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ENVIRONMENTAL EDUCATION 9

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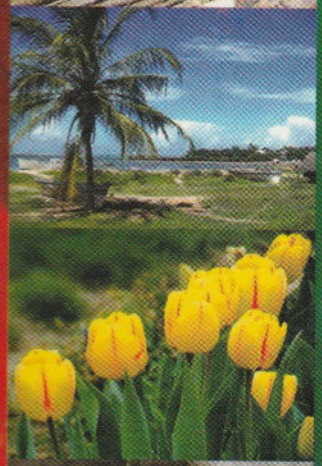






Beeta Publications

CONTENTS

INTRODUCTION

UNDERSTANDING ECOSYSTEM

The term environment means the surroundings of an organism. It includes both living and non-living components. Man and other living organisms are surrounded by non-living components such as land, air, atmosphere, water, and by living components like plants and animals. Further, the environment includes the pollutants, and other factors that adversely affect our life. **Environment, therefore, refers to the sum total of all the forces, materials and influences around us at a given point of time and place.**

Natural Environment

Environmental Science is the application of knowledge from many disciplines to the study and management of the environment. *Ecology* is a section of Environmental Science.

Ecology

Ecology is the scientific study of plants and animals in relation to each other and to their environment. A German biologist, Hanns Reiter (1868), introduced the term 'ecology' (Oekologie) by combining two Greek words - Oikos (house) and logos (study of).

Ecology and Environmental Science

Environmental Science is the application of knowledge from many disciplines for the study and management of the environment. Ecology is one of the disciplines of environmental science.

Ecosystems

The term ecosystem was coined by Sir Arthur Tansley in 1935. According to Fitzpatric, a group of organisms interacting among themselves and with environment is known as Ecosystem. Ecosystem is essentially a technical term for 'nature'. **Ecosystem is a self-regulating and self-sustaining structural and functional unit of the biosphere. This system depends upon the sun for its energy.**

Ecosystems can be small or large and are placed in nature side by side. There is an exchange of materials and energy within the ecosystem as well as between adjoining ecosystems. They are all interconnected and hence, interrelated. The vast network of all interconnected ecosystems constitutes the *biosphere*. It is that part of the earth's terrestrial system — including air, land, and water — in which life develops and where life process in turn get transformed. It is the life zone of the earth.

Terms Related to Ecosystems

Organism: An organism is a fundamental functional unit in ecology because it interacts directly with the environment as well as with other organisms, e.g., a rabbit.

Population: It refers to the organisms of the same species that are in proximity to one another, e.g., a group of rabbits.

Community: It includes all the populations occupying a given area. The size of a community depends on our scale of reference. We might use community to refer to all of the living things in a particular area like a pond or we might restrict our interest to the fish community or the plant community.

The community and the non-living environment together are referred to as an ecological system or ecosystem, *e.g.*, a pond with fish and plants.

Our Earth

Biome: It refers to a large regional or subcontinental ecosystem characterised by similarity in vegetation and climate. It is made of many similar ecosystems. An ecosystem is much smaller than a biome. For example, a grassland biome implies many ecosystems that are similar because grasses are their principal plants and grazers are their predominant animals.

COMPONENTS OF AN ECOSYSTEM

An ecosystem has two basic components:

Abiotic Components

These are the non-living components that affect the distribution, number, metabolism and behaviour of organisms in an ecosystem. These include:

- *Inorganic substances* like carbon, nitrogen, oxygen and water.
- *Dead organic matter* containing proteins, carbohydrates, lipids, humic substances, etc.
- *Climatic factors* (i) atmospheric factors like temperature, moisture, sunlight; and (ii) edaphic factors such as soil texture and topography.

Biotic Components

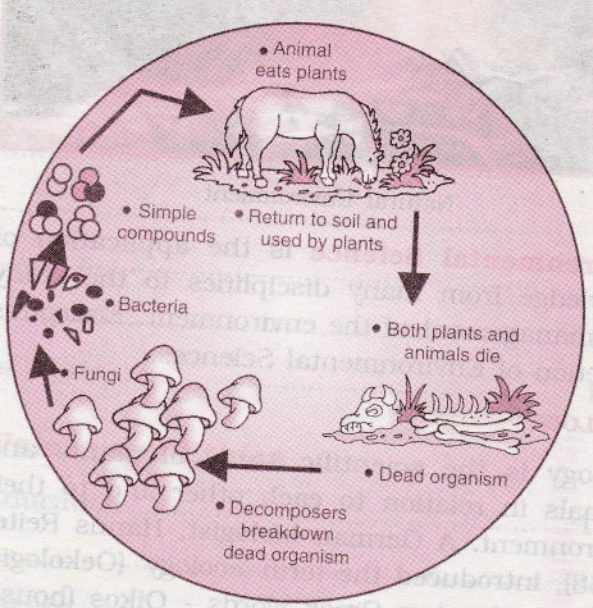
These include the living components of the ecosystem that interact with the non-living components. They are: *Producers* and *Consumers*.

Producers: They are *autotrophic* or self-nourishing. They are the organisms, which produce their own food by fixing solar energy in the presence of abiotic substances. Since they produce food for the other organisms, they are known as producers. For example, green plants.

Consumers: They are *heterotrophic* or those organisms which consume the food produced by the producers. They derive their nutrition by feeding on other living organisms. A consumer which derives nutrition by eating plants is called primary consumer or *herbivore* (e.g., grazing cattle). The secondary consumer or *carnivore* is an animal that gets its nutrition by eating the flesh of herbivores or other animals. The organism which can feed on both plants and animals is called an *omnivore* (cockroaches, fox, human beings, etc).

Decomposers or Saprotrophs

The word *sapro* means to decompose. These are heterotrophic organisms, consisting mostly of bacteria and fungi which live on dead organic matter or detritus. In terrestrial ecosystem bacteria generally act on animal tissue; and fungi on plants. They act on dead bodies of producers and consumers and are responsible for the breakdown of complex materials into similar substances, which are again used as energy by producers.



Decomposers breakdown dead organisms

There is a constant interaction between abiotic and biotic components of the ecosystem resulting in the transfer of food and energy, which makes it a dynamic but stable system.

UNIT 1 – UNDERSTANDING ECOSYSTEM

CHAPTER 1

TYPES OF ECOSYSTEM

Course Content—Syllabus and Scope

Types of ecosystem—forest, grassland, desert, aquatic, coastal, marine.

An understanding of environment and ecosystems — basic definition of the two.

Terrestrial ecosystems like forest, grassland and desert—general climate type, flora and fauna of each.

Aquatic ecosystems like marshes, swamps, ponds, lakes, rivers, estuaries, marine—general climate type, flora and fauna of each.

Environment refers to all that surrounds us, both the living and the non-living components, which influence the lives of organisms present in a specific area at a given point of time. Thus, **environment is the sum total of all conditions and influences that affects the life and development of organisms**.

Living organisms cannot live in isolation from their non-living environment. This is because the non-living environment provides materials and energy for the survival of the living organisms. The community with all the plants and animals forms the living or *biotic component*. The organic and inorganic substances together with climatic factors constitute the non-living or *abiotic component* of the ecosystem. Therefore, an ecosystem is a natural functional unit comprising living organisms (biotic community) and their non-living (abiotic community) environment that interact with each other to form a stable self-supporting system. **Ecosystem is a self-regulating and self-sustaining structural and functional unit of biosphere.** A pond, lake, desert, grassland, meadow, forests, etc. are common examples of ecosystems.

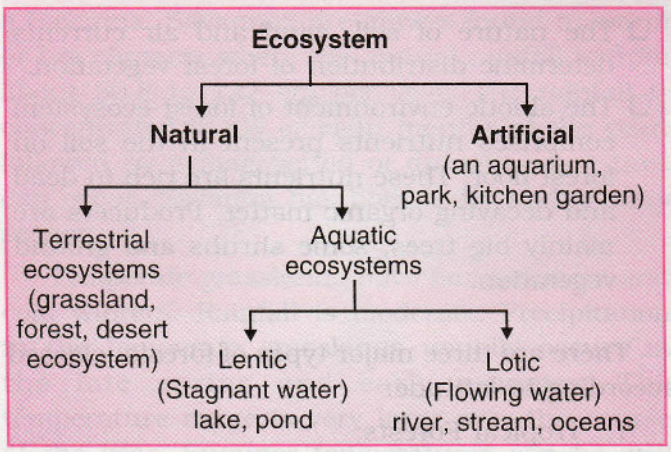
TYPES OF ECOSYSTEM

There are two types of ecosystems:

1. Natural Ecosystems
2. Artificial Ecosystems.

Natural Ecosystems: They are self-regulating systems without much direct human interferences and manipulations. For example, ecosystems existing in a pond, lake, river, stream, spring, sea, ocean, forest, grassland, desert, etc.

