and forest fires. However, majority of acid rain is caused by human activity such as burning of coal by electricity generating plants, industrial boilers and large smelters that obtain metals from ores. In addition, nitrogen oxides are emitted by automobiles. The causes of acid rain due to human activities are called **anthropogenic sources**.

Effects of Acid Rain

The acid rain is harmful in number of ways. These include:

i) It increases soil acidity.

ii) Acid rain damages life in farms and forests.

iii) It kills aquatic organisms and prevents their successful reproduction.

iv) It also increases the quantity of certain metals such as **Aluminium** that may prove toxic to many organisms in the ecosystem.

v) Acid rain causes extensive damage to buildings and stone structures, which is known as **stone cancer**.

vi) Acid rain adversely affects the nervous, respiratory and digestive system of man.

25.5.4 Ozone Depletion

The ozone layer protects all life from sun's harmful radiations. The earth's atmosphere is composed of several layers. The lower layer is called **troposphere** (10 km altitude). The next layer is **stratosphere** which is 10-50 km. The ozone layer is concentrated in 15-30 km, above the earth's surface in stratosphere. The ozone layer

contains O_3 molecules. It is constantly being formed and broken down in the high atmosphere. Today, there is widespread concern that the ozone layer is deteriorating due to the release of pollution, containing the chemicals **chlorine** and **fluorine**.

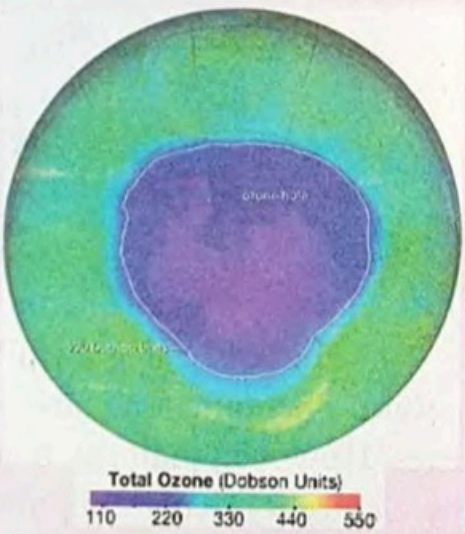
Composition of Ozone Layer

Ozone is a bluish, explosive and highly poisonous gas. In the stratosphere, the normal concentration of ozone is about 0.1 part per million (ppm), compared with 0.02 part per million in the lower atmosphere.

Ozone Hole

The ozone hole is not technically a "hole" where no ozone is present, but is actually a region of depleted ozone in the stratosphere over the Antarctic that happens at the beginning of Southern Hemisphere spring (August-October).

The average concentration of ozone in the atmosphere is about 300 Dobson Unit; any area where the concentration drops below 220 Dobson Units is considered part of the ozone hole.



Formation of Ozone Layer

Ozone is formed in the atmosphere when ultraviolet radiation from the sun splits one oxygen molecule into two oxygen atoms. The atomic oxygen then combines with another oxygen molecule to form ozone (O_3).

Causes of Ozone Layer Depletion

Ozone molecules splits into one oxygen atomic form and two oxygen in molecular form. In the stratosphere, there is a group of commercially important compounds called **chlorofluorocarbons (CFCs)**. These have been used as **propellants** in **aerosol cans**, **coolants** (*e.g.* Freon) in air conditioners and refrigerators, foam (*e.g.* Styrofoam) for insulation and packing and cleaners in the electronic industry. Ultraviolet radiation breaks CFCs and similar compounds into chlorine, fluorine and carbon. Under certain stratospheric conditions, chlorine and fluorine are capable of reacting with ozone, converting it into molecular oxygen (O_2) and atomic oxygen (O).

Interesting Information

Pollution is one of the biggest global killer affecting over 100 million people. That's comparable to global diseases like malaria and HIV.

Role of Ozone Layer in Protecting the Life on Earth

Ozone molecules in the stratosphere absorb incoming solar ultraviolet radiations and this protects life on Earth from harmful UV rays.

Extra Information

In 1985, it was discovered that the springtime levels of stratospheric separate ozone over Antarctica had declined by over 40% since 1977. A hole had been punctured in Earth's protective shield.

