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COMPONENTS AND SUBCOMPONENTS OF ENVIRONMENT

1.1 CLASSIFICATION OF ENVIRONMENT

The term Environment can be broadly defined as one's surroundings. To be more specific we can say that it is the physical and biological habitat that surrounds us, which can be felt by our physical faculties (seen, heard, touched, smelled and tasted.)

The two major classifications of environment are :

(A) **Physical Environment:** External physical factors like Air, Water, and Land etc. This is also called the **Abiotic Environment.**

(B) **Living Environment:** All living organisms around us viz. plants, animals, and microorganisms. This is also called the **Biotic Environment.**

Earth's environment can be further subdivided into the following four segments:

(1) Lithosphere

(2) Hydrosphere

(3) Atmosphere

(4) Biosphere.

LITHOSPHERE

The earth's crust consisting of the soil and rocks is the lithosphere. The soil is made up of inorganic and organic matter and water. The main mineral constituents are compounds or mixtures derived from the elements of Si, Ca, K, Al, Fe, Mn, Ti, O etc. (Oxides, Silicates, and Carbonates). The organic constituents are mainly polysaccharides, organo compounds of N, P and S. The organic constituents even though form only around 4% – 6% of the lithosphere, they are responsible for the fertility of the soil and hence its productivity.

HYDROSPHERE

This comprises all water resources both surface and ground water. The world's water is found in oceans and seas, lakes and reservoirs, rivers and streams, glaciers and snowcaps in the Polar Regions in addition to ground water below the land areas. The distribution of water among these resources is as under Table 1.1

Table 1.1

Oceans and Seas	96–97 %
Glaciers and polar icecaps	2–3 %
Fresh water	< 1%

The water locked up in the Oceans and Seas are too salty and cannot be used directly for human consumption, domestic, agriculture or Industrial purposes. Only less than 1% of water resources are available for human exploitation. Water is considered to be a common compound with uncommon properties. These uncommon properties (e.g. anomalous expansion of water) are mainly responsible for supporting terrestrial and aquatic life on earth.

BIOSPHERE

The biosphere is a capsule encircling the earth's surface wherein all the living things exist. This portion extends from 10000 m below sea level to 6000 m above sea level. Life forms do not exist outside this zone. The biosphere covers parts of other segments of the environment viz. Lithosphere, Hydrosphere and Atmosphere. Life sustaining resources like food, water and oxygen present in the biosphere are being withdrawn and waste products in increasing quantities are being dumped. The biosphere has been absorbing this and assimilating them. However the rate of waste dumping has gone beyond the assimilating capability of the biosphere and signals of this stress is becoming evident.

ATMOSPHERE

It is the gaseous envelope surrounding the earth and extends upto 500 kms above the earth's surface. The composition of the atmosphere is given in Table 1.2

Table 1.2

Constituent	Volume %
Nitrogen	78.1
Oxygen	20.9
Water vapour	0.1–5
Argon	0.9
Carbon dioxide	0.03
Trace constituents*	Balance

*The trace constituents include Helium, Neon, Krypton, xenon, SO_2, NO_2, Ammonia, Ozone, and Carbon monoxide etc.

The atmosphere, which is a gaseous cover, protects the earth from cosmic radiations and provides life sustaining Oxygen, the macronutrient Nitrogen and Carbon dioxide needed for photosynthesis. The atmosphere screens the dangerous UV radiations from the sun and allows only radiations in the range of 300 nm – 2500 nm (near UV to near IR) and radio waves. The atmosphere plays a major role in maintaining the heat balance of the earth by absorbing the re-emitted radiation from the earth. In addition the atmosphere is the medium of carriage of water from the oceans to the land in the hydrological cycle.

The Structure of the Atmosphere

The atmosphere is broadly divided into four major zones viz. Troposphere, Stratosphere, Mesosphere and Thermosphere. Characteristics of these zones are pictorially represented below in Fig. 1.1

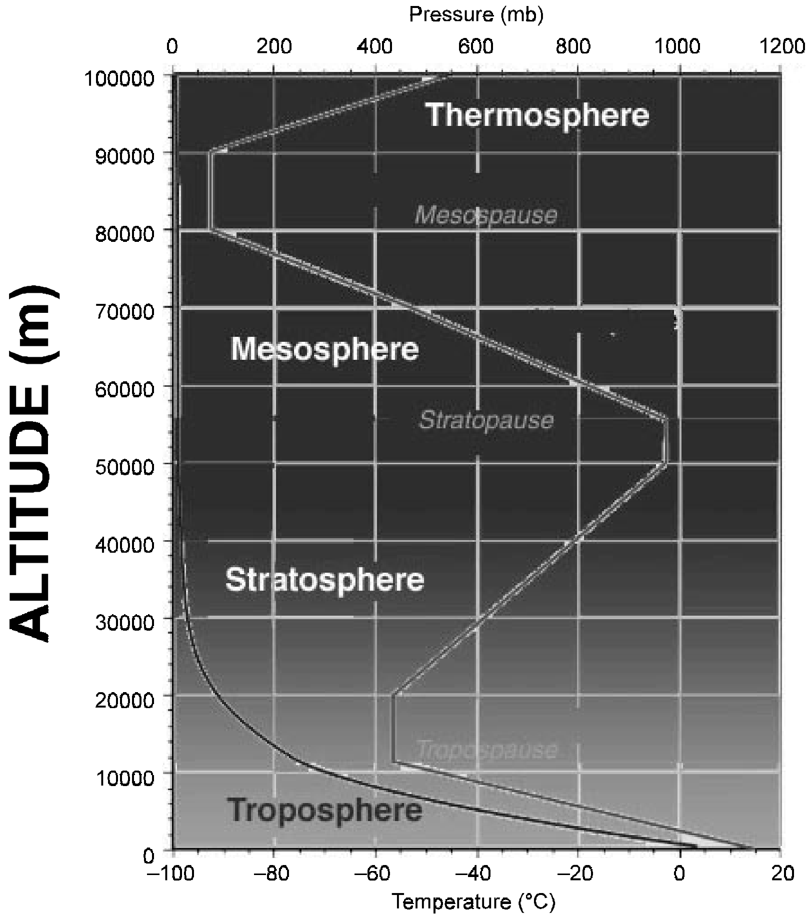


Figure 1.1

TROPOSPHERE

Troposphere is the layer of air nearest to the ground. Temperature decreases with height. The average temperature drops from 15ºC at sea level to –56.5ºC at 11,000 m above sea level. Mixing of the air molecules due to their constant movement (winds) keeps the composition of the gases more or less same throughout the troposphere. An exception to this is water vapor. Most water vapor evaporates from the surface of the Earth and is found in the lower troposphere. Most of the weather occurs in the troposphere. Tropopause is the top of the troposphere, which is a transition layer between Troposphere and Stratosphere

STRATOSPHERE

Stratosphere is the layer of air above the troposphere where temperature increases with height. The average temperature rises to –2.5ºC at 50,000 m above sea level. Ozone is found in higher concentrations between 20 and 30 km above the surface. Hence sometimes this layer is referred to as the "ozone layer". Ozone absorbs radiant energy from the sun and hence warmer temperatures are encountered in the stratosphere. Stratopause is the top of the stratosphere, which is a transition layer between Stratosphere and Mesosphere.

MESOSPHERE

Mesosphere is the layer of air above the stratosphere where temperature decreases with height. The average temperature decreases to –90°C at 90,000 m. This is the coldest layer of the atmosphere. Mesopause is the top of the mesosphere, which is a transition layer between Mesosphere and Thermosphere.

THERMOSPHERE

Thermosphere is the layer of air above the mesosphere. The temperatures in the thermosphere increase with increasing height, but there are not many molecules in this layer. The air becomes less and less dense as we reach space.

1.2 INTER-RELATIONSHIP BETWEEN THE COMPONENTS AND SUBCOMPONENTS

Matter (chemicals) as well as living beings on earth are distributed among the four major Environmental Components viz. Lithosphere, Hydrosphere, Atmosphere and Biosphere. While for the purpose of studying and understanding the Global Environment this division may be convenient, constant interaction by way of mass and energy transfer between these components and subcomponents is constantly taking place. This is pictorially indicated in Fig. 1.2

Every sphere has a flow of matter and energy to every other sphere, which is a two-way linkage as shown in the figure. Such two-way interactions are also taking place within individual spheres. This indicates movement of matter/energy from one location to another without exiting the sphere. Environmental problems are hence not confined only to the component/system where they arise but spread to other components as well. A clear example of this is the Acid Rain. Emissions of air pollutants like oxides of Sulfur and Nitrogen are transported over long distances where they are brought down to land and fresh water bodies by rain, creating damage to crops, lands, fresh water resources including ground water, properties and aquatic life. Another classical example is the buildup of gases like Carbon dioxide in the atmosphere. The emissions may be localized but the impact is massive and global in nature leading to global warming which has far reaching consequences in terms of both area and time.

1.3 STRUCTURE AND FUNCTIONAL COMPONENTS OF THE ECO SYSTEM

1.3.1 Ecology and Ecosystem

The study and understanding of Ecology is an integral part of Environment Science learning. Every living being however small or big depends on the environment for its existence and also competes with others for essentials in life. For survival, living beings form groups and different groups compete with each other for survival. The study of interrelationships between organisms and group of organisms is called the science of Ecology. The word Ecology has its roots from two Greek words "ikos" meaning a house or dwelling or place of living or habitat and "logos" meaning study. Ecology is hence the study of interrelationship among plants and animals and their interactions with the physical environment.