Based on the particular kind of habitat, the natural ecosystems are further categorised into terrestrial and aquatic. *Terrestrial Ecosystems* include forests, grasslands and deserts. *Aquatic ecosystems* can be either freshwater (ponds, lakes, streams), or salt water (marine, estuaries) type.



Artificial Ecosystems: They are man-made. Human activities modify or convert natural ecosystems into man-made ecosystems. For example, natural forests are cut and the land is used for tree plantations or agricultural activities. Other examples of artificial ecosystems include gardens, parks and aquaria. In these ecosystems, man manipulates the physio-chemical environment for his own benefit.

TERRESTRIAL OR LAND-BASED ECOSYSTEMS

Terrestrial ecosystem are land-based ecosystems that extend from uplands to wetlands. They are governed by yearly differences of temperature, rainfall, soil condition, availability of nutrients and of sunlight and many other abiotic as well as biotic factors of the environment. The terrestrial ecosystems are of different types. (a) Forest Ecosystem; (b) Grassland Ecosystem; and (c) Desert Ecosystem.

FOREST ECOSYSTEM

A forest ecosystem is composed of trees, shrubs or any other woody vegetation with closed canopy cover. These are usually found in regions where there is plenty of rainfall.

Features of Forest Ecosystems

- The forest ecosystem comprises complex collection of different kinds of biotic communities.
- Optimum conditions of temperature and ground moisture, responsible for the growth of trees, result in the establishment of forest communities.
- The nature of soil, wind and air currents determine distribution of forest vegetation.
- The abiotic environment of forest ecosystem comprises nutrients present in the soil on forest floor. These nutrients are rich in dead and decaying organic matter. Producers are mainly big trees, some shrubs and ground vegetation.

There are three major types of forests, classed according to latitude:

1. Tropical Forests;
2. Temperate Forests; and
3. Boreal or Taiga Forests

General Climate: Every forest type has its own peculiar climatic conditions. In the Tropical forests, there is no winter, and there are only two seasons (rainy and dry). The length of daylight is 12 hours and varies little. The temperate forests have moderate climate and a growing season of 140-200 days with 4-6 frost-free months. In the Taiga forests, temperatures are very low and precipitation is in the form of snow. Seasons are divided into short, moist, and moderately warm summers and long, cold, and dry winters. The length of the growing season in these forests is 130 days.

Fig. 1.1. Forest Ecosystem

Flora

Based on the type of forests, the flora also varies from forest to forest.

- In Tropical Forests one square kilometer may contain as many as 100 different tree species. Trees are 25-35 m tall, with shallow roots, mostly evergreen, with large dark green leaves. Plants such as *orchids, bromeliads, vines (lianas), ferns, mosses, and palms* are present in the tropical forests.
- Flora is characterised by 3-4 tree species per square kilometer in the Temperate forests. Trees are distinguished by broad leaves which shed their leaves annually during dry season. They include such species as *oak, hickory, beech, hemlock, maple, basswood, cottonwood, elm, willow, and spring-flowering herbs.*
- Taiga forests consist mostly of cold-tolerant evergreen conifers with needle-like leaves, such as pine, fir, and spruce.

Fauna

Forests are home to a wide variety of animals and birds. Tropical forests have the largest variety of life forms in all of nature, with thousands of different species of mammals, birds, reptiles, amphibians and insects. Many of the animals in

these forests are highly adapted to their diverse environment having developed camouflage or strong defences.

Animal life in the Taiga forests consists mainly of birds, mammals and various rodents. They include woodpeckers, hawks, moose, bear, weasel, lynx, fox, wolf, deer, hares, chipmunks, shrews, and bats. Most of the animals in these forests are well-adapted to the cold climate and hibernate during the long winters.

Temperate forests have a thin canopy of trees which allows more light and heat to penetrate and permit the survival of smaller an cold-blooded animals like garter snakes, turtles and a few amphibians. Besides these, squirrels, rabbits, skunks, birds, deer, mountain lion, bobcat, timber wolf, fox, and black bear are found in these forests. Many species of temperate forests either hibernate or burrow in the ground to pass the winter months.

GRASSLAND ECOSYSTEM

Grasslands are found on every continent except Antarctica. These terrestrial ecosystems occupy roughly 19 per cent of the earth's surface. They are characterised by treeless herbaceous plant cover, dominated by a wide variety of grass species.

Features of Grassland Ecosystems

- Land is dominated by grasses. Large shrubs or trees are not there.
- Grasslands have rich variety of animals.
- Grasslands have been the home for grazing animals for million of years. Since the grass height is low and trees are few, animals found in their areas are exposed to the stress of sun and sweeping winds.

There are two main divisions of grasslands:

- Tropical grasslands or Savannas; and
- Temperate grasslands

Tropical grasslands are those close to the Equator. They are hot all year long. These grasslands cover almost half the surface of Africa and large areas of Australia, South America and India.

Fig. 1.2. Grassland Ecosystem

Temperate grasslands are those further from the Equator, with hot summers and harsh winters. The major Temperate grasslands are the *Veldts* of South Africa, the *Puszta* of Hungary, the *Pampas* of Argentina and Uruguay, the *Steppes* of the former Soviet Union, and the plains and *Prairies* of Central North America.

General Climate

Climate is the most important factor in creating a Savanna. Savannas are always found in warm or hot climates where the annual rainfall is from about 50.8 to 127 cm per year. The rainfall is concentrated in six or eight months of the year, followed by a long period of drought when fires can occur. Savanna has both a dry and a rainy season.

Temperate grasslands have hot summers and cold winters. Rainfall is moderate. Precipitation in the temperate grasslands usually occurs in the late spring and early summer. The temperature range is very large over the course of the year. Summer temperatures can be well over 38° C (100 degrees Fahrenheit), while winter temperatures can be as low as -40° C.

Flora

The main plants that grow on grasslands are grasses. There are thousands of different types of grasses. Grasses are plants that are found from the edge of the sea to high up in mountains, and in every continent except Antarctica. They are very successful plants because they survive the

harshest conditions. There are many wildflowers that grow in grasslands. Flowering plants grow amongst the grassses, generally flowering in spring and summer.

Grasses grow from the base, not the top. Creeping stems above the ground are called *stolons*, and below the ground are called *rhizomes*. As these creeping stems spread out, shoots grow up and produce leaves. Grass can be cut quite close to the ground, and new leaves (blades of grass) sprout from the base of the plant.

Fauna

Many animals live in grasslands, different animals in different countries. Some of them are very small such as mice, prairie dogs, snakes, lizards and insects. These animals can hide easily in the grasses. There are also large grasslands animals such as elephants, lions, zebra, giraffes, cheetah and rhinoceros in Africa, bison in North America, kangaroos in Australia. These animals are too large to hide in the grasses, so they must protect themselves in other ways, such as by speed or camouflage. Some, like African elephants, giraffes and rhinos, are so large that predators cannot easily attack a healthy adult.

Fig. 1.3. Kangaroo

Many grassland animals live in large groups, called herds. Living in groups means that [illegible] protection from predators for the weaker [illegible]. There are more eyes to spot danger, [illegible] members surround weaker ones.

Typical birds of the grasslands are prairie chickens, sharp-tailed grouse, meadows larks and a variety of sparrows.

DESERT ECOSYSTEM

Deserts make up about one-fifth of the surface of earth and occur where rainfall is less than 50 cm/year. The major deserts are the Sahara, the Arabian, Kalahari and Namib of Africa, the Atacama of South America, the Mojave, Sonoran and Chihuahuan of North America and the Australian deserts. Besides, there are the Thar Desert in western India and Pakistan and the Gobi Desert of Mongolia.

Features of Desert Ecosystems

- The soil in the desert is coarse.
- In the deserts, days are very hot and nights are cold. So the plants and animals are exposed to both types of extremes.
- The predominant plants found in the deserts are succulent species with waxy surfaces, such as cacti, which can conserve water for longer periods of time, or deciduous shrubs, also with thick waxy leaves.
- The animal types in the deserts are few. These include burrowing and nocturnal rodents, reptiles, insects and arachnids (Scorpions, spiders etc.). These animals adapt themselves to the temperature extremes and desiccation of desert air by living beneath the surface during the day and moving out only at night. Most of them have remarkable water conservation adaptations.
- Most of the animals living in the deserts are nocturnal (active only at night). Common animals are camels, foxes, kangaroos, rats squirrels, etc.
- Many of the insects have waxy coats and reduced water loss through the cuticles.

Desert biomes can be classified according to several characteristics. There are three major types of deserts:

- Hot and dry deserts
- Coastal deserts
- Cold deserts

Deserts can be hot or cold. The Australian desert is one example of a hot desert, and the Gobi desert in Mongolia is an example of a cold desert. Antarctica is the world's largest desert. The Atacama desert of Chile and the Sahara desert in Africa receive less than 1.5 cm rain a year.