Effects of Ultra Violet Radiation on Human Health

With depletion of the ozone layer, UV radiations reach to the Earth's surface. Excessive exposure to UV radiation is linked to a number of human health problems, including sunburn, premature aging of skin, skin cancer and **cataracts**. Photosynthesis by phytoplankton is also affected and reduced by ultraviolet radiation.

25.6 Environmental Resources and their Depletion

Wherever humans have gone, they have altered the environment according to their needs. Living organisms are important natural resources. Earth is a self-contained unit. The future of the mankind depends on protection and conservation of environmental resources.

25.6.1 Kinds of Natural Resources

Environment is full of resources. All resources of environment can be divided into two groups *i.e.* renewable and non-renewable resources.

Renewable Resources

Renewable resources are un-exhaustible resources that replace themselves quickly enough to keep pace with consumptions. Examples are air, water, land and wild life. Living organisms use these resources continuously but these are constantly replaced by natural cycles *e.g.* water cycle, carbon cycle, oxygen cycle, nitrogen cycle, *etc.*

Non-renewable Resources

Non-renewable resources are formed at a rate much slower than their environmental consumption. These are exhaustible and cannot be replaced if destroyed. Examples are various metals, non-metallic minerals, coal, oil and natural gas, *etc.*

Interesting Information

27,000 trees are cut down each day so we can have toilet paper.

25.6.2 Conventional and Non-Conventional Energy sources

There are plenty of energy resources to get energy. These resources can be classified as conventional and non-conventional sources.

Conventional Energy Sources

The energy source that has been used for long time is called conventional sources

of energy. The examples of conventional energy sources are fossil fuels (coal, natural gas, oil), firewood and sources of energy *i.e.* electricity, coal, oil, wood, peat and uranium.

Extra Information

Fóssil fuels include coal, oil and gas. They provide 95% of the energy requirement. They are non-renewable. They are called fossil fuels because they are remains of plants and animal that lived millions of years ago.

Human prefer to use conventional sources of energy because these are **inexpensive** and require established technologies that can produce energy around the clock *e.g.* fossil fuel. The disadvantages of conventional sources of energy are that they have a limited supply because eventually these sources (fossil fuels) will be used up. In addition, burning fossil fuels release significant amounts of greenhouse gases (carbon dioxide, methane, nitrous oxide, *etc.*) and contribute to acid rain and rain Pollution.

Non-conventional Energy Sources

These resources of energy are continuously replenished by natural processes. These are not commonly used, so called non-conventional resources. These include solar energy, **Hydro-electric energy** (dams in rivers), Wind energy, Tidal energy, Ocean wave energy, **Geothermal** energy (heat from deep under the ground), **Ocean thermal power** (the difference in heat between shallow and deep water), **Biomass** (burning of vegetation to stop it producing methane), **Bio-fuel** producing ethanol (petroleum) from plants, Bio-gas. It is also known as renewal energy sources.

Interesting Information

The conventional energy sources are the non-renewable resources in Pakistan that includes: thermal energy and nuclear energy. Thermal sources in Pakistan are coal, oil, natural gas. The non-conventional sources of energy in Pakistan are wind energy, hydroelectric power, solar energy and biogas.

The **advantages** of non-conventional source of energy are that these are abundant in nature. Solar and wind energy is great source of energy but so for these sources are not used abundantly. There are pollution free and eco- friendly. These sources can be renewed with minimum effort and less energy, consumption for their renewable. The disadvantages of nonconventional energy sources include inconsistent, high operating cost, harmful to wild life and environment, *etc.*

Depletion of Resources

Resource depletion is a term referring to the exhaustion of raw materials within a region. Use of resources beyond their rate of replacement is considered to be resource

depletion.

Causes of resource depletion

There are many causes of depletion of natural resources. These include over consumption/ excessive or unnecessary use of resources, non-equitable distribution of resources, overpopulation, slash and burn agricultural practices, technological and industrial development, erosion, irrigation, mining for oil minerals and pollution or contamination of resources.

25.6.3 Protection of Environmental Resources

Environmental resources are very important for our existence. Our health and well- being are closely linked to the quality of our air, water, soil and biological resources. There are many things we can do to protect these resources *e.g.* reuse and recycle, educate common masses, conserve resources, and use renewable resources for energy production, planting trees.