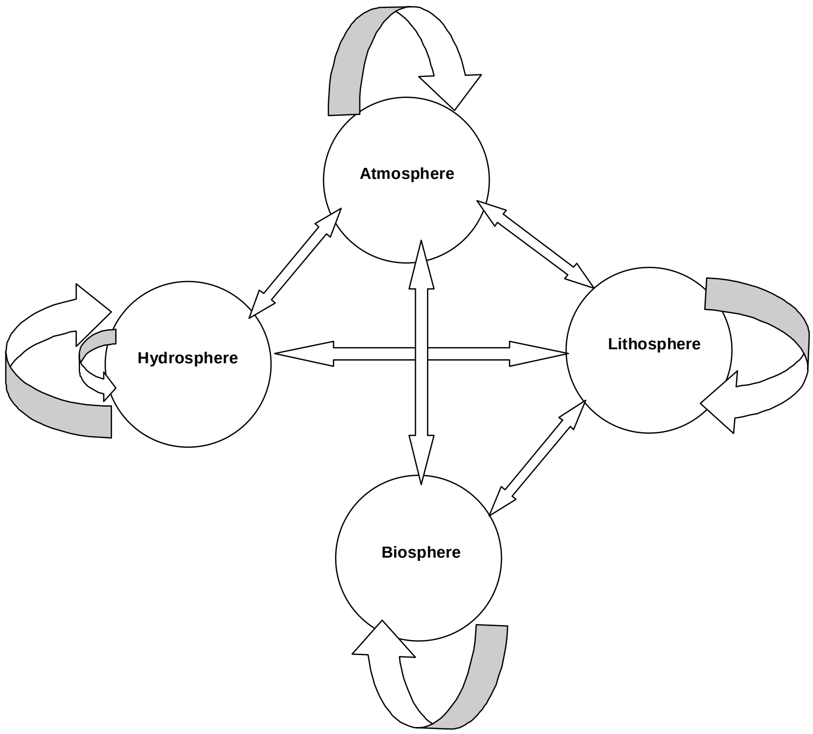


Figure 1.2

There are two important divisions of Ecology. They are :

(1) **Autoecology or Species Ecology:** This is the study of an individual species. i.e. behavior, adaptation and interaction of a particular species in its environment.

(2) **Synecology or Ecology of Communities:** This is the study of Communities and their interaction with the environment.

An Ecosystem is defined as a group of plants, animals or living organisms living together and interacting with the physical environment in which they live. An Eco system has a more or less a closed boundary and the flow of mass in and out of the system is very less as compared to the internal movement of mass. Ecosystems can be large or small. Examples of large eco systems are rain forests, deserts, salt marshes, coral reefs, lakes and ponds, open ocean, grass lands etc.

1.3.2 STRUCTURE AND FUNCTIONAL COMPONENTS OF ECOSYSTEM

Any Ecosystem consists of both living (biotic) and nonliving (abiotic) components, which are called Environmental or ecological factors. A factor is hence an ecological status, which directly or indirectly affects the life of an organism.

Abiotic Components

The physical factors of the environment (which are nonliving) have a major influence on the life of organisms. The abiotic components are of two types. They are :

(a) Climatic factors

(b) Edaphic factors

(a) Climatic factors consist of Temperature, rainfall and snow, wind, light, humidity etc. The climate of an area is the result of several factors such as latitude, elevation, nearness to the sea, and monsoon activities and ocean currents.

Temperature influences the rates of biochemical reactions in plants, with the reaction rates approximately doubling with every 10°C increase. Plant species require a range of temperature to survive. Below a minimum temperature they are inactive, and above a maximum temperature biochemical reactions stop. Normally in many plants growth is possible above 6°C. In areas with extremes of temperature, such as the tundra and tropical deserts the plants have mechanisms to adapt to such conditions.

Light levels decide the magnitude of photosynthesis reactions. Different plants have their characteristic light requirements in respect of light intensity, duration and wavelength. Some plants, termed heliphytes, require high levels, whereas sciophytes can grow in shady, low light conditions.

Water is an essential factor for biochemical plant processes, including photosynthesis. Plants growing on lands obtain their water requirements from the soil through their roots by the osmosis process. Plants called Hydrophytes grow in fresh water and they cannot withstand drought. Xerophytes survive long periods of drought, and halophytes are able to survive in saline water. Mesophytes require moderate conditions (neither waterlogged nor drought) and are found mainly in temperate areas.

(b) Edaphic factors or soil factors are pH, mineral and organic matter in soil and texture of soil.

Soil is the major source of nutrients and moisture in almost all the land ecosystems. Soil is formed when a rock weathers .The rocks brake down into a collection of different inorganic or mineral particles. The climate influences the type and rate of the weathering of the rocks as well as the nature of the vegetation growing on it. Nutrients are recycled in the soil by the plants and animals in their life cycles of growth, death and decomposition. Thus humus material essential to soil fertility is produced.

Soil mineral matter is derived from the weathering of rock material. These consist of two types viz. stable primary materials like quartz and various secondary materials like clays and oxides of Al and Fe.

Soil texture is the different size range of mineral particles varying from fine clay to coarse gravel. The varying percentages of each size range produce soils with different characteristics.

Soil organic matter is called humus that is formed by the decomposition of plant and animal matter. The rate of decay depends upon the nature of the material and the climate. The humus produced and incorporated into the soil, is known as clay-humus complexes, which are important soil nutrients.

Soil organisms carry out following three main groups of processes. Decomposition of organic material, such as plant and animal parts by bacteria, fungi, actinomycetes and earthworms. Bacteria and fungi also breakdown soil mineral matter generating nutrients.

Transformation and fixation of Nitrogen (which is an essential plant nutrient) obtained through rainwater or from nitrogen gas in the air. Bacteria like Azobacter and Rhizobium in the root nodules of leguminous plants, fix nitrogen from the air. Some types of bacteria have the ability to transform pesticides and herbicides into less toxic compounds.

Structural processes are carried out by atinomycetes and fungi. Mineral particles are bound together forming larger structures by these organisms. Earthworms, insects and burrowing mammals, such as moles, assist in the improvement of soil porosity resulting in better aeration and water holding ability.

Soil Nutrients are obtained from the weathering of rock material, rainwater, fixing of gases by soil and the decomposition of plant and animal matter. They are available to plants in solution and in clay humus complexes.

Soil pH indicates the level acidity or alkalinity of the soil. pH is the concentration of hydrogen ions in the soil. It is measured on a scale from 0 to 14, with 7 being neutral. A pH value of >7 indicates alkalinity while a value <7 indicates acidity.

Soil profile is the vertical sectional view of the soil. Soil consists of a series of layers, or horizons, produced by the vertical movement of soil materials. Generally soil profile consists of four horizons.

Biotic Components

The live component of an ecosystem comprises plants, animals, and microorganisms (Bacteria and Fungi). They carry out different functions and based on their role they are classified into three main groups. They are:

(1) Producers

(2) Consumers

(3) Decomposers

Producers are mainly green plants having chlorophyll. They produce carbohydrates by photosynthesis process. In effect the plants convert solar energy into chemical energy using water and carbon di oxide. These are called Autotrophs (self feeder) since they produce their own food. Part of the food produced by the autotrophs are utilized for their own consumption for survival and growth while the remaining is stored in the plant parts for future consumption. This becomes the food for other biotic components in the environment.

Consumers are living things, which do not have chlorophyll, and hence they are unable to produce their own food. They rely on the producers for their food requirements. Consumers are called Heterotrophs. Consumers are classified into four categories. They are

Primary Consumers or Herbivores: They are also called first order consumers. They eat the producers or plants. Examples are cattle like cow and goat, deer, rabbit etc.

Secondary Consumers or Primary Carnivores: They are also called second order consumers. They eat herbivores Examples are snakes, cats foxes etc.

Tertiary Consumers: They are also called third order consumers. They feed on secondary consumers. They are large Carnivores. Example is Wolf.

Quaternary Consumers: They are also called fourth order consumers. They feed on secondary consumers. They are very large Carnivores and feed on tertiary consumers and are not consumed by other animals. Examples are lions and tigers.

Decomposers called, as Sapotrophs are mainly microorganisms like Bacteria and Fungi. The dead organic materials of producers and consumers are their food. They break down the organic matter into simple compounds during their metabolic process. These simple compounds are nutrients, which are absorbed by the producers thus completing a cyclic exchange matter between the biotic and abiotic components of the ecosystem.

1.4 DEVELOPMENT AND EVOLUTION OF ECOSYSTEM

When the earth was formed around 4.6 billion years ago there were no life on it since the surroundings were inhospitable to living organisms. Earth was formed from solidified cloud of dust and gases left over from the creation of the Sun. For around 500 million years, the interior of Earth stayed solid and relatively cool, at around 2000°F. The main ingredients were iron and silicates, with small amounts of other elements, some of them radioactive. As millions of years passed, energy released by radioactive decay-mostly of uranium, thorium, and potassium-gradually heated Earth, melting some of its constituents. The iron melted before the silicates, and, being heavier sank toward the center. This forced up the silicates. After many years, the iron reached the center and began to accumulate. Exploding volcanoes, and flowing lava covering almost everything. Finally, the iron in the center accumulated as the core. Around it, a thin but fairly stable crust of solid rock formed as Earth cooled. Depressions in the crust were natural basins in which water, rising from the interior of the planet through volcanoes and fissures, collected to form the oceans. Slowly, Earth acquired its present appearance.

One billion years later there were with prokaryotic life forms, which are considered to be ancestors to all present living things. The last common ancestor of all presently living organisms must have characteristics, which are now present in the organisms. The common characteristics of living species can be enumerated as:

(1) All life is cellular in nature.

(2) All living things are made of 50 to 90% water, the source of protons, hydrogen and oxygen in photosynthesis and the solvent of biomolecules.

(3) The major elements in all living beings are carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur.

(4) There is a set of molecules (i.e. sugars, amino acids, nucleotides, fatty acids, phospholipids, vitamins and coenzymes. proteins, lipids, carbohydrates and nucleic acids) universally found in all living organisms.

(5) There is a universal type of membrane structure (i.e. the lipid bilayer).

The early earth is possibly provided all the elements and chemicals needed for life to begin. The **Miller-Urey experiments** showed that inorganic processes under primitive earth conditions could form organic molecules. By discharging electric sparks in a large flask containing boiling water, methane, hydrogen and ammonia, conditions presumed to be similar to those of the early earth, they produced amino acids and other organic molecules experimentally. Using variations of their technique, most of the major building blocks of life have been produced: amino acids, sugars, nucleic acid bases and lipids. Another source of amino acids and other organic molecule is meteorites

The first organisms presumably consumed these molecules both as building blocks and as sources of energy. The first forms of photosynthesis were probably non-oxygenic using inorganic molecules as a source of electrons to reduce carbon dioxide. However, when these sources were exhausted, oxygen-generating photosynthesis was developed using water as the electron source. The generation of oxygen had a most dramatic effect on future evolution.