Although rain doesn't fall very often in deserts, sometimes not for years, there can be sudden, heavy rains that cause flooding.

Deserts are also found along coastlines, such as the Atacama desert, or in the interior of continents, such as the Great Basin desert of North America.

The location of the desert and of mountain ranges help determine what type of desert it is. Coastal deserts are located on west coasts of continents.The winds blow in an easterly direction and prevent the moisture from moving onto the land. Some deserts, like the Gobi desert, are affected by high mountain ranges that produce a rainshadow effect, which means the mountains prevent moisture from reaching an area. The Himalaya Mountains prevent rainfall from reaching the Gobi desert.

General Climate

Because they are dry, deserts have wide variations in temperature each day. In the daytime when there is little moisture in the air to block the sun's rays, it becomes very hot. When the sun goes down, the heat absorbed by the ground during the day quickly evaporates into the air and the temperature becomes very cold.

Fig. 1.4. Desert Ecosystem

In the Hot and Dry Deserts, temperature ranges from 20 to 25° C. The extreme maximum temperature for Hot Desert ranges from 43.5 to 49° C.

The precipitation in Hot and Dry Deserts and the precipitation in Cold Deserts is different. Hot and Dry Deserts usually have very little rainfall or concentrated rainfall in short periods between long rainless periods. This averages out to under 15 cm a year.

Hot and Dry Deserts, are warm throughout the autumn and spring seasons and very hot during the summer. The winters usually have very little if any rainfall.

In the Cold Deserts, temperatures in winter range from -2 to 4° C and in the summer from 21 to 26° C a year. Cold Deserts usually have lots of snow. They also have rain around spring. This averages out to 15-26 cm a year. Cold Deserts have quite a bit of snow during winter. The summer and the beginning of the spring are barely warm enough for a few lichens, grasses and mosses to grow.

Coastal deserts are found in areas that are moderately warm or cool. The winters are usually cool and short, while the summers are long and warm.

Flora

The amount and kinds of plants vary according to where a desert is located. Short grasses can be found in nearly all deserts. Desert plants include *sagebrush, creosote bushes* and *cacti.*

Desert plants have had to develop different ways of capturing water in order to survive in their habitat. These changes are called *adaptation.* A common adaptation is to store water in the roots, stems, leaves or fruit. Plants that store water in this way are called *succulents*, one of which is the cactus. Some plants have developed very long roots that go deep into the ground to reach underground water. Others have developed spreading root systems lying just below the surface and stretching widely. This gives the plant many tiny roots that capture water when it rains.

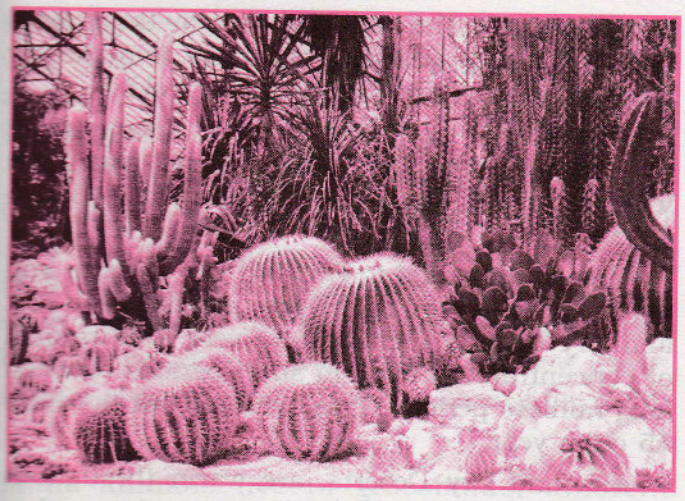


Fig. 1.5. Desert Plants

Another desert adaptation is seen in the leaves. Desert plants limit water loss through their leaf surface by the size, sheen, or texture of their leaves. Small or spiny leaves limit the surface area exposed to the drying heat. Glossy leaves reflect the sun's rays, reducing leaf temperatures and evaporation rates. Waxy leaves prevent moisture from escaping. Some plants only open their leaf pores at night when it is cool and water loss from leaves is low.

Fauna

Deserts are home to many reptiles, insects, birds, and small mammals. Australia's bilby and kowari and the kangaroo mice of North America are just a few examples of small mammals that live in the desert. Hot and Dry Desert animals include small nocturnal (only active at night) carnivores. There are also insects, reptiles, and birds. Some examples of these animals are Borrowers, Mourning Wheatears, and Horned Vipers. Cold Deserts have animals like Antelope, Ground Squirrels, Jack Rabbits, and Kangaroo Rats. Animals of the coastal desert include rough skinned amphibians, birds of prey, scavenger mammals, reptiles and insects.

Most of the animals in the cold desert are burrowers, even the carnivores and reptiles which even though cold-blooded, have made their homes in the cold desert. Deer and other larger herbivores are only found during the winter, as the supply of grass is more abundant during that period.

In order to survive, desert animals have developed a number of ways of adapting to their habitat. The most common adaptation in behaviour is staying in the shade of plants or rocks or by burrowing underground in the heat of the day. Many desert animals are *nocturnal* i.e., they stay inactive in shelter during the day and hunt at night when it is cool.

Some animals get all the moisture they need from the insects, plants and seeds they eat, and do not need to drink water. Most pass little moisture out of their bodies. They do not have sweat glands and pass only small amounts of concentrated urine.

Fat increases body heat, so some desert animals have concentrated the body's fat in one place, such as a hump or tail, rather than having it all through the body.

Some animals develop unique ways of surviving. The *Thorny Devil*, a lizard that lives in Australian desert areas, has a body that channels raindrops directly into its mouth when rain falls. The water-holding frog spends most of the year under the ground in Australian desert areas, and develop a sort of cocoon that enables them to store water to keep them going through the dry times. When it rains, they emerge to lay their eggs in puddles. The eggs hatch within days and the tadpoles develop quickly, before the water dries out.

Camels are one of the few large mammals to survive in the desert, and have many special adaptations to help them survive in the harsh desert conditions.

AQUATIC ECOSYSTEM

An aquatic ecosystem is an ecosystem located in water bodies. The two main types of aquatic ecosystems are *freshwater ecosystem* and *marine ecosystem*.

FRESHWATER ECOSYSTEM

Freshwater is defined as having a low salt concentration — usually less than 1%. Plants and animals in freshwater regions are adjusted to the low salt content and cannot survive in areas of high salt concentration (i.e., ocean).

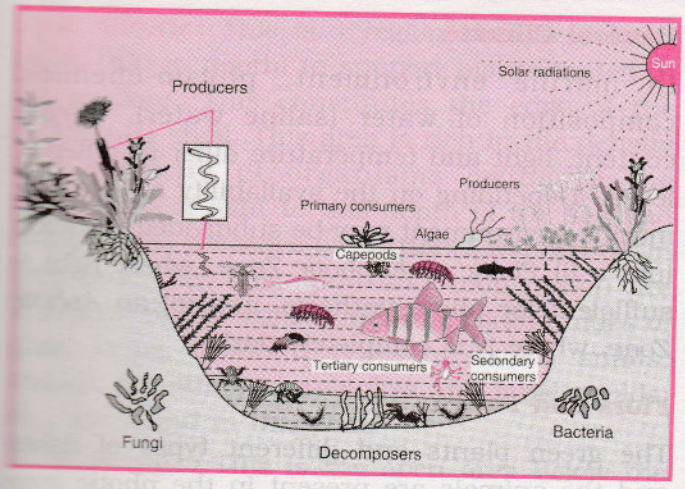


Fig. 1.6. Freshwater Ecosystem

Freshwater ecosystems can be divided into two categories:

(i) *Standing water or lentic* (lenis, meaning calm) ecosystems like a lake, pond, marshes, or swamp. These are also known as Pond ecosystems.

(ii) *Running water or lotic* ecosystems are that of a river or a spring.

POND ECOSYSTEMS

These regions range in size from just a few square metres to thousands of square kilometres. Many ponds are seasonal, lasting just a couple of months while lakes may exist for hundreds of years or more.

General Climate

Temperature varies in ponds and lakes seasonally. During the summer, the temperature can range from 4° C near the bottom to 22° C at the top. During the winter, the temperature at the bottom can be 4° C while the top is 0° C (ice). In between the two layers, there is a narrow zone called the *thermocline* where the temperature of the water changes rapidly. During the spring and fall seasons, there is a mixing of the top and bottom layers, usually due to winds, which results in a uniform water temperature of around 4° C. This mixing also circulates oxygen throughout the lake. Of course there are many lakes and ponds that do not freeze during the winter, thus the top layer would be a little warmer.

Flora and Fauna

Lakes and ponds are divided into three different "zones" which are usually determined by depth and distance from the shoreline.