Role of Government

In protecting the environmental resources, government can play very important role. The governments control and develop forests, dams, major irrigation system, power stations, railways, ports, roads, mines and industries of the country. The ministry of environment is entrusted with planning, protection and coordination of environment and forestry programmes. The ministry is involved in conservation and survey of flora, fauna, forests and wildlife, prevention and control of pollution, afforestation, and regeneration of degraded areas and protection of overall environments. The assessment of environmental impact prior to implementing any project which can damage environment is taken up by ministry of environment. To educate the people every year, earth day on 22nd of April and tree plantation week are observed. However, Government should take steps like protection of key ecosystems, promote small agricultural producers, promote green energy, protect wild life, ban on hunting, *etc.*

Extra Information

Tsunami Billion Tree Scheme was launched in 2014 by the Government of Khyber Pakhtunkhwa (KPK), Pakistan as a response to the challenge of global warming. This scheme restores 350000 hectares of forests and degraded land to suppress its Bonn challenge commitment.

Role of Non-Governmental Organizations (NGOs)

NGOs are playing a very important role in environmental protection and management and creating mass awareness towards environment. They have made people aware of the environmental problems, which are caused due to neglect and uncontrolled

exploitation of natural resources. Some of the NGOs are working for environmental awareness while some are working in research field. Pakistan is facing number of environmental problems like deforestation, air pollution, climate changes, pesticide misuse, and desertification. Pakistan is a developing country and government alone cannot tackle these problems efficiently, so NGOs should play their role to overcome these environmental issues.

Activity

Draw a concept map that shows how population grows. Include the following terms: exponential growth, logistic growth, birth rate, death rate, immigration, emigration. Add any other terms that you think are useful to complete the map.

Extra Reading Material

Control of Population Growth in Pakistan

The Ministry of Population Welfare, Government of Pakistan is responsible for the control of population growth in Pakistan. Population welfare program is an on-going program launched by the ministry of population of Pakistan since 1960. The first ever population policy in Pakistan was announced on 11th July, 2002. The population policy is wide in scope. It states a commitment to reduce the incidence of unwanted fertility, promote small family norm, make an investment in youthful population and focus on male involvement. The overall vision of population policy is to achieve population stabilization replacement level. A total fertility rate of 2:1 child per woman by 2020. Thus increase awareness of adverse consequences of rapid population growth at the national, provincial, district and community level. Promote family planning as an entitlement based on informed and voluntary choice and attain reduction in infertility.

Science, Technology and Society (STS)

Investigate the careers related to the study of environmental resources.

- Aquarium Director of Education
- Desert Ecologist
- Environmental Attorney
- Environmental Planner
- Environmental Organizing Consultant
- Forest Ranger
- Natural Resource Specialist
- Outdoor Adventure Educator
- State Park Resources Ecologist
- Wildlife Biologist
- Professor
- Ecologist

- Director in Antipollution Department
- Legal consultant
- Act of Wild Life
- Implication of Environment Acts
- Role of Forest and Forest Department
- International Union for Conversation of Nature (IUCN)
- World Wild Fund for Nature (WWF)

SUMMARY

- The flow of chemical elements and compounds between living organisms and their physical environment is known as biogeochemical cycle.
- A lot of energy is lost to the environment as food is transferred from one trophic level to the next.
- Nitrogen is the necessary element of some organic molecules such as protein and nucleic acid.
- The cycle of energy is based on the flow of energy through different trophic levels in an ecosystem.
- Productivity in ecosystem depends on temperature and moisture.
- The diagram that shows the relative amount of energy or matter or number of organisms within each trophic level in a food chain or food web is called pyramid.
- Ecological Succession is the gradual process by which ecosystem changes and develops over time.
- Population dynamics is the branch of life science concerned with the long term and short term changes in size, age and composition of population.
- The carrying capacity is defined as the maximum population size that a particular environment can support.
- Nuclear power is the release of nuclear energy to generate electricity and heat.
- Human activities have been affecting the environment for thousands of years.
- The amount of CO_2 is increasing in the air day by day.
- Acid rain or acid deposition is a broad term that includes any form of precipitation that contains acidic components.
- In the stratosphere, there is a group of commercially important compounds called chlorofluorocarbons.
- Non-renewable resources form at much slower than their environmental consumption.
- Pakistan is facing number of environmental problems like deforestation, air pollution, climate change, pesticides misuse, desertification, *etc.*