Formation of **closed, membrane vesicles** was an early event in cellular evolution. Lipid molecules spontaneously form membrane vesicles or liposomes.

An ecosystem is made up of organisms, which established themselves in the given area and have continued to survive and has not become extinct. The species hence possess genes, which fit the environment and are tolerant to disturbances like flood, fire, drought; and a reproductive rate that balances the natural catastrophes. The birth rate of organisms will have to be optimum to avoid overpopulation and hence starvation. The human population is a good example. As technological evolution brings down our normal death rate, social evolution lowers the birth rate to strike a balance. Biological evolution is however much slower than social or technological.

In ecosystems, organisms constantly adjust themselves to geologic or climatic changes and to each other. As an example, the bats developed sonar to find the moths and the moths developed ears sensitive to the bat's frequency. The behavioral adaptations are also reflected in the anatomy or the body structure of the organisms. This evolutionary pattern is very common and is called **character displacement**. The process of life evolution started from lower plants and progressing to higher plants, lower animals, higher animals and finally to man.

1.5 ENERGY FLOW IN ECOSYSTEMS

The sun is the source of all our energy. It is a continuously exploding hydrogen bomb where hydrogen is converted to helium with the release of energy. This energy is mostly in the region of 0.2 to 4 m m (Ultraviolet to Infra Red). Around 50% of the radiation is in the visible range. The energy reaches the earth at a constant rate called the Solar Flux or Solar Constant, which is the amount of radiant energy crossing unit area in unit time. This value is approximately 1.4 KJ per sq. meter per second.

Chlorophyll bearing plants convert this energy from the sun into carbohydrates and sugars using carbon di oxide and water. This process is known as Photosynthesis. The generalized form of the photosynthetic reaction is

$$\begin{array}{ccccccccc} 6CO_2 & + & 12H_2O & \longrightarrow & C_6H_{12}O_6 & + & 6O_2 & + & 6H_2O \\ \text{Carbon dioxide} & + & \text{water} & \longrightarrow & \text{glucose} & + & \text{oxygen} & + & \text{water} \end{array}$$

The carbohydrates produced by photosynthesis undergo further modifications such as production of proteins and nucleic acids by combining with nitrogen, phosphorous and sulphur. Starch polymerizes to cellulose.

The sun's energy thus enters the living beings through photosynthetic reactions and is passed from one organism to another in the form of food. The flow of energy is uni directional and is governed by the thermodynamic law that states that Energy is neither created nor destroyed and can transform into different forms.

When energy travels from producers to different levels of consumers in an ecosystem there is loss at each level due to the energy dissipated as heat during the metabolic processes of the organisms. Hence as we move step by step away from the primary producers the amount of available energy decreases rapidly. Hence only 3 to 5 feeding levels are possible. These are referred to as Tropic levels. Figure 1.3 illustrates the energy travel in an ecosystem.

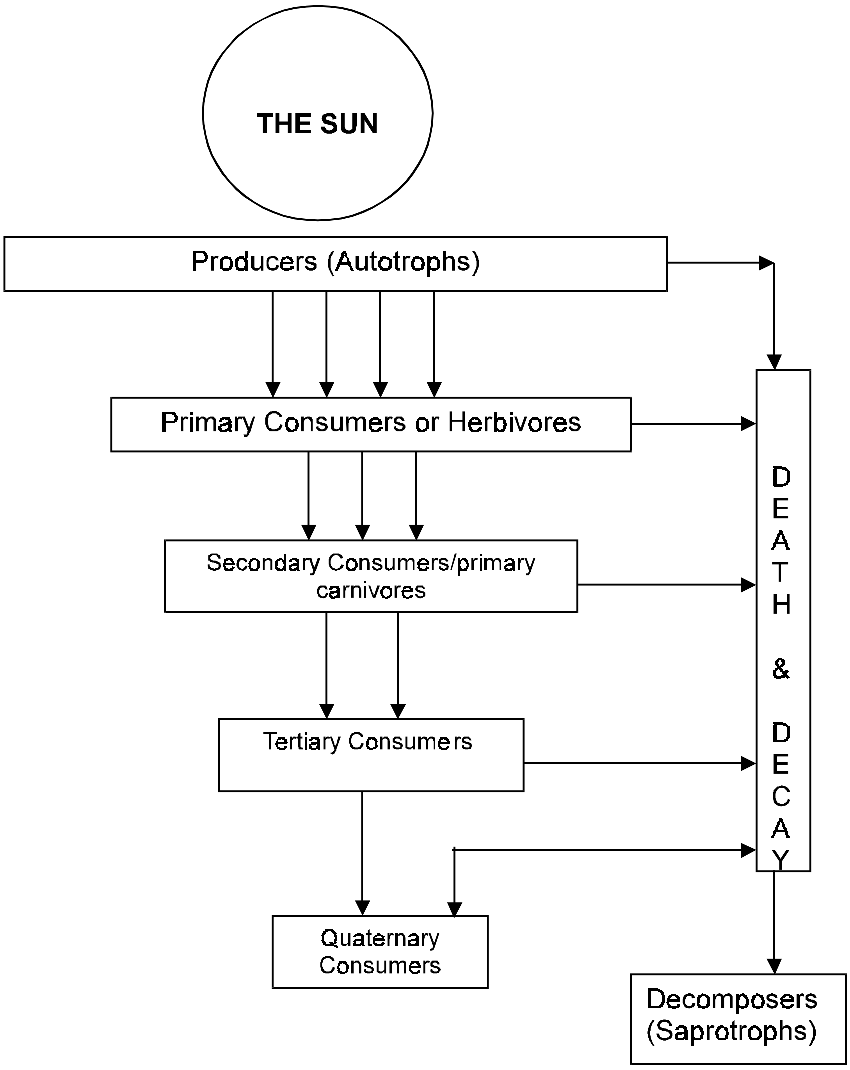


Figure 1.3

Food Chain and Food Web

The food chain is an ideal model of flow of energy in the ecosystem. According to this scheme the plants or producers are eaten by only the primary consumers, primary consumers are eaten by only the secondary consumers and so on. The producers are called Autotrophs. A food chain has three main tropic levels viz. Producers, consumers and Decomposers. The energy efficiency of each tropic level is very low. Hence shorter the food chain greater will be the availability of food.

A typical food chain in a field ecosystem might be

Grass $\longrightarrow$ Grasshopper $\longrightarrow$ Mouse $\longrightarrow$ Snake $\longrightarrow$ Hawk

Food webs are more complex and are interlinked at different trophic levels. This means that organisms have more than one alternative for food and hence survivability is better. Hawks don't limit their food to snakes, snakes eat things other than mice, mice eat grass as well as grasshoppers, and so on. A more realistic depiction of eating habits in an eco system is called a food web. An example is shown in Fig. 1.4

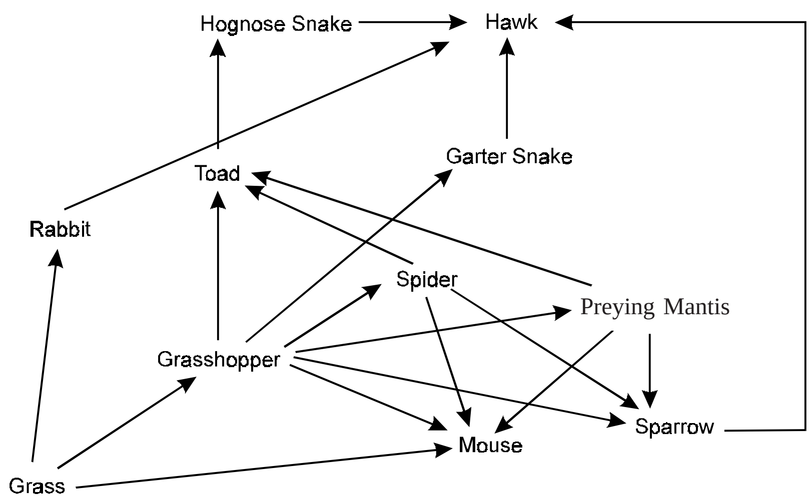


Figure 1.4

1.6 MATERIAL CYCLES IN ECOSYSTEMS

As energy flows through the ecosystem there is also a constant flow of matter. Living beings take up several nutrients from their abiotic environment and when they die they are returned to the environment. This cyclic movement of nutrient material between the biotic and abiotic environment is called **Biogeochemical Cycle.** These cycles depict the material movement and their conservation.

The most important and common biogeochemical cycles are :

(1) Water Cycle or Hydrological Cycle

(2) Carbon Cycle

(3) Nitrogen Cycle

(4) Oxygen Cycle

(5) Sulphur Cycle

(6) Phosphorous Cycle.

Water Cycle or Hydrological Cycle

There is a constant and continuous exchange of water between air, land, sea and living beings. Considerable part of the solar energy incident on the earth is used for the massive evaporation of water from the oceans, seas and other exposed water bodies leading to cloud formation and precipitation in the form of rainfall or snow. This is the major source of fresh water for the living beings. Surface water run off results in part of fresh water returning to the sea through rivers and streams. Underground water or simply Ground water is replenished by surface accumulated water from precipitation. Ground water depletion takes place due to exploitation of the same by pumping. The plants also absorb ground water. Thus hydrological cycle hence is the continuous and balanced process of evaporation, precipitation, transpiration and runoff of water.