Littoral Zone: The topmost zone near the shore of a lake or pond is the *littoral zone*. This zone is the warmest since it is shallow and can absorb more of the Sun's heat. It sustains a fairly diverse community, which can include several species of algae (like diatoms), rooted and floating aquatic plants, grazing snails, clams, insects, crustaceans, fishes, and amphibians. The vegetation and animals living in the littoral zone are food for other creatures such as turtles, snakes, and ducks.

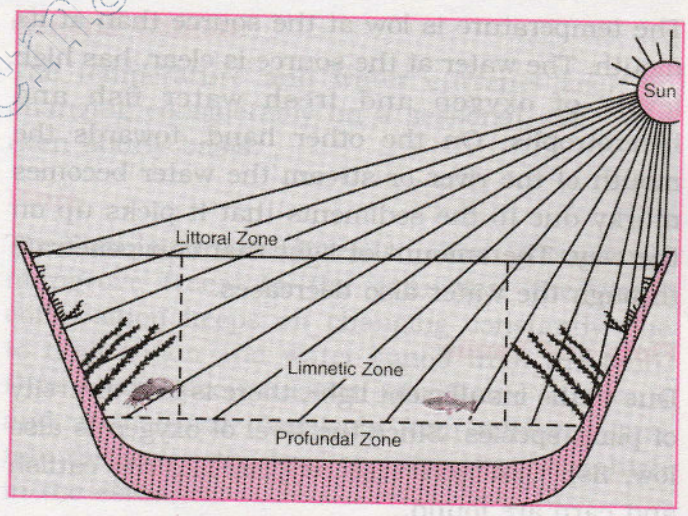


Fig. 1.7. Different zones of a Fresh Water Pond

Limnetic Zone: The near-surface open water surrounded by the *littoral zone* is the *limnetic zone*. The limnetic zone is well-lighted (like the littoral zone) and is dominated by *plankton*, both phytoplankton and zooplankton. Plankton are small organisms that play a crucial role in the food chain. Without aquatic plankton, there would be few living organisms in the world, and certainly no humans. A variety of freshwater fish also occupy this zone.

Profundal Zone: The deep-water part of the lake or pond is called the *profundal zone*. This

zone is much colder and denser than the other two. Little light penetrates all the way through the limnetic zone into the profundal zone. The fauna are heterotrophs, meaning that they eat dead organisms and use oxygen for cellular *respiration.*

River and Streams

Streams and rivers can be found everywhere — they get their starts at headwaters, which may be springs, snowmelt or even lakes, and then travel all the way to their mouths, usually another water channel or the ocean. These water bodies move in one direction. However, the characteristics of a river or a stream change during its journey from the source to its mouth.

General Climate

The temperature is low at the source than at its mouth. The water at the source is clear, has high levels of oxygen and fresh water fish and heterotrophs. On the other hand, towards the mouth of the river or stream the water becomes murky due to the sediments that it picks up on the way. The amount of light that can penetrate through the water also decreases.

Flora and Fauna

Due to the insufficient light, there is less diversity of plant species. Since the level of oxygen is also low, fish that need less oxygen, like the catfish and carp are found.

MARINE ECOSYSTEM

The marine ecosystems are divided between oceans and coastal ecosystems. The average depth of the marine environment is about 3000 metres. Living organisms are found at all depths but with a decreasing density.

Ocean Ecosystems

The oceans are large bodies of water which form the largest of all the ecosystems. All the oceans and major seas of the world are connected. Together they form a wide variety of ecosystems.

General Climate

In marine environment, physio-chemical composition of water (saline water), oxygen content, light and temperature differ at *different levels*. Depending on the availability of light, the marine environment may be subdivided vertically into a (i) *Photic* or *Euphotic* Zone, where light is sufficient for photosynthesis, and (ii) an *Aphotic Zone*, where it is completely dark.

Flora and Fauna

The green plants and different types of fishes and the animals are present in the photic zone while non-photosynthetic fungi, bacteria and some animals are present in the aphotic zone.

The waves and tides (which are produced by the pull of moon and sun) also influence the marine ecosystem.

The major zones in marine ecosystem are:

1. Littoral: This is the seashore area extending between the highest high tide and lowest low tide levels. Waves and tides have maximum effect on this zone. This zone is some times, exposed to air. Different types of species like algae, star fish, crustaceans, etc. are found in this zone. It supports growth of algae and other sea animals. Common animals found here include snails, clams, barnacles, crustaceans, sea cucumbers, sea urchins, etc.

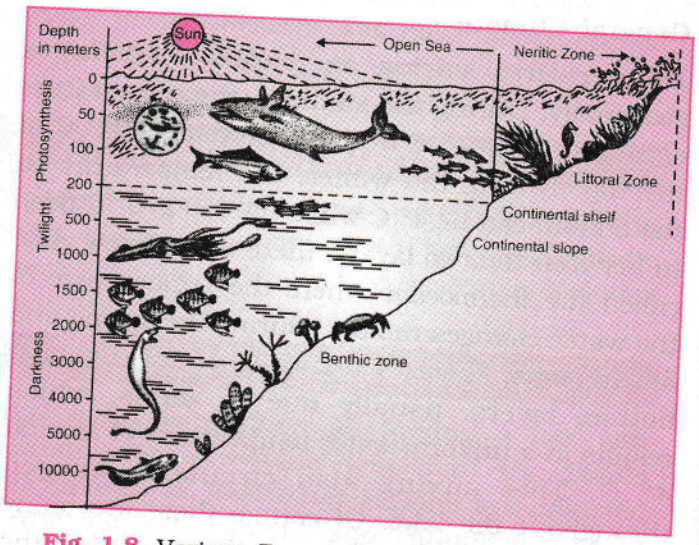


Fig. 1.8. Various Zones of the Marine Ecosystem

2. Neritic: This is a region shallow enough (up to 200 m depth) to support plants rooted in the seafloor. This constitutes the edge of the continental shelf. This area is rich in the density and diversity of organisms owing to the penetration of light to this depth of the sea and owing to the presence of nutrients washed down from land. Phytoplankton and zooplankton are abundant in this zone. Extensive communities of giant kelps, different types of fishes, snails, whales, sea-otters, sea-snakes and large squids, etc., are found in this zone.

3. Pelagic: This is the open area below the Neritic region. On the surface of this zone various types of phytoplankton are found. In addition, there are zooplankton along with shrimp and jelly fish, etc.

4. Benthic: This forms the floor of the ocean. Production, in this zone, is limited by low nutrient supply. Most of the organisms found here are luminescent. Rooted organisms are sea lilies, sea fan, sponges, etc. Snails and clams are embedded in the mud whereas star fish and sea urchins move on the surface.

Coastal Ecosystem

A Coastal Ecosystem includes estuaries and coastal waters and lands located at the lower end of drainage basins. It is a unique ecosystem where stream and river systems interact with the sea and sea tides also play their role. This ecosystem has the features of terrestrial, aquatic and marine ecosystems. It is a transition zone that provides habitat for a number of plants and animals.

Fig. 1.9. Coastal Ecosystem

Flora and Fauna

Rivers and streams drain into estuaries, bringing in nutrients from uplands. Plants use them together with the Sun's energy, carbon dioxide and water to manufacture food. The coasts provide habitats for a number of species of birds, mammals, fish and other wild life. Coasts are ideal breeding and nesting areas for coastal birds, including several endangered species such as brown pelicans.

Estuaries

Estuaries are transitional zones between the sea and rivers where freshwater streams or rivers merge with the ocean.

General Climate

The temperature and water currents keep on changing considerably on a seasonal, daily and even hourly basis.

Flora

The flora includes sea weeds, marsh grasses and mangrove trees. In the estuaries, the water composition keeps on changing constantly due to tidal action and water runoff from the land. Due to the accumulation of organic materials and agricultural chemicals from adjacent land into the water, the level of nutrients is also high in the estuaries.

The primary producers in the estuaries are phytoplankton, which are consumed directly by some fish. However, most of these phytoplankton form the primary food for small crustaceans and the zooplankton, which in turn are food for fish.

Fauna

Estuaries constitute a variety of fauna including worms, oysters, crabs and waterfowl. The estuarine animals show a number of adaptations to the unstable conditions of the environment. They have special ability to maintain salt and water balance in the presence of changing environment. They also have special adaptations to tidal and wave action.

CHAPTER 2

INTERACTION BETWEEN BIOTIC AND ABIOTIC FACTORS IN AN ECOSYSTEM

Course Content—Syllabus and Scope

Interaction between biotic and abiotic factors in an ecosystem.

Biotic components consisting of producers, consumers, decomposers.

Abiotic or non-living components such as air, soil, water and climatic factors like sunlight, temperature, humidity and wind.