EXERCISE

SECTION-I: OBJECTIVE QUESTIONS

Multiple Choice Questions (MCQs)

A. Select the correct answer:

1. Change in community structure of an ecosystem over a period of time:
   (a) Niche (b) Unstable ecosystem
   (c) Succession (d) Pioneer
2. Herbaceous stage in xerosere is the:
   (a) First stage (b) Third stage
   (c) Fourth stage (d) Last stage
3. The ozone layer has developed a hole over the:
   (a) Arctic (b) Equator
   (c) Antarctica (d) Tropics
4. As CFCs rise to the atmosphere, the ultraviolet rays release:
   (a) Fluorine (b) Chlorine
   (c) Carbon (d) Nitrogen
5. The group of organisms that fix atmospheric nitrogen are
   (a) Plants (b) Bacteria
   (c) Fungi (d) Insects
6. The producers of ecosystem are
   (a) Decomposers (b) Absorptive heterotrophs
   (c) Ingestive heterotrophs (d) Autotrophs
7. Ozone layer is found in
   (a) Troposphere (b) Stratosphere
   (c) Hydrosphere (d) Mesophere
8. The cause of greenhouse effect is
   (a) CO_2 (b) Hydrogen
   (c) Nitrogen (d) Oxygen
9. The graphical representation of ecological data of an ecosystem is called
   (a) Succession (b) Niche
   (c) Habitat (d) Pyramid
10. Which of these levels of ecological study involves both abiotic and biotic components
    (a) Organisms (b) Population
    (c) Ecosystem (d) Community

11. Which of the following is renewable resource?
(a) Oil and natural gas (b) Water and oil
(c) Air and water (d) Oil and coal

12. About 95% of our daily energy requirements are fulfilled by
(a) Atomic energy (b) Hydroelectric power
(c) Fossil fuel (d) Wind energy

13. The ozone molecule is made up of by building of three atoms of
(a) Nitrogen (b) Hydrogen
(c) Oxygen (d) Carbon

B. Fill in the Blanks.

1. Every organism must get nutrients for its .....
2. The water cycle is driven by ..... energy.
3. The total amount of solar energy which is fixed by the producers during photosynthesis is called .....
4. Ecological succession which begins in water is called .....
5. Increase in the number of individuals of a population is called ..... growth.
6. The maximum population size that a particular environment can store is called ..... capacity.
7. The energy resources that have been used from long time is called ..... source of energy.
8. Acid rain may fall hundreds of miles away from the source of .....
9. The Chernobyl disaster incidence took place on 26, April .....

SECTION-II: SHORT QUESTIONS

C. Give the short answers of the following questions.

1. Describe trophic level.
2. Define nitrification and role of bacteria in this process.
3. Differentiate between denitrification and nitrification.
4. Illustrate ecological pyramids.
5. Write the reasons why food chains are shorter?
6. Write some causes of acid rain.
7. Describe briefly greenhouse effect.
8. Differentiate between industrial and biological fixation of nitrogen.
9. Differentiate between hydrosere and xerosere.

10. Define the following terms.
    i) Aquifers
    ii) Net primary production
    iii) Climax community
11. Briefly describe role of NGOs to tackle environmental problems.
12. Differentiate between renewable and non-renewable energy resources.
13. Describe effects of ozone layer depletion.

SECTION-III: EXTENSIVE QUESTIONS

D. Give detailed answers of the following questions.

1. Describe water cycle.
2. Describe different components of ecosystem.
3. Define ecological pyramid and explain pyramid of energy biomass and number.
4. Define succession. Explain two types of ecological succession
5. Explain the characteristics of population dynamics?
6. Define nuclear energy and explain its advantages and disadvantages.
7. Define ozone layer and describe its composition, formation, role and causes of its depletion.
8. Differentiate between conventional and non-conventional energy resources, Discuss them in detail.
9. Explain different stages of xerosere succession.