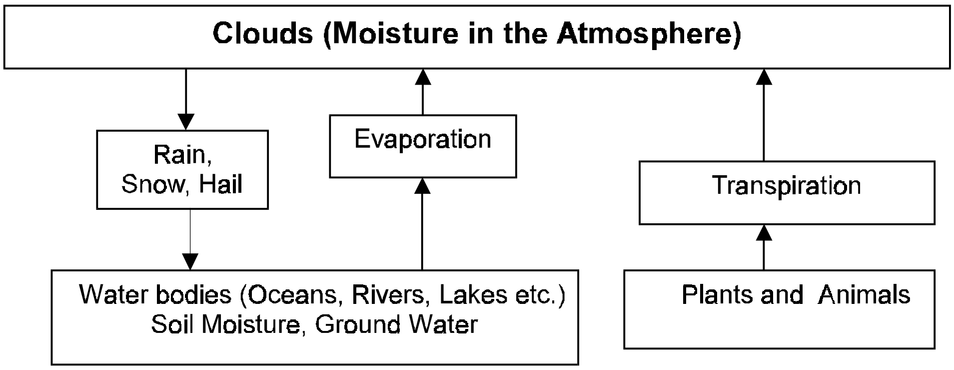


Figure 1.5

Carbon Cycle

Carbon is an essential component of all plant, animal and organic matter. The atmosphere is an important source of carbon which is present in the form of carbon dioxide which the plants or producers absorb by photosynthesis and generate several organic compounds. These

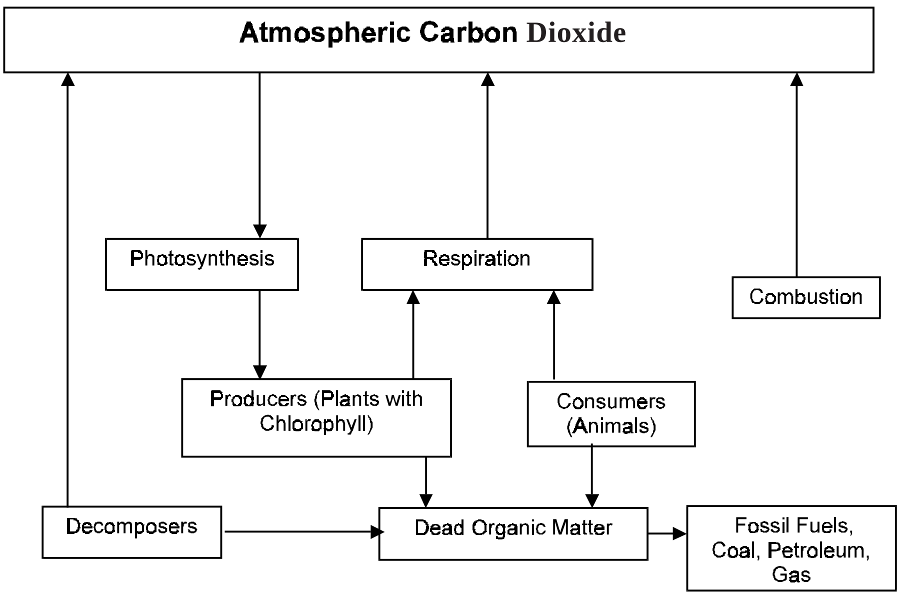


Figure 1.6

are passed to the consumers (Herbivores and Carnivores) in the form of food. Part of this is returned to the atmosphere by respiration. The dead organic matter from plants and animals are decomposed by microorganisms releasing Carbon dioxide to the atmosphere. Burning of fossil fuels releases large quantities of carbon di oxide. There is a steady buildup of carbon dioxide in the atmosphere due the increased utilization of fossil fuels as well as reduction of green plants (Deforestation). The seas and oceans also serve as sink for carbon oxide by absorbing the same and converting it into bicarbonates and mineral deposits and thus they play a vital role in regulation of carbon cycle.

Nitrogen Cycle

Nitrogen and its compounds form a vital ingredient in all forms of life in the biosphere. Availability of Nitrogen is from the atmosphere as molecular Nitrogen in the gaseous form, which cannot be directly absorbed by the plants or producers. In order to be absorbed by the plants it has to be converted into water-soluble compounds with elements like Hydrogen, Carbon, and oxygen. This process is known as Fixation of Nitrogen. Nitrogen fixation takes place by Bacteria, Algae and electrical storms. Synthetic fixation of Nitrogen is done by the manufacture of nitrogenous fertilizers through ammonia conversion route. The plants absorb the fixed Nitrogen from the soil and convert them into proteins and other compounds during the metabolic process. Decomposers, ammonifying bacteria and Nitrate bacteria also help in the fixing process by converting dead animal and plant parts into absorbable nitrates. The denitrifying bacteria complete the cycle, which helps in releasing gaseous Nitrogen back to the atmosphere from the soil.

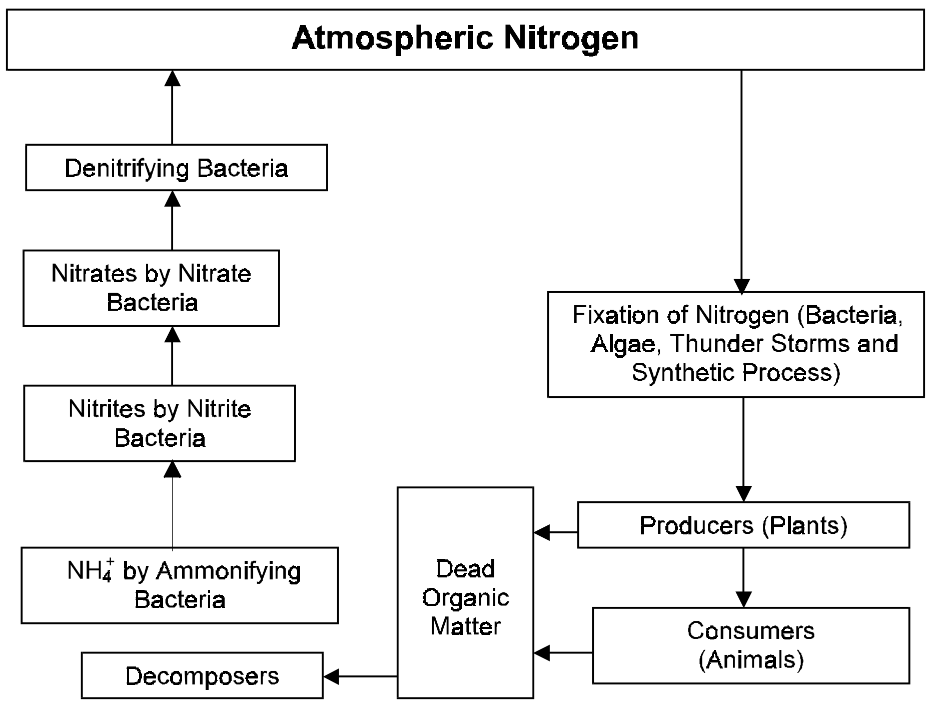


Figure 1.7

Oxygen Cycle

Oxygen is essential for the existence of all flora and fauna. The source of Oxygen is atmosphere. Plants and animals absorb oxygen during respiration either from air or water. Part of the Oxygen returns to the atmosphere in the form of carbon dioxide and water vapor in the respiration process itself. Gaseous oxygen is released during photosynthesis process (Refer photo synthetic reaction) completing the Oxygen cycle.

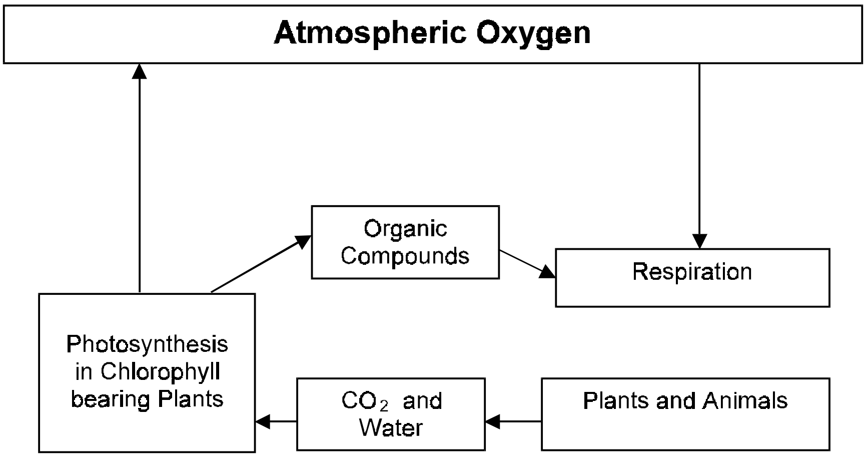


Figure 1.8

Sulphur Cycle

Amino acids and proteins need sulphur compounds for their production. In the atmosphere it is present as Sulphur di oxide and hydrogen sulfide and in the soil as sulfates or sulfides. Volcanic emissions and burning of fossil fuels are the supply of Sulphur dioxide to the atmosphere while hydrogen sulfide is from bacterial emissions. Atmospheric Sulphur dioxide is also oxidized to Sulphur trioxide, which eventually reaches the earth along with rainfall. Anaerobic and aerobic Sulphur bacteria also play a vital role in the interchange and movement of Sulphur compounds in the ecosystem. The Sulphur compounds in the plant and animal parts are absorbed by the soil after their death and decay and converted into sulfides and sulfates by Sulphur bacteria, which are subsequently used up by the plants. As in the case of carbon dioxide the atmosphere is receiving excess quantities of Sulphur dioxide, which is leading to adverse environmental effects.

Phosphorous Cycle

The bones and teeth of animals including human beings contain Phosphates, which is necessary for their development and growth. In addition phosphates are essential for cells in the production of DNA and RNA. Phosphates are available in the lithosphere in rocks and soil in inorganic form. Plants absorb them and convert them into organo phosphates. Phosphates are also added to the soil through phosphatic fertilizers. Soluble phosphates reaching rivers and streams from agricultural lands made rich in phosphates causes excess algal growth leading to eutrification. Return of phosphates to the earth is by the decay of plant and animal matter and subsequent absorption.

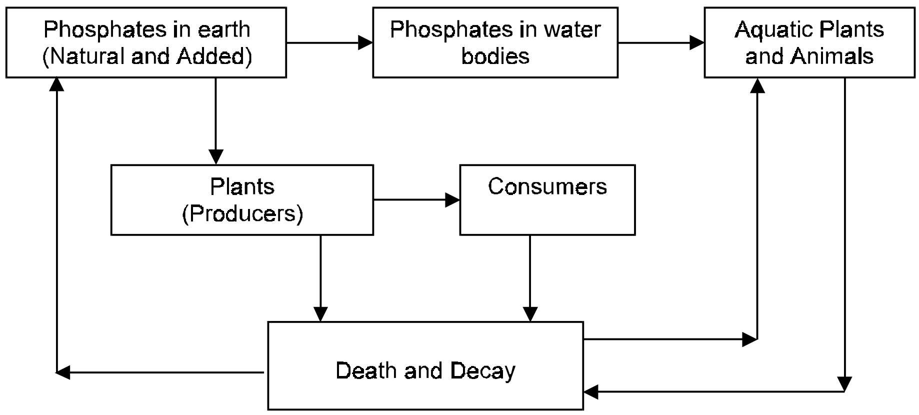


Figure 1.9

1.7 NATURAL AND MAN-MADE IMPACTS ON WATER, AIR AND LAND

1.7.1 Background

The damage to the environment is caused both by natural (Non Anthropogenic) and man made (Anthropogenic) reasons. The natural impacts are non-preventable and on many occasions unpredictable. However knowledge of natural hazards is essential in order to take mitigative actions so that loss of life and property can be minimized. On the other hand Anthropogenic detrimental impacts on environment are eminently preventable but only with a focused global effort.