INTERACTION BETWEEN BIOTIC AND ABIOTIC FACTORS IN AN ECOSYSTEM

In Chapter 1 we studied the different types of ecosystems and their components. There exists an interdependence of living organisms (biotic factors) and the physical environment (abiotic factors) in all ecosystems. For example, animals cannot produce their own food so they depend on plants directly or indirectly, for their nutrition. Plants are able to synthesise their own food but they are dependent on the physical environment for the raw materials (water, light, carbon dioxide, etc.). Micro-organisms like bacteria and fungi act on dead animals and plants as well as their waste products decomposing them to enrich the physical environment with nutrients.

Thus, the biotic and abiotic components interact intimately and greatly influence each other. The biotic and abiotic components do not exist in isolation from one another. The living organisms not only depend on the physical environment but also affect the conditions of the physical environment. A good example is the change in global climate as a result of human technology and land use patterns.

ABIOTIC FACTORS

There are three broad categories of abiotic components in all ecosystems.

INORGANIC SUBSTANCES: The various life processes of living organisms require at least 40 elements in different quantities. Elements that are needed in large amounts are called *macronutrients*. For example, carbon, hydrogen, oxygen (components of all organic compounds), nitrogen and potassium. We shall study their cycles in detail in Chapter 3. Calcium, sodium, magnesium, iron, phosphorus and sulphur are other macronutrients. The Table given on the next page lists the major functions of some macronutrients.

Substances required in small amounts are called *micronutrients*. They include Copper (Cu), Manganese (Mn), Selenium (Se), Zinc (Zn), Molybdenum (Mo), Boron (B), Silicon (Si), etc. Some of these micronutrients (e.g., Zn, B) may often serve as limiting factors to affect the growth, survival and propagation of living organisms.

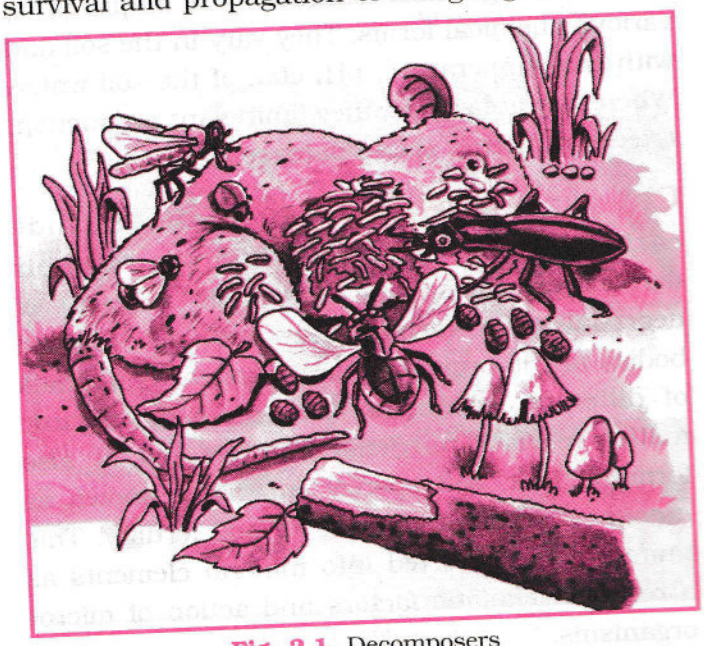


Fig. 2.1. Decomposers

Element	Function
Carbon (C), Hydrogen (H)	The basic constituents of life that drive all life processes.
Nitrogen (N)	Structural component of proteins and nucleic acids.
Phosphorus (P)	Structural component of nucleic acids, phospholipids and bone.
Sulphur (S)	Structural component of many proteins.
Potassium (K)	Major solute in animal cells.
Calcium (Ca)	Structural component of bone; regulator of cell permeability.
Magnesium (Mg)	Structural component of Chlorophyll; involved in function of many enzymes.
Iron (Fe)	Structural component of haemoglobin and many enzymes.
Sodium (Na)	Major solute in extracellular fluids of animals.

The inorganic substances are required in various chemical forms. They vary in the soil and with the temperature, pH, etc., of the soil water. When they are scarce, they limit plant production. Excess nutrients cause damage to plants.

ORGANIC SUBSTANCES: These include carbohydrates, proteins, lipids and their derivatives. These are formed as a result of degradation of various dead and decomposed bodies of the organisms and excretory materials of different organisms. Decomposing organic matter releases nutrients into the soil. It also forms a dark, soft spongy substance known as *humus*, which is important for soil fertility. This humus gets converted into mineral elements as a result of climatic factors and action of micro-organisms.

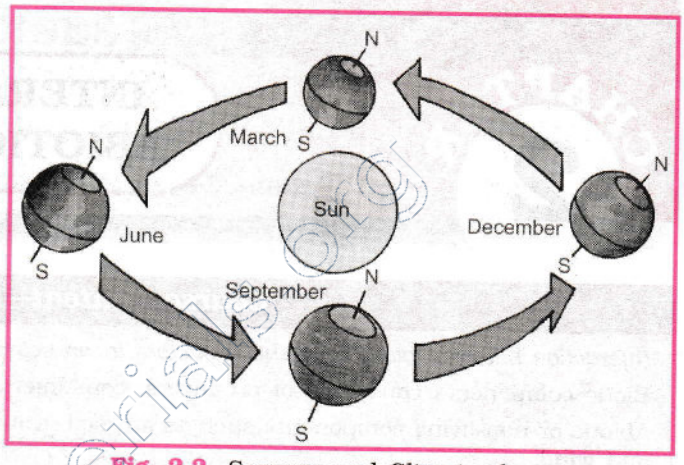


Fig. 2.2. Seasons and Climate change

ECOLOGICAL FACTORS

These factors are classified as follows:

- *Climatic Factors:* Light, temperature, wind velocity, atmospheric gases, rainfall and atmospheric humidity.
- *Edaphic Factors:* Soil—mineral matter, organic matter, soil water and soil air.
- *Topographic Factors:* Altitude, steepness of slope and direction of slope.
- *Limiting Factors:* Plants and animals all have a range of tolerance for certain environmental factors like temperature humidity, etc. If an environmental factor essential for life is absent or is below or above the critical range for a particular species, the factor is called a *limiting factor* for that species. An organism may have a wide range of tolerance for one factor but a narrow range for another. For example, fresh water fishes have a wide range of tolerance for temperature but narrow range of tolerance for salts; so they perish when the concentration of salts in water increases (i.e., in sea water).

Climatic Factors

(a) Light: The Sun is the ultimate source of energy for all living organisms. Energy from the Sun reaches the earth in the form of electromagnetic waves. This solar radiation warms the Earth's atmosphere sufficiently to provide favourable global temperature to support life. Light from the Sun is an essential factor for living

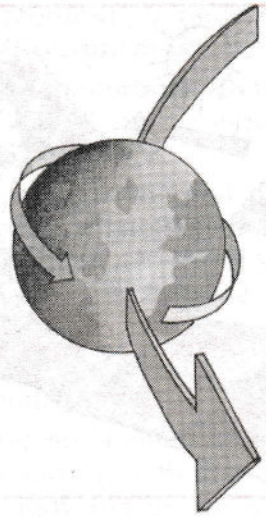


Fig. 2.3. Motions of the Earth

The visible part of the electromagnetic spectrum (solar radiation) between 400 and 700 nm wavelength is required for photosynthesis and is called *Photosynthetically Active Radiation* (PAR). Rate of photosynthesis also depends on intensity, duration and direction of light, all of which vary diurnally and seasonally. Photosynthesis provides food for the whole ecosystem.

Living organisms receive light by light receptors (e.g., eye, photoreceptors, stigma, ocelli, etc). Thus, light is used as a stimulus for activity cycles. The timing of light received daily and seasonally is called *photoperiod*. For example, when the duration of daylight reduces, animals go into hibernation. Photoperiod causes programming of life-cycles, coordination of opening of buds and flowers in plants and migration in animals.

Breeding time in most organisms is determined by photoperiod in such a way that their offspring have greatest chance of survival.

Temperature: The primary effect of temperature involves the stability and activity of enzymes which are responsible for the biochemical reactions in cells of living organisms. Temperature may act on any stage of the life cycle of an organism. It can limit living organisms through the effects on:

Survival: Different organisms can survive within a range of temperature called *optimum temperature*. At temperatures, above and below its optimum range the organism perishes. For example, reef building corals can survive at temperatures higher than 20ºC. For most of the organisms, the favourable temperature lies between 10° and 35°C. The temperature tolerance for insects and fish is 50°C. Certain bacteria, blue green algae and lichens can also tolerate subzero temperatures.

(ii) Growth, Development and Reproduction: Activities of organisms also occur within a given range. For example, some reptiles living in altitudes higher than 1200 m are viviparous (give birth to the young ones) while those living below 1200 m are oviparous (lay eggs).