1.7.2 Natural Hazards

For a systematic understanding the natural hazards can be structured as in Table 1.3

Table 1.3

Physical	Biological
(1) Earthquakes	(1) Fungal diseases
(2) Volcanic Eruptions	(2) Bacterial or Viral diseases
(3) Floods	(3) Infestations in Plants and Animals
(4) Cyclones, Hurricanes	(4) Poisonous weeds and plants
(5) Tsunamis	(5) Poisonous animal bites
(6) Snow and Ice	
(7) Avalanches and land slides	
(8) Heat waves	
(9) Forest fires	
(10) Fog, frost, hail	
(11) Droughts	

Earthquakes

Earthquakes occur as the result of the release of pressure along a fault in the tectonic plate boundaries but can occur anywhere. Earthquakes last only few seconds but they cause extensive damage to buildings, gas and water pipes, power and communication lines, and roadways. They can also serve as triggers for several other natural hazards. In fact, the primary cause of damage in recent earthquakes is fire from damaged gas pipes and power lines. Slope failures are triggered by the energy release associated with earthquakes. When earthquakes occur in an ocean or large lake, a tsunami may form and flood surrounding coastlines. Earthquakes often occur along with volcanic activity, which results in a variety of additional threats.

Volcanic Eruptions

Volcanoes are vents in the earth's surface through which magma, gases, and other materials are discharged from the core. They are found primarily at tectonic plate boundaries. They also exist at hot spots, which are places in the earth's crust where hot mantle plumes have broken through. Some volcanoes erupt explosively, while others erupt slowly. Explosive volcanoes present many potential threats including the release of toxic gases, flows containing fragments of hot rock and ash, fast moving clouds of extremely hot gases and fine ash and large volumes of ash. It is common for volcanoes to trigger other natural hazards like debris flows, earthquakes, floods, landslides and fires. Volcano and earthquake risk maps overlap considerably.

Floods

Floods are high water levels above the banks of a stream channel, lakeshore, or ocean coast that submerge areas of land usually not submerged. They are natural, reoccurring events in every stream, lake, and coastal environment. A flood can be caused by unusually intense or prolonged precipitation, storms, dam collapses, etc. Since most of the world's population lives on or near coasts and plains, floods are a threat to hundreds of millions of people. Floods can cause loss of life, extensive damage to property, contamination of drinking water, and destruction of crops and fields. They can also help produce rich soils for agriculture, which encourages people to live in floodplains. Floods occur in arid and wet environments, highlands and lowlands, and in both populated and unpopulated regions. They are less common in dry environments and highlands. Floods occur in many temperate regions around the world. However, floods can occur at any time of the year, depending on location. The timing of floods is largely dependent on climate and seasonal weather patterns. In India, floods are a common feature during monsoons.

Cyclones, Hurricanes and Tornadoes

Tropical cyclones are greatly intensified low-pressure areas that spend most of their lives over the oceans. In the Atlantic Ocean, they are called hurricanes. In the Pacific Ocean, they are usually referred to as typhoons. Warm temperatures and moisture drive them. When a hurricane moves over land or cool water, it loses strength. Tropical storms become hurricanes once their winds exceed 74 mph (119 kph). In a hurricane, building doors and windows are frequently broken by debris picked up in the hurricane's strong and sustained winds. These winds can rip roofs from buildings, topple trees, and damage power and communication lines. In some cases, hurricanes can produce tornado-like vortices (called "mini-swirls"), which can completely destroy buildings. Coastal flooding is a major threat in hurricanes, due to the combination of storm surges and torrential rain.

Storm surges are rises in ocean levels produced by the effects of high wind and low atmospheric pressure. Storm surges also increases coastal erosion, potentially resulting in slope failures. Hurricanes can even start fires by damaging power lines. Contamination of drinking water and disruption of utility services (such as electricity, communications, and sewer) are common occurrences during a hurricane.

Hurricanes are greatly intensified low-pressure cells born over the tropical oceans. They require vast amounts of warm, moist air to survive. Hurricanes lose strength over land or Cool Ocean water.

Tornadoes are fast rotating columns of air associated with severe thunderstorms. A thunderstorm can produce many tornadoes, and a tornado can have more than one vortex. Wind speeds as much as 450 kph are possible. These high winds can quickly destroy entire buildings and in some cases, entire communities. The debris carried by such high winds causes severe injury or death to people and other life. Hail is commonly associated with thunderstorms and is also capable of causing extensive damage in a very short time. Tornadoes move along the surface at up to 70 mph (113 kph) and remain on the ground for several minutes. Most tornadoes occur between the 4:00 P.M. and 6:00 P.M., when the lower atmosphere is most unstable. Many tornadoes also occur after sunset—these tornadoes can be very dangerous because they are difficult to see and people are less easily alerted.

Tsunamis

Seismic ocean waves are now commonly referred to as tsunamis (Japanese for "harbor waves"). A tsunami is traditionally defined as a series of ocean waves with very long wavelengths that can travel great distances. Tsunamis can also occur in large lakes. In deep oceans, tsunamis can reach speeds over 800 kph. Tsunami wave heights near a shore average 9 meters, but have been recorded over 30 meters. They can carry large ocean vessels inland, inundate coasts, and drag entire communities out to sea as they recede. Tsunamis can be generated by any event that displaces a large volume of ocean water, such as an earthquake, volcanic eruption or landslide. Tsunamis threaten coasts throughout the Pacific Ocean, which has frequent earthquakes. Although they are rare, Tsunamis do occur in the Atlantic Ocean, Mediterranean Sea, and large lakes.

Snow and Ice

Snow and ice are well known hazards to those living in mountainous areas or regions north of about 35 degrees N latitude. Prolonged power failures, automobile accidents, transportation delays, damage to buildings, and dangerous walkways are often attributed to snow and ice during the winter months. Slippery surfaces and reduced visibility are responsible for many accidents. Snow can be warm, causing wet and slushy conditions, or cold, creating dry and powdery conditions. The latter leads to blizzards and drifting when mixed with high winds. Blizzards can quickly reduce visibility to zero. Drifting can block roadways, airport runways, and even bury buildings. Both are often associated with low windchills, which are dangerous to exposed skin, especially when wet from snow. In many mountainous regions, **avalanches** are a common hazard. When large masses of mountain snow begin to melt in the spring, floods often become an imminent hazard to people living in valleys. The total amount of snow received at any location is dependent on temperature, atmospheric pressure, topography and proximity to moisture sources.

Thunderstorms

Thunderstorms are relatively small, organized parcels of warm and moist air that rise and produce lightning and thunder. They are one of nature's ways of balancing the amount of energy in the atmosphere—it is estimated that over 40,000 thunderstorms occur each day around the world. Although most last only 30 minutes, thunderstorms can create several dangerous phenomena:

- **Torrential rain** produced by thunderstorms is usually intense, but short in duration—flash flooding is often associated with this type of precipitation. In fact, flooding is the greatest threat from thunderstorms; also, slope failures can be triggered by the intense precipitation from thunderstorms in areas with steep, unstable hillsides.
- **High wind:** Inside a thunderstorm, air rises and descends rapidly, transferring vast amounts of energy. Such movement is dangerous for airplanes. Winds at the surface beneath a thunderstorm can reach well over 80 kph.
- **Hail** falling at speeds of several meters per second can result in extensive damage to crops and property in just a few minutes and can injure or kill people and other organisms
- **Lightning** frequently starts fires, which threaten homes, businesses, and lives. Power and communication failures caused by lightning (as well as wind) can result in large-scale disruption of everyday activities.

Droughts

A drought is an extended period of depleted soil water. Drought occurs when more water is taken out of an area than is added to it. This is often the result of a combination of persisting high pressure over a region, which produces clear skies with little or no precipitation, and excessive use of water for human activities. Droughts can result in decreased crop yields, decreased drinking water quality and availability and food shortages. Thus, as population increases and the demand for food and water increases the probability of drought increases and the implications of drought become more and more serious. Also, when vegetation becomes dry during a drought, fire risk increases, threatening homes, crops, and lives. The greatest threat from drought occurs when agricultural regions receive very low rainfall, leading to plant desiccation. When this happens, crop yields decrease resulting in increased food prices, food shortages, and even famine. Most agricultural crops are grown in the semi-arid and humid regions of the world. Water shortages in either of these regions can pose an immediate threat to agricultural productivity. With global climate change, droughts are expected to become a major problem for several agricultural regions. In semi-arid and arid regions, droughts commonly result in deteriorating drinking water quality and availability. Besides the immediate impacts associated with water shortages and poor water quality, delayed impacts (such as susceptibility to disease) are major problems in several less-developed regions of the world.

El Nino and La Nina

El Nino and La Nina are triggers for many natural hazards because they produce unusual weather throughout the world. The Earth's oceans and atmosphere are closely connected and hence a change in one produces an immediate or delayed change in the other. El Nino involves the warming of sea surface temperatures in the equatorial Pacific Ocean. This temperature change at the ocean's surface causes the usual positions of the jet streams and pressure cells to shift.

This causes changes in the global weather patterns produces floods , droughts and other hazards, leading to thousands of deaths and property damages. A La Nina event usually occurs the year after the end of an El Nino event and involves abnormal cooling of the same ocean waters. This can also cause changes in atmospheric circulation, thereby altering weather patterns for many locations around the world.