There is a variation in vegetation from equator to higher latitudes as well as from sea level to higher altitudes, i.e., the density of vegetation reduces.

Competition with other organisms (parasitism, predation, disease, etc.) also influences biota distribution.

Deserts represent regions that exhibit extreme diurnal variations in temperature from 50ºC during a summer day to below 10ºC the same night. Organisms inhabiting such extreme situations have evolved special adaptive features that allow them to withstand extreme temperatures and even droughts. Desert animals

Fig. 2.4. Hibernation

have adopted three ways to deal with high temperatures, i.e., *avoidance, tolerance* or *use of water for evaporation* to remain cool. Many insects and rodents avoid heat by living underground in burrows during the day and remain active during night. Man can survive high temperatures for long periods by evaporating water. This is done through sweating. During hot summer days a man sweats more than one litre of water per hour; this water is evaporated and results in cooling effect. However, animals like camels do not sweat as profusely as man. The body temperature of the camels varies from day to night. It is 40°C during the day and 35°C during night. Hence, excessive heat stored during the day is dissipated during night without the need for evaporation.

(c) Wind-velocity: The strong moving wind or the wind velocity directly influences transpiration, dispersal of seeds and fruits. The growth of plants is restricted on the side on which wind effect is the most. Its effect is quite common on sea coasts and mountains. There the wind is more effective in killing buds and thereby checking branch development on windward side.

(d) Atmospheric Gases: Nitrogen, oxygen and carbon dioxide in the atmosphere are important for living organisms. Except for water vapour, the concentration of gases in the atmosphere is fixed.

(i) Oxygen (O_2)	21.0%
(ii) Carbon dioxide (CO_2)	0.03%
(iii) Nitrogen (N_2)	78%

All atmospheric gases are usually available in proper amount to living organisms because, concentrations of gases do not vary in the environment, hence they are not considered as part of changing environment.

Beside the dust particles, smoke, micro-organisms, pollen grains and various gases coming from industries and volcanoes like SO_2, NH_3, SO_3 etc., are present in the atmosphere. Decomposition of dead plants and animals on muddy soils release some organic gases like methane into the atmosphere. In industrial areas sometimes plants die due to excess smog. Plants on the roadside contain dust particles on the leaf surface. These particles influence photosynthesis and respiration, due to which growth is stopped and sometimes plants die.

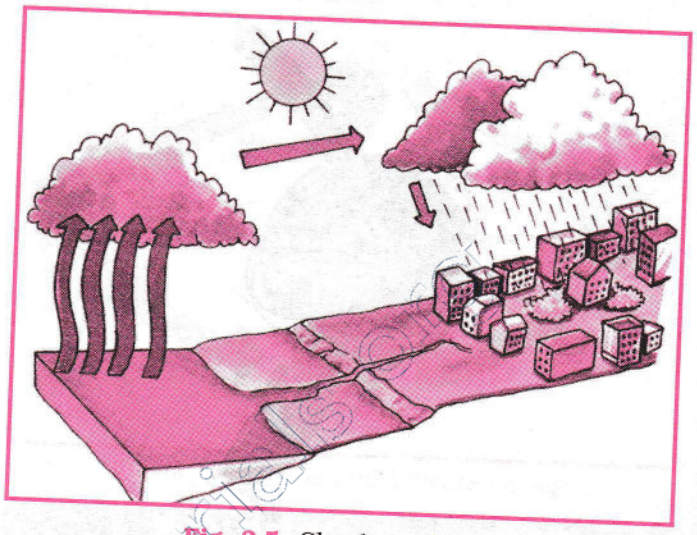


Fig. 2.5. Cloud and Wind

We shall study about the cycling of these atmospheric gases in detail in the next Chapter.

(e) Biogenic Salts: Dissolved salts important for life are called biogenic salts. They are an important limiting factor in both terrestrial and aquatic environments. Phosphorus salts are the most important as their ratio in living organisms is considerably greater. Deficiency of phosphorus limits the productivity of a region more than any other substance except water. Nitrogen, potassium, calcium, sulphur and magnesium are also important. Calcium is needed in large quantities by molluscs and vertebrates. Magnesium is a necessary component of chlorophyll.

(f) Water: It is the most prominent and essential feature of all ecosystems for the following reasons:

- All organisms are composed mostly of water. Plant or animal body contains large percentage of water, sometimes 90 per cent or more.
- Water is the medium in which primitive life first developed.
- Water is a good solvent. Most of the nutrients dissolve in water or remain suspended in it.
- Nutrients utilised for various metabolic activities travel via the organism's internal aqueous medium.

- Water is required to remove the excretory products of organisms.
- Water is an important circulating medium over the earth as is evident from the hydrological cycle.
- Water has unique thermal properties which protect aquatic organisms from seasonal and diurnal differences in temperature and prevents complete freezing of oceans and lakes.
- Transparency of water allows light penetration in water bodies.
- Surface tension of water allows movement of water into and through organisms as well as rise of groundwater in the soil.

Water Balance: For all the living organisms, aquatic as well as terrestrial, maintenance of the proper water balance is crucial. For aquatic organisms there is a problem maintaining the balance of osmotic pressure between the inside of the organism and the outside. Marine fishes have less osmotic pressure (less salt contents) in the blood so they excrete water to maintain the balance. Many aquatic organisms have exoskeletons, cuticular sheaths or scales to check the free passage of water.

For terrestrial organisms it is important for the organism to adapt in such a way so that it can secure and retain sufficient water. In dry regions plants have swollen leaves and sunken stomata to retain water. In such areas many animals are active only during night when loss of water is less. Herbivores get their water from plants and carnivores from the blood of their prey.

Edaphic Factors

Soil: Soil is an important medium for living organisms. It provides anchorage for the roots of plants, habitat for soil micro-organisms, sites for burrowing animals, support for terrestrial animals. It supplies materials for plants and indwelling members of the biota.

The abundance of plants and animals is dependent on the chemical composition or the type of soil. Coarser textured soils allow deeper penetration of roots and facilitate the passage of burrowing animals. Fine textured soils retain more water for the use of plants and animals. Loamy soil (intermediate textured) is most favourable for plant growth.

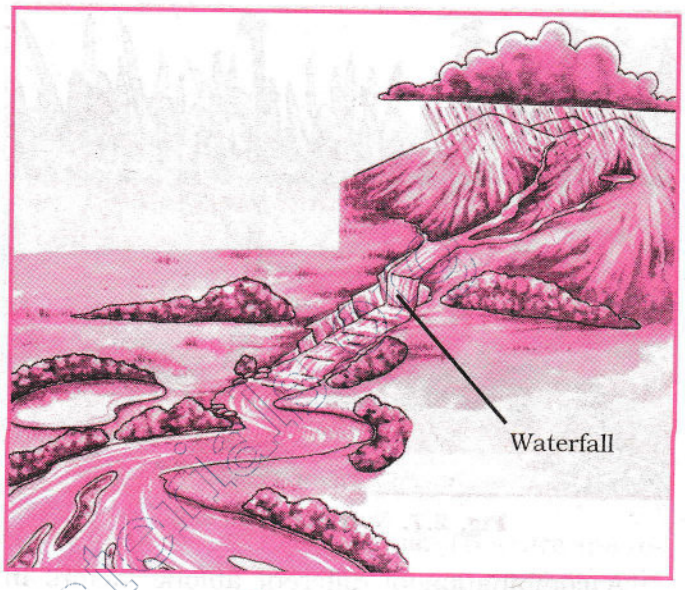


Fig. 2.6. A River

Generally plants are found growing well in all types of soil except desert soil. Burrowing animals (rodents and moles) are found almost everywhere. Many types of reptiles, amphibians and a few species of birds spend at least a part of their lives burrowing in soil. Earthworms, insect larvae, spiders, millipedes are inhabitants of the land substratum. The number of micro-organisms in soil is much greater (e.g., protozoa, fungi and bacteria) than other organisms.

Some important factors related to the soil are:

(a) *Soil Water:* It has a great effect on the growth of plants. All the water that most plants require is absorbed from the soil. The major source of soil water is the rain water that seeps into the soil through the pores.

(b) *Soil Air:* The soil contains gases that enter from the atmosphere. It is necessary for the underground parts of the plant to respire.

(c) *Soil Organisms:* These consist of micro-organisms, earthworms and rodents. They mix up the soil and thus increase its fertility.

(d) *Soil Fertility:* The fertility of the soil is determined by the amount of humus present in it. Humus helps to retain water in the soil. It is formed by the decomposition of dead organic remains of plants and animals. It is a source of excellent nutrients for the plants. Most of the nitrogen, sulphur and phosphorus return to the soil through humus.

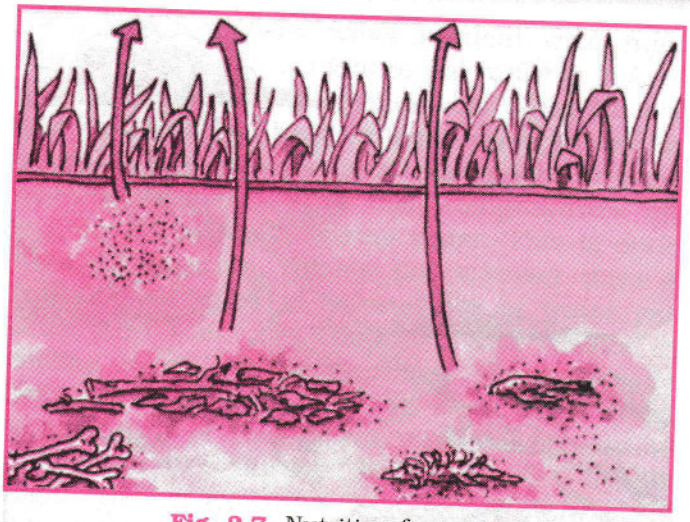


Fig. 2.7. Nutrition from soil

A combination of different abiotic factors in different intensities regulates the occurrence and abundance of living organisms. Some times deficiency of one factor is compensated by another. Effect of every nutrient depends on the quality of other nutrients present there simultaneously. The following are the four ways by which organisms respond to their environment:

(i) *Structural Adaptation*: Due to water scarcity in deserts leaves of the plants become spines.

(ii) *Physiological adjustments*: Animals hibernate in cold weather.

(iii) *Community relationships*: Colonies of ants, termites etc., hunt and store food for winter and monsoon.

(iv) *Behavioral patterns*: Animals in deserts are nocturnal to beat the high daytime temperatures.

Limiting Factors

Limiting factors are both biotic and abiotic. They control the actual distribution and abundance of organisms in nature. The important abiotic limiting factors are light, water, soil, temperature, atmospheric gases and biogenic salts.

Rainfall, humidity and evaporating power are the chief factors playing limiting function. Water is essential for carrying out various physiological activities of the protoplasm and therefore is present in higher percentage (about 90% or more in cells). The distribution of rainfall over the year is an important limiting factor for organisms. In an area with less rainfall, plants and animals show capacity to resist the long periods of drought. Generally, rainfall seems to be evenly distributed in tropical and subtropical as well as in temperate areas. Rainfall in deserts is 25 cm or less per year; 25-75 cm per year in grasslands and open woodlands; 75-125 cm per year in wet forests. Humidity refers to the amount of water vapour present in the air. Absolute humidity represents the actual amount of vapour in air expressed as weight of water per unit of air. The relative humidity is the percentage of vapour present in the air being compared with saturation under normal conditions. Humidity is usually high at night and low during the day. It modifies the effects of temperature and light, thus regulating the activities of the organisms.

BIOTIC FACTORS

Biotic factors are the living elements of the ecosystem. Based on the mode of nutrition or trophic structure (trophe, meaning nutrition) the components are

1. Autotrophic (self-nourishing) component consisting mostly of green plants which can utilise simple inorganic substances to build complex organic substances (food) by fixing solar energy. The autotrophic component of the biota is also referred to as Producers.

2. Heterotrophic (other nourishing) component consisting of non-green plants,

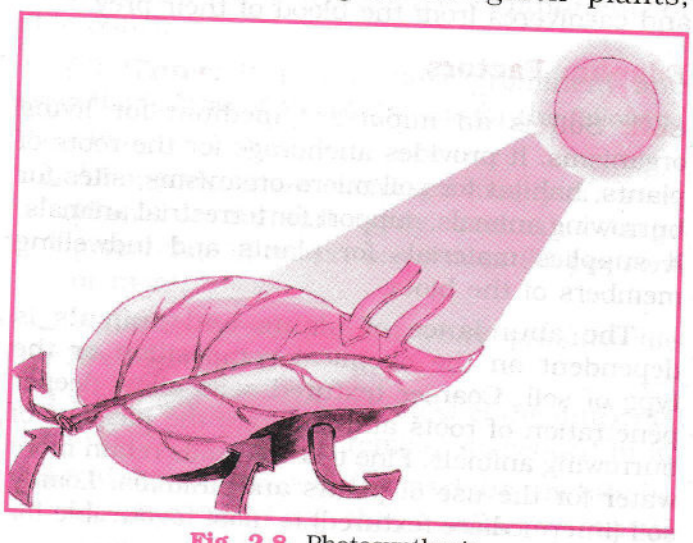


Fig. 2.8. Photosynthesis

animals and micro-organisms which consume complex organic substances and utilise, rearrange or decompose them. Heterotrophs cannot produce their own food; so they depend on others for nourishment. They are of two types: *consumers* and *decomposers*.

Thus each biotic community comprises (1) Producers, (2) Consumers and (3) Decomposers.

1. Producers: The green autotrophic plants are regarded as producers. They are able to synthesise carbohydrates, proteins, fats, amino acids etc., (complex organic compounds) from certain inorganic constituents (CO_2, H_2O, mineral salts, etc) obtained from the surrounding environment with the help of chlorophyll in the presence of sunlight. The process of producing food using the sunlight is known as *Photosynthesis*. Certain bacteria can synthesise their food even in the absence of sunlight from simple inorganic compounds. The process of such synthesis is called *chemosynthesis*.

2. Consumers (Or Phagotrophs): The living organisms that cannot produce their own food and procure their food or nutrition by consuming producers directly or indirectly are called consumers. They are of three types:

(a) *Primary Consumers:* They are commonly called herbivores. They are animals that derive their nutrition directly by consuming producers or green plants. Insects, rabbits, cow, goat, etc., are some of the common herbivores in the terrestrial ecosystem. Small crustaceans, snails and fishes, etc., are herbivores in the aquatic habitat.

(b) *Secondary Consumers:* They are commonly called carnivores or flesh eating animals. They derive their nutrition indirectly from producers by consuming herbivores (directly get nutrition from producers). The examples are crow, fox, frogs, cats, snakes, etc.

Omnivores are animals that are both herbivores and carnivores i.e. they consume plants as well as animals. For example, termites, human etc.

(c) *Tertiary Consumers:* These are the top consumers which prey upon carnivores, omnivores and herbivores. Lions, tigers, shark, eagle, etc., are considered tertiary consumers.

Fig. 2.9. Primary Consumers

3. Decomposers or Saprotrophs: They are micro-organisms mostly bacteria, fungi, protozoa etc. Instead of ingesting food as done by the heterotrophs, they release enzymes into the dead organic matter and then absorb some of the degraded product. Decomposers attack the dead remains of producers and consumers and degrade the complex organic substances into simpler compounds. They utilise the organic matter, derive energy and release inorganic substances for recycling. These inorganic substances are reused by producers for the process of photosynthesis.

Recycling of nutrients in the ecosystem through the process of mineralisation of dead organic materials is the most important role of decomposers. Mineralisation is the conversion of dead organic matter into simple forms of nutrients that can be used again by producers. Apart from processing and removing organic wastes, decomposers regenerate ecosystem fertility by releasing nutrients that were locked up in the organic matter.

Factors Affecting Decomposition

The rate of decomposition is regulated by the climatic factors like temperature and soil moisture as well as by the chemical quality of detritus (dead matter). These factors limit the rate of decomposition through their regulatory effect on the activities of soil microbes.

(a) Temperature and Soil Moisture: Organic waste matter decomposes rapidly at high temperatures (<25°C) and moist conditions of

Fig. 2.10. A Carnivore

humid tropical regions. Within a few weeks or months, complete decomposition occurs. However, low temperature (>10°C) sharply reduces decomposition rate even if moisture content of the soil is high.

(b) Chemical Quality of Detritus: The chemical quality of detritus is determined by the relative proportions of water-soluble substances like sugars, polyphenols, lignin and nitrogen. Within the same climatic conditions decomposition rate is high when detritus is rich in nitrogen and has low amounts of lignin. High quantities of lignin and chitin lower the rate of decomposition.

INTERACTION BETWEEN LIVING BEINGS

No organism can survive as an individual, independent of all other living beings. Vital processes, such as growth, nutrition and reproduction depend on the interactions between the individuals of the same species (*intraspecific interaction*) or between those of different species (*interspecific interaction*).

Plants have interactions with animals and other plants. Animals interact with plants and other animals. For example, pollination, seeds and fruit disposal, grazing, parasitism are common examples of such interactions. Thus, in an ecosystem, there exist organisms of different species. The presence of different species is important for getting food, shelter and other necessities. The relationship between species may be beneficial to both, harmful to both or beneficial or harmful to one and neutral for the other.