Because El Nino and La Nina produce considerable changes in atmospheric circulation, the effects are noticeable globally. However, certain locations feel the effects of El Nino and La Nina more than others due to a variety of factors. El Nino events usually begin between January and March and peak during the month of December. Not every El Nino event is followed by a La Nina event. When it happens, the effects of La Nina are usually most noticeable between the months of December and January.

Fog

Fog is a cloud near the ground. A cloud is an area of condensed water droplets (or ice crystals in the upper atmosphere). The processes that produce clouds high above the ground also produce clouds near the surface. Fog forms when air is unable to hold all of the moisture it contains. This happens when air is cooled to its dew point, or the amount of moisture in the air increases. Once air reaches its dew point, water vapor condenses onto very small particles forming tiny water droplets that comprise fog. Fog is a hazard because of reduction in visibility. Airport delays, automobile accidents, shipwrecks, plane crashes, and many other transportation problems are frequently caused by fog. When air pollution (such as smoke) combines with fog, visibility decreases even more. Acid fog, resulting from the combination of air pollutants (such as nitrogen and sulfur oxides) with water droplets can create health problems, for people with respiratory problems. Fog can also be beneficial. Several species of plants depend on fog for moisture.

Fog can occur during any season and almost anywhere in the world. The following are common types of fog:

- *Advection Fog:* When warm, moist air is blown over a cold surface, the surface can lower the temperature of the air to its dew point.
- *Evaporation Fog:* Water evaporates from the surface of streams, lakes, and oceans and accumulates near the earth surface.
- *Radiation (or Ground) Fog:* Common on clear nights with little or no wind, this type of fog is formed from the rapid cooling of the Earth’s surface in the absence of clouds.
- *Upslope Fog:* Whenever air rises, it cools. If air is blown over high hills or mountains, it may cool enough to reach its dew point.

Forest/Wild Fires

Wild land fires most commonly occur in semi arid and temperate regions having abundant vegetation and extensive dry periods. Fire is a potential hazard whenever vegetation desiccates. This often occurs as the result of drought. Fires occur less frequently in colder and wetter climates, Winds can increase a fire’s intensity while providing few escape routes. Lightning is a most common cause of wildfire during the growing season. Dry weather prior to thunderstorms during spring, summer, or fall increases the risk of a fire from lightning.

1.7.3 Manmade Impacts on Air, Water and Land

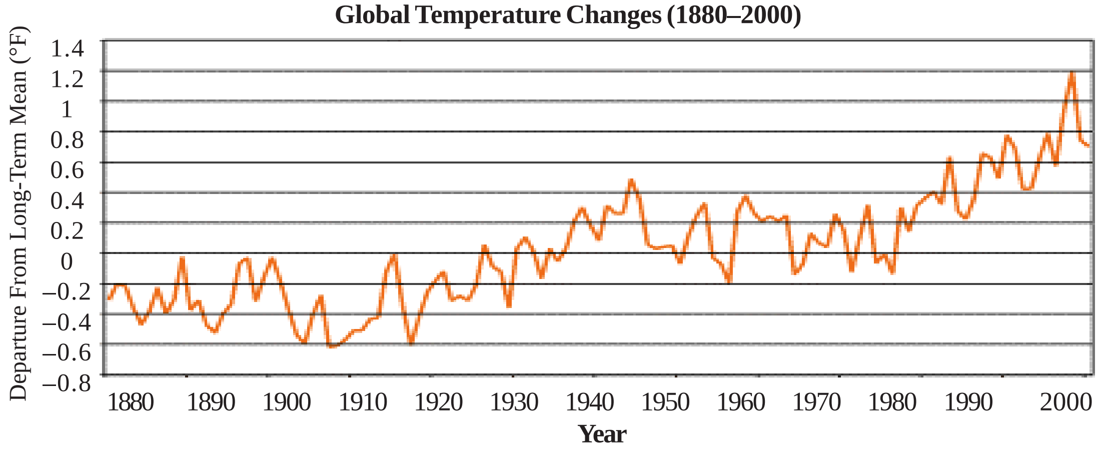
Increasing human population coupled with unprecedented technological growth has led to severe environmental stress. This has led to several problems on a global scale. The biotic as well as abiotic components of the environment has come to be seriously affected by the large scale human activities like agriculture, industrial production, energy production and consumption, transport, lumbering, harmful emissions, disposal of toxic chemicals etc. Some of the well-documented anthropogenic environmental impacts are

1. Global Warming
2. Acid Rain
3. Ozone layer depletion
4. Air, Water and land pollution
5. Eutrophication
6. Loss of Biodiversity

A brief analysis of the nature, causes, impacts and remedial measures of these global environmental issues is presented here.

Global Warming

During the 20th century, the average temperature of the earth has increased by about 0.6°C. The average temperatures in 1998 and 2002 were the highest ever recorded since reliable measurements began in the mid-19th century. This is attributed mainly to the emissions of carbon dioxide and other greenhouse gases in increasing quantities into the atmosphere. Some of the gases in the earth's atmosphere (in particular, water vapor and carbon dioxide) have an ability to absorb infrared radiation (heat). They do not prevent sunlight reaching the earth's surface and warming it, but they trap some of the infrared radiation emitted back into space by the earth. In other words, they function the same way as the glass in a greenhouse. Without the natural greenhouse effect of the atmosphere, life on earth would be impossible—the surface of our planet would be almost 35°C colder than it is now.



Source : U.S. National Climatic Data Center, 2000

Figure 1.10

Greenhouse gases (i.e. gases which contribute to the greenhouse effect) have always been present in the atmosphere, but now concentrations of several of them are rising as a result of human activities. This is intensifying the greenhouse effect.

Carbon Dioxide from Fossil Fuels

Carbon dioxide is produced and released into the atmosphere whenever organic material (which contains carbon) is burnt. As long as wood was the main fuel (Bio Fuel) there was no impact on the amount of this gas in the atmosphere. The carbon dioxide that is released into the air was absorbed by new vegetation. However, when usage of fossil fuels was started on a large scale by humanity natural cycling of carbon between plants and the atmosphere was disturbed. Over the last 100 years we have extracted and burnt a significant proportion of the oil, coal and gas from beneath the earth's surface. These fuels are the remains of plants and animals that inhabited the earth long ago. In a short space of time we have released into the atmosphere a large quantity the carbon taken up over millions of years by the organisms of past ages. The plants living today are unable to remove the surplus of carbon dioxide in the air. The problem is further aggravated by the widespread deforestation. This has led to a buildup of Carbon dioxide in the atmosphere, which is illustrated in Fig. 1.11.

The carbon dioxide concentration is about 30% higher than that of pre-industrial times (around 200 years ago), and every year the level rises by another roughly 0.4%. Unfortunately carbon dioxide is very stable. It can probably continue to circulate between the atmosphere and the oceans for many thousands of years. This means that carbon dioxide from fossil fuels could still contribute to the greenhouse effect several millennia hence, even if emissions were to cease completely in the near future. If emissions were instead held at their present levels, the concentration of carbon dioxide would go on rising in both the atmosphere and the sea, gradually strengthening the greenhouse effect

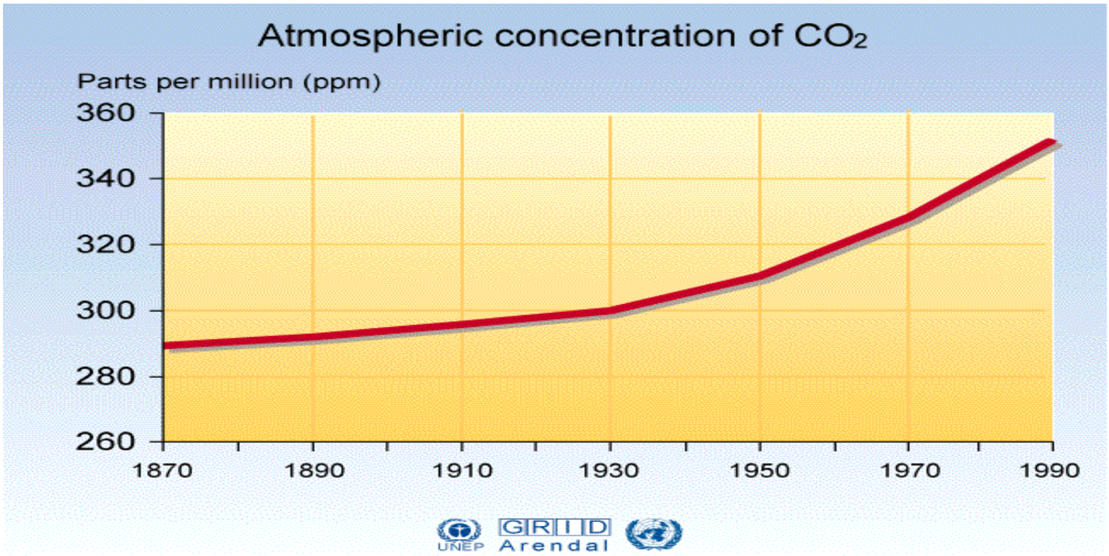


Figure 1.11

Apart from carbon dioxide, the other greenhouse gases being emitted in large quantities now are nitrous oxide, methane and compounds containing fluorine, among them HFCs (compounds of hydrogen, fluorine and carbon).

These substances are much more effective as greenhouse gases than carbon dioxide even though their concentrations are far less. Some of the fluorine compounds have a very long atmospheric life that they will contribute to the greenhouse effect for tens of thousands of years to come.

Impacts Global Warming

- Rapid change in climate will be too great that many ecosystems will not be able to adapt, and hence the rate of species extinction will most likely increase.
- In addition impacts on wildlife and species, biodiversity, agriculture, forestry, dry lands, water resources and health will be adverse.
- Melting of polar ice caps and glaciers will result in increased sea levels
- leading to flooding of coastal lines causing damage to life and property.
- Massive soil erosion, contamination of fresh water and water borne diseases.
- In temperate areas summers will be longer and hotter and winters shorter and warmer.
- Sub-tropical regions will become drier and tropical regions wetter.
- Desertification, droughts and famine.
- Altered weather patters will have altered crop patterns and adverse effects on plant and animal life.

Remedial Measures

- Reduce/avoid use of fossil fuels by encouraging use of renewable energy sources like solar energy, biofuels, wind and hydroelectric power etc. Per capita, the developing countries emit only a fraction of the carbon dioxide released by the industrialized nations, and the latter therefore have the main responsibility for reducing emissions.
- Reduce deforestation and increase vegetation to serve as sink for carbon dioxide.

Acid Rain

Gaseous atmospheric pollutants, particularly oxides of sulphur and nitrogen, can cause precipitation to become more acidic when converted to sulphuric and nitric acids, hence the term acid rain. This is also referred to as acid precipitation. Precipitation (rain or snow) is naturally acidic because of carbon dioxide in the atmosphere. The burning of fossil fuels (coal, oil and gas) produces sulphur dioxide and nitrogen oxides. These gases interact with water vapor and sunlight resulting in the production of Sulphuric acid and Nitric acid.

$$S + O_2 \longrightarrow SO_2 \quad \text{(Combustion of fossil fuels)}$$

$$SO_2 + 1/2O_2 \longrightarrow SO_3 \quad \text{(Photo chemical oxidation in the atmosphere)}$$

$$SO_3 + H_2O \longrightarrow H_2SO_4 \quad \text{(Sulphuric Acid–Acid Rain)}$$

When these acids are carried down to the earth by precipitation (rain, snow, dew or hail) acid rain or acid precipitation occurs. Sources of sulphur dioxide and oxides of nitrogen may be natural such as volcanoes, oceans, and biological decay and forest fires. The increasing demand for electricity and the rise in the number of motor vehicles in recent decades has increased emissions of acidifying pollutants Emissions of such pollutants are heavily concentrated in the northern hemisphere, especially in Europe and North America. Acid rain became an international concern since the air borne pollutants are transported over large distances i.e. thousands of kilometers.

The average pH of acid rain is below 5.5. (The pH scale ranges from 0, which is strongly acid, to 14, which is strongly alkaline, the scale point 7 being neutral.).

Impacts of Acid Rain

- Destruction of aquatic flora and fauna due to excessive acidification.
- Contamination of drinking water.
- Increase in the acidity of soil leading to loss of nutrients.
- Destruction of certain plants and trees due to loss of chlorophyll.
- Accumulation of toxic elements in the soil leading to the destruction of beneficial earthworms.
- Corrosive damage to buildings and structures.
- Damage to historic monuments like Taj Mahal.

Remedial Measures

- Reduce/avoid use of fossil fuels by encouraging use of renewable energy sources like solar energy, biofuels, Wind and hydroelectric power etc.
- Adopt sulphur recovery techniques for fuels to minimize SO_2 emission.
- Use of catalytic converters in automobiles to ensure lower acidic emissions.
- Treatment of stack gases to eliminate SO_2 and Oxides of Nitrogen emissions.

Ozone Depletion

Ozone (O_3) gas present in the stratosphere filters out incoming radiation from the sun the cell-damaging ultraviolet (UV) part of the spectrum. Concentrations of ozone in the stratosphere fluctuate naturally in response to variations in weather conditions and amounts of energy being released from the sun and due to major volcanic eruptions. During the 1970s it was realized that man-made emissions of Chlorofluorocarbons (CFCs) and other chemicals used in refrigeration, aerosols and cleansing agents may cause a significant destruction of ozone in the stratosphere, thereby letting through more of the harmful ultraviolet radiation. Then in 1985 evidence of a large ozone hole was discovered above the continent of Antarctica during the springtime. This reappeared annually, generally growing larger and deeper each year. More recently significant ozone depletion over the Arctic, closer to the more populous regions of the Northern Hemisphere is noticed. In response to this ozone depletion, the Montreal Protocol on Substances that Deplete the Ozone Layer was implemented in 1987. This legally binding international treaty called for the participating developed nations to reduce the use of CFCs and other ozone depleting substances. In 1990 and again in 1992, subsequent amendments to the protocol brought forward the phase out date for CFCs for developed countries to 1995. Near the ground, however ozone is considered to be a pollutant since it causes a number of respiratory problems, particularly for young children.

Impacts of Ozone Depletion

Protecting the ozone layer is essential. Ultraviolet radiation from the sun can cause a variety of health problems in humans, including skin cancers, eye cataracts and a reduction in the body's immunity to diseases. In addition ultraviolet radiation can be damaging to microscopic life in the surface of oceans which forms the basis of the world's marine food chain, certain varieties of crops including rice and soya, and polymers used in paints and clothing. A loss of ozone in the stratosphere may even affect the global climate.

Causes of Ozone Depletion

Ozone depletion occurs when the natural balance between the production and destruction of stratospheric ozone is disturbed in favor of removal. Halogens like chlorine and bromine released from man-made chemical compounds such as CFCs are the main cause of this depletion. Chlorofluorocarbons are not scrubbed back to earth by rain or destroyed in reactions with other chemicals. They simply do not break down in the lower atmosphere and they can remain in the atmosphere from 20 to 120 years or more. Due to their high chemical stability CFCs move into the stratosphere where they are eventually broken down by ultraviolet (UV) rays from the sun, releasing free chlorine. The chlorine is actively involved in the process of destruction of ozone. Two molecules of ozone give rise to three of molecules of oxygen. The chemical reactions involved are as under.

$$Cl + O_3 \longrightarrow ClO + O_2$$

$$2ClO + O \longrightarrow Cl_2 + O_2$$

The chlorine atom is released back and continues the process repeatedly leading to a reduced level of ozone. Bromine compounds can also destroy stratospheric ozone. Emissions of CFCs are responsible for around 80% of total stratospheric ozone depletion.

Remedial Measures

As has been earlier indicated the best way out is to avoid/minimize use of CFCs. These include proper disposal of old refrigerators, use of aerosols and refrigerants, which do not contain CFCs, use of halon-free fire extinguishers and the recycling of foam and other non-disposable packaging. While emissions of ozone depleting compounds are now being controlled, the ozone layer is not likely to fully heal for several decades due to the stable nature of these compounds. Hence we should take precautions when exposing ourselves to minimize the effect of UV radiation.

Air, Water and Land Pollution

Air pollution is a major problem since very long. In the middle Ages, the burning of coal released large amounts of smoke and sulphur dioxide to the atmosphere. In the late 18th century, the Industrial Revolution led to escalation in pollutant emissions by the industry. After the disastrous London Smog of 1952, pollution from industries and homes was sought to be reduced to prevent recurrence of these events. Recently pollution from motor vehicles has become a very important air quality issue. The number of vehicles in most countries around the world is steadily increasing.

Impacts of Air Pollution

Air pollution can be either natural or man-made, and occur both indoor and outside. Although natural emissions of air pollution may affect the environment from time to time, man-made air pollution leads to poor air quality on a more regular basis.

Common outdoor air pollutants, which affect ambient air quality, include sulphur dioxide, nitrogen oxides, carbon monoxide, particulate matter and volatile organic compounds (VOCs) emitted through the burning of fossil fuels for energy and transportation. Ozone, a secondary pollutant, is formed in the atmosphere near ground level when primary pollutants are oxidized in the presence of sunlight. The resulting pollution can have detrimental effects on human health, wildlife and vegetation. Asthma is an increasingly common respiratory disease, which may be triggered by air pollution. In addition, sulphur dioxide and nitrogen oxides cause acid rain.

Indoors, poor ventilation can lead to a build-up of air pollutants, including carbon monoxide and nitrogen dioxide from faulty gas heaters and cookers, carbon monoxide and benzene from cigarette smoke, and volatile organic compounds from synthetic furnishings, vinyl flooring and paints. Since most of us spend up to 90% of the time indoors, indoor air quality could have a real bearing on our health.

Water Pollution is yet another major manmade environmental problem. Water is essential for survival of all forms of life and it is also an important requirement in most of the industrial activities. Deterioration of water quality is a major environmental issue especially in developing countries like India. Increase in industrial activity and human population has adverse impact on the quality of not only surface water but also on ground water. The pollutants encountered in water are

- Oxygen Demanding Wastes (BOD)
- Pathogenic Micro Organisms
- Synthetic Organic and Inorganic Chemicals
- Heavy Metals
- Sewerage and Agricultural Runoffs
- Suspended Solids and Sediments
- Radioactive Materials
- Thermal Discharges.

Impacts of Water Pollution

Waterborne infectious diseases like typhoid, dysentry, cholera etc. are caused by consuming contaminated water. Fluoride in drinking water causes fluorosis a disease of the teeth and bones. Effluents from industries like paper mills, tanneries, diaries, breweries, slaughterhouses and municipal sewerage are contaminated with organic pollutants, which reduce the Dissolved Oxygen (DO) levels in the water killing aquatic organisms. Agricultural runoffs pollute water with plant nutrients like Phosphates and Nitrates and Pesticides. The plant nutrients promote wild growth of oxygen consuming Algae leading to the destruction of aquatic life. Pesticides are toxic to humans, and animal life. Industrial pollutants from certain factories contain heavy metals like Mercury, Lead, Cadmium, Nickel, and Chromium, which are absorbed by plants and animals including human beings. Oil pollutants from petroleum industry have resulted in the death of several birds and animals. Thermal discharges reduce DO levels of water bodies leading to destruction of aquatic life.

Remedial Measures

Adopting cleaner production technologies (Prevent Pollution rather than treat pollution) is the correct strategy. This should be coupled with water conservation measures and end of the pipe treatment techniques.

Land pollution is an area requiring urgent attention. Land pollution is also closely related to ground water contamination. Disposal of industrial and municipal solid wastes and hazardous chemicals on land has resulted in not only polluting land but also has resulted in increase of toxic chemicals in the underground water. In India around 90 million tones of solid waste and 6 million tones of hazardous waste are being generated annually. These wastes are mostly dumped in an uncontrolled fashion on public land .In addition to the municipalities and corporations (human dwellings) the major industrial sources of solid wastes are Thermal power plants, Ferrous and nonferrous metals manufacturing and processing units, Sugar, Paper, Textile, Petroleum Refining, Petrochemicals and fertilizers, Cements and Polymer Industries. Mining and quarrying industry uses up fertile land areas.

Biomedical wastes from hospitals like body parts, used and discarded syringes, needles and surgical instruments, dressing and hospital linen are mixed with municipal wastes, which pose a major health hazard in developing countries like India. Loss of soil fertility results from excess application of fertilizers and pesticides.

Developmental projects for housing, industry, road, rail, and air transport are using up agricultural or forestlands increasing pressure on the available land resource. Deforestation is a global issue, which is considered to be one of the major reasons of global warming.

Impacts of Land Pollution

Disruption of hydrological cycle, Ground water and surface water pollution, Air pollutants emission, destruction of the habitats of many plants and animals leading to loss of biodiversity, reduction in food production, negative effects on human, plant and animal health are some of the adverse impacts of land pollution.

Remedial Measures

Proper land development policies and their implementation, adopting correct solid waste disposal techniques like composting, sanitary land filling, incineration, pyrolysis will to some extent mitigate the adverse impacts on land or soil pollution. Waste minimization, recycle and reuse will pay rich dividends in this regard.

Eutrophication

When aquatic plant growth is stimulated to produce excessive choking growth eutrophication occurs. The process involves a complex series of inter-related changes in the chemical and biological status of a water body mostly due to a depletion of the oxygen content caused by decay of organic matter resulting from a high level of primary productivity and typically caused by enhanced nutrient input. Sewage is an important source of organic materials in water bodies. Fertilizers and detergents containing Nitrogen and Phosphorous are also the major sources of nutrients. These nutrients greatly increase the productivity in aquatic environments and contribute to eutrophication. Algal blooms are an indication of eutrophication of a water body. A small part of the algal blooms are consumed by zooplanktons and other aquatic organisms like fishes and most of them stay and decay in the water depleting dissolved oxygen. Toxic gases like Hydrogen sulphide is generated. An unpleasant greenish slimy layer is formed on the surface of the water body. This results in the suffocation and eventually death of aquatic organisms. The water body emits bad odor. The anaerobic conditions (Lack of Oxygen) generate toxins in the algae, which can kill surface organisms like birds and animals. The water body cannot be used as a source of water supply nor used for any other activity like recreational use.

Remedial Measures

Treated effluents devoid of nutrients only should be discharged into water bodies. Sludge removal and routine dredging is a must. Algaecides like copper sulphate, chlorine can be added in controlled quantities.

Biodiversity

Biodiversity in the broad sense means the different forms of life and life sustaining systems and processes available on the earth. Even though it is impossible to access the number of species of living things on earth an approximate estimate puts it at 10 to 80 million species. The different types of biodiversity are:

(1) *Genetic Diversity*: This is the difference in the genetic makeup in one individual species. (I.e.) Variability within the species

(2) *Species Diversity*: This is the variety or variance of distinct types of living organisms in different habitats.

(3) *Ecological Diversity*: This includes the different types of forests, grass lands, wet lands, water bodies like streams, lakes and oceans, coral reefs, rocky mountains etc.

(4) *Functional Diversity*: This includes the different types of biological and chemical processes such as mass and energy flow essential for the survival of living organisms.

Importance of Biodiversity

- Biological diversity is very important for the existence of the human race. In addition to the practical importance, Biodiversity lends aesthetic beauty to nature. The benefits arising from biological diversity are:
- **Ecosystem Services**
  - **Protection of water resources** like maintenance of hydrological cycles, regulating and stabilising water runoff, and buffer against extreme events such as flood and drought.
  - **Soils formation and protection:** Formation and maintenance of soil structure and the retention of moisture and nutrient levels.
  - **Nutrient storage and cycling:** Plants take up nutrients from the soil as well as from the air, and these nutrients can then form the basis of food chains, to be used by a wide range of other life forms. Pollution breakdown and absorption
  - **Breakdown and absorpion of pollutants:** Ecosystems and components of ecosystems from bacteria to higher life forms are involved in breakdown and assimilative processes of pollutants. Natural and artificial wetlands are being used to filter effluents to remove nutrients, heavy metals and suspended solids, reduce the biochemical oxygen demand and destroy potentially harmful microorganisms.
  - **Contribution to climate stability:** Vegetation influences climate at the macro and micro levels. Undisturbed forest helps to maintain the rainfall in its immediate vicinity by recycling water vapour at a steady rate back into the atmosphere.

  - **Recovery from unpredictable events:** Healthy ecosystems improve the chances of recovery of plant and animal populations from unpredictable natural catastophic events such as fire, flood and cyclones and from disasters caused by humans.

- **Biological Resources**
  - **Food :** Existence of human beings and that of most other organisms is heavily dependent on primary producers, mainly plants.
  - **Medicinal resources:** Plant and animal products have long since been used as medicines due to their curative properties. Indian and Chinese medical systems make elaborate use of herbs and herbal products.
  - **Wood products:** Wood is a basic commodity used worldwide. It is a primary source of fuel, is used in construction, and forms the basis for paper production.
  - **Ornamental plants:** Ornamental and horticultural purposes, for providing aesthetic beauty
  - **Breeding stocks, population reservoirs:** Natural areas provide support systems for commercially valuable resources .
  - **Future resources:** The wild and unknown population of plants and animals offer enormous scope for research and development in areas of agriculture, industry and medicine.

- **Social Benefits**
  - **Research, education and monitoring:** Natural areas provide excellent living laboratories for research in ecology and evolution.
  - **Recreation:** Diverse biological assemblies like animal habitats, forests, mountains, parks and gardens, costal areas and beaches, provide aesthetic beauty to our environment.
  - **Cultural values:** The aesthetic values of our natural ecosystems and landscapes contribute to the emotional and spiritual well-being of human beings.

Major Factors Responsible for Loss/Reduction in Biodiversity

- Overexploitation of natural resources and destruction of ecosystems for meeting the human requirements of food, shelter and comfort.
- Environmental pollutants like pesticides, heavy metals, chlorinated hydrocarbons, acid rain, global warming etc.
- Eutrophication leading to promotion of growth of some specific species suppressing others.
- Natural causes like earthquakes, floods, droughts, forest fires, epidemics.
- Excessive importance of specific species for cultivation (15 types of species provides 90% of the worlds food supply).
- Hunting for pleasure and poaching for commercial purposes of certain animal species like elephants, rhinos, whales, crocodile, snakes etc.

Restoration and Conservation of Biodiversity

The following remedial measures will be useful for the repair and revamping of the biotic resources in the globe.

- Assesment of the biodiversity inventory and prepare detailed mapping
- Wildlife conservation measures focussing on protecting animal and plant life in zoos, sanctuaries, parks and gardens, Biosphere reserves. Two basic approaches viz " *Ex-situ* conservation" and "*In-situ* conservation"
  - ***Ex-situ* Conservation:** In this approach, wild life conservation is done in capitivity under human care. Endangered plants and animals are collected and are cared for and reproduced in controlled conditions like zoos, sanctuaries and national parks. This approach ensures assured supply of basic requirements like food, water, shelter and mates. Due to the security provided hunting and poaching is avoided. In addition genetic research is possible. However the organisms kept under captivity are unable to adopt for changing environmental conditions leading to stagnation of the gene pool. It is also expensive.
  - ***In-situ* Conservation:** In this approach large areas of the earth surface are kept reserve for wild life.
- Modification of agricultural practices encouraging mixed cropping and poly culture and there by reducing excessive importance on specific species of plants.
- Setting up of seed banks and gene banks.
- Restoration of habitats and eco-systems which are important for biological communities. Reforestation, prevention of soil erosion, fencing, fertilisation , reintroduction of expired species etc.
- Imparting Environmental Education and awareness and motivate communities to conserve resources.
- Introduction of stringent legislations and implementation of the same.
- Population control and check on indiscriminate urbanisation.

Other Man Made Impacts on the Environment

Some of the other man made impacts on the environment, which has acute adverse effects, are briefly described.

Photochemical smogs are generated by the interaction of air pollutants (from automobiles and industries) like Hydrocarbons, Oxides of nitrogen and Sulphur, Particulate Matter in the presence of sunlight. The smog (Smoke + Fog) is the product of these interactions and contains toxic components like Ozone, Peroxyacylnitrate (PAN), Carbon monoxide, ketones and aldehydes. In stagnant air and in cold conditions the smog assumes lethal proportions and creates acute respiratory problems. The great London Smog killed around 4000 persons in December 1952 mainly due to suffocation. The incident repeated in 1956 and in 1962 in London and in 1966 in Los Angeles in US resulting in more deaths and respiratory disorders. Photochemical smogs also trigger eye irritation, degradation of natural and synthetic polymers and harms plant and animal life. Reduced visibility due to smogs has led to road and aviation accidents.

Nuclear disasters are yet another man made Environmental Tragedy. The Chernobyl Nuclear Disaster took place in 1986 in the former Soviet Union. A nuclear explosion in the atomic reactor used for power generation threw up radioactive material exposing over 400 million people to radiation. The death toll was more than 2000 and radioactive fallout was felt in regions as far away as 2000 kilometers in Scandinavian Countries. The radioactive pollution damages plant and animal life and produces chronic health effects in humans such as cancer, blood abnormalities, thyroid damages and mutagenic and somatic changes.

Two atom bombs were dropped on Japan in 1945 during World War II killing and injuring instantly lakhs of people .The radioactive fallout will cause generations to suffer from several physical, mental and genetic disorders in addition to the permanent damages to the flora, fauna and soil. The threat of a full blown nuclear war is a reality with several nations acquiring the technology for making the nuclear bombs.

The Bhopal Gas Tragedy is one of the deadliest environmental disasters that the human kind has ever encountered. Methyl Isocyanate gas used for the manufacturing of pesticides leaked into the atmosphere from a factory in the city of Bhopal in central India .The toxic gas killed thousands of people and the suffering continues for many more even today. The survivors are affected and disabled for not only a lifetime but even beyond due the severe genetic effects. The problem is more acute and painful since many of the victims are poor.

Mianamita disease occurred in a place called Minamita in Japan. A chemical plant dumped mercury-containing wastes in the sea in the Minamita Bay. It was assumed that the heavy elemental Mercury would sink to the sea floor and remain there inert and harmless. But the bacteria in the sediments of the sea floor converted the Mercury into water soluble methyl mercury and was absorbed by fishes and eventually by humans. This led to an epidemic affecting nervous systems, numbness, blurred vision, speech deficiencies loss of control of muscles etc. Many countries where mercury compounds are used as fungicides and algaecides are prone to Minamata disease.