These interactions can be broadly classified as:

(i) Positive Interactions; and

(ii) Negative Interactions

POSITIVE INTERACTIONS

These interactions are beneficial to both parties and are not harmful to any one species. These include the following:

1. Mutualism: Both species are mutually benefited. It is of different types:

(a) Lichens: These are examples of mutualism where contact is close and permanent as well as obligatory. It is the relationship between algae and fungus. The algae is embedded within the fungus. The algae produces food photosynthetically. Algae depends upon the fungus for water and protection, and in turn provides food to the fungus.

(b) Symbiosis: The best example of symbiosis is shown by nitrogen fixing rhizobium bacteria

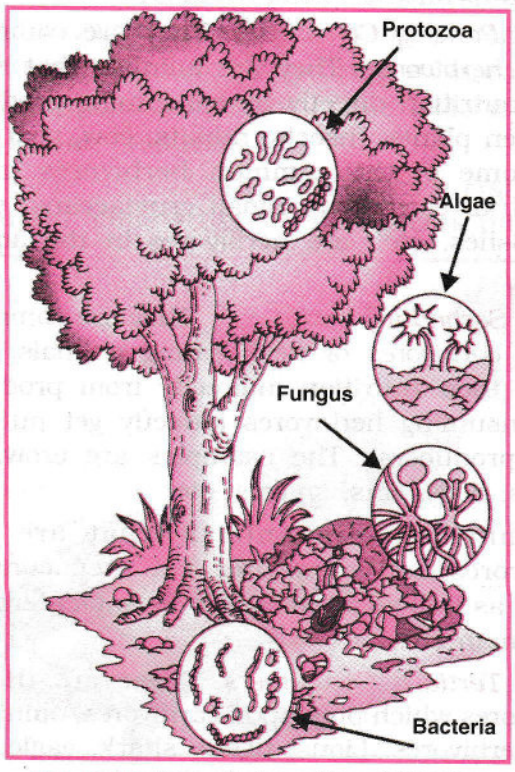


Fig. 2.11. Chemical quality of detritus

that forms nodules in the roots of leguminous plants. The bacteria receives carbohydrates and other substances from the juices of the host (leguminous plant), while plant gets the nitrogen fixed by the bacteria.

(c) Mutualism between Plants and Animals: It is exhibited by unicellular green algae (Zoochlorellae) and brown or yellow algae (Zooxanthellae) that are found in the outer tissues of some sponges, molluscs and worms. The algae release oxygen (during photosynthesis) and produce nitrogen compounds, which are important to the host as food. The algae get a regular supply of raw materials.

Some unicellular micro-organisms that live in the gut of cockroaches and termites digest wood. Some bacteria living in the intestines of animals produce various types of Vitamin B and other materials in return for nutrition.

(d) Dispersal of seeds of fruits: Seeds of many plants are distributed by animals. The fruits are consumed as food by birds, bats and other mammals and the seeds contained in the fruits are dropped in the excretement far from the parent plant.

(e) Removal of Parasites: Parasites are removed from backs of grazing animals by birds (cowbirds, oxpecker). Birds enter the mouth of crocodiles to remove leeches from the latter's teeth.

2. Proto-cooperation or Non-obligatory Mutualism: This is a type of mutualism, where the contact between two species is for a short period. The association is beneficial to both parties but is not essential for their survival. For example, sea anemone attaches itself to the shell of hermit crab to travel to new feeding areas and in turn protects the crab from predators.

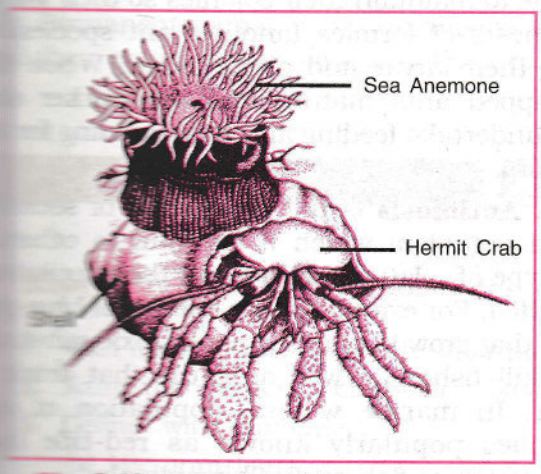


Fig. 2.12. Example of Proto-cooperation

Pollination of flowers is helped by bees, moths, butterflies, humming birds, etc.

3. Commensalism refers to the association of different species in which only one of the organisms is benefited, but the other organism is not benefited, or adversely affected under normal conditions:

(*a*) Commensalism with continuous contact wherein the commensals (the guest organism) are in permanent contact with their hosts. For example epiphytes, the plants that grow perched on other plants or trees. The epiphytes are not rooted into the soil. They use trees to get sunlight as well as support but they produce their own food through photosynthesis and don't depend on the host for nourishment. Many micro-organisms are found in the gut of animals, which consume the undigested food and secretions, e.g., E.coli bacteria found in human colon. Another example is epiphytic green algae that grows on the long grooved hair of the sloth (tree-living South American mammal). Abundance of algae gives green colour to the host which is advantageous to the sloth in concealing itself on the trees.

(*b*) Commensalism also exists without continuous contact. For example, suckerfish attaches itself to the underside of sharks and feeds on fragments of residuals from the shark's meal. Certain fish find shelter under the umbrella of jellyfish. Squirrels, monkeys, tree frogs, snakes, birds and some insects use trees or other plants for substratum, shelter or breeding sites.

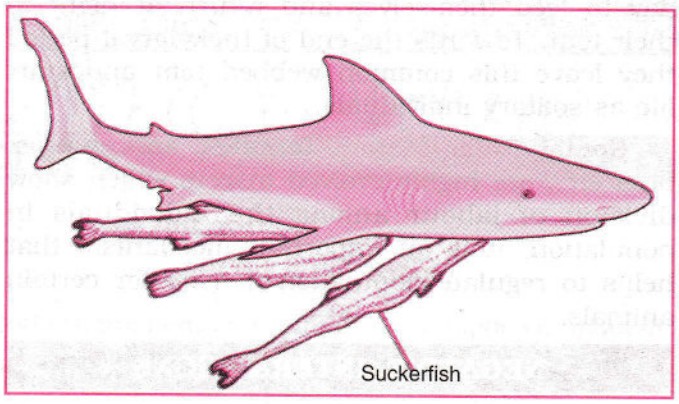


Fig. 2.13. Suckerfish Attached to a Shark (Commensalism without continuous contact)

Fig. 2.14. Colonisation

Fig. 2.15. Aggregation

Intraspecific Interactions

Colonisation: Colonial life, exhibited by animals, demonstrates shades of mutualism and commensalism because they give protection to one another from enemies and adverse temperature conditions and other environmental factors. Colonisation results in collective efforts in gathering food and greater chance of fertilisation during reproductive phase. Parental care is found in female earwig, male stickleback, many of the amphibians, reptiles, birds and mammals.

Aggregation: It refers to concentration of animals in numbers larger than found in normal distribution. Aggregation of animals is advantageous due to its group survival value. It may be permanent or temporary. Permanent aggregation is found in termites, ants, etc. Social life exhibited by some tent caterpillars (malacosoma) is an example of temporary aggregation. The larvae make webbed tent in the fork of a tree. These larvae leave the tent in the day to feed themselves and return at night to their tent. Towards the end of their larval period they leave this common webbed tent and start life as solitary individuals.

Social Organisation: Termites, ants, wasps, bees etc., are highly evolved insects which show division of labour among the individuals in population. It is an important mechanism that helps to regulate population density for certain animals.

NEGATIVE INTERACTIONS

1. Competition is the phenomenon wherein the association of two or more species, each species is adversely affected by the presence of the other species in respect of food, shelter, space, light, etc. Competition is of two types, namely:

Interspecific: Competition between different species of group of organism for same feature of the ecosystem (e.g., nutrition) which is in short supply. For example carnivores (lion, tiger) feeding on herbivores (deer, sheep etc), fishes eating zooplankton.

Intraspecific: Competition between organisms of the same species, e.g., large fishes feed on small fishes.

2. Predation is an association between two species, where one species (predator) kills to feed on the second (prey). Predation maintains population balance in an ecosystem. (For details refer to Chapter 3.)

3. Exploitation is the relationship in which one organism is benefited by the direct utilisation of another. This is best exhibited by the enslavement of one species of ant by another. Polyergus is a species of slave-making ants. These ants are unable to maintain their colonies so their workers raid nests of formica (another ant species) and bring their larvae and pupae home. When these kidnapped ants mature into the worker stage, they undertake feeding and nest building for their masters.

4. Antibiosis is the production of secretions by an organism which is harmful to others. In this type of relationship none of the population is benefited. For example some species of blue-green algae that grow in ponds produce toxic substances that kill fishes as well as cattle that drink the water. In marine waters, population of some microbes popularly known as red-tide cause destruction of fish and other animals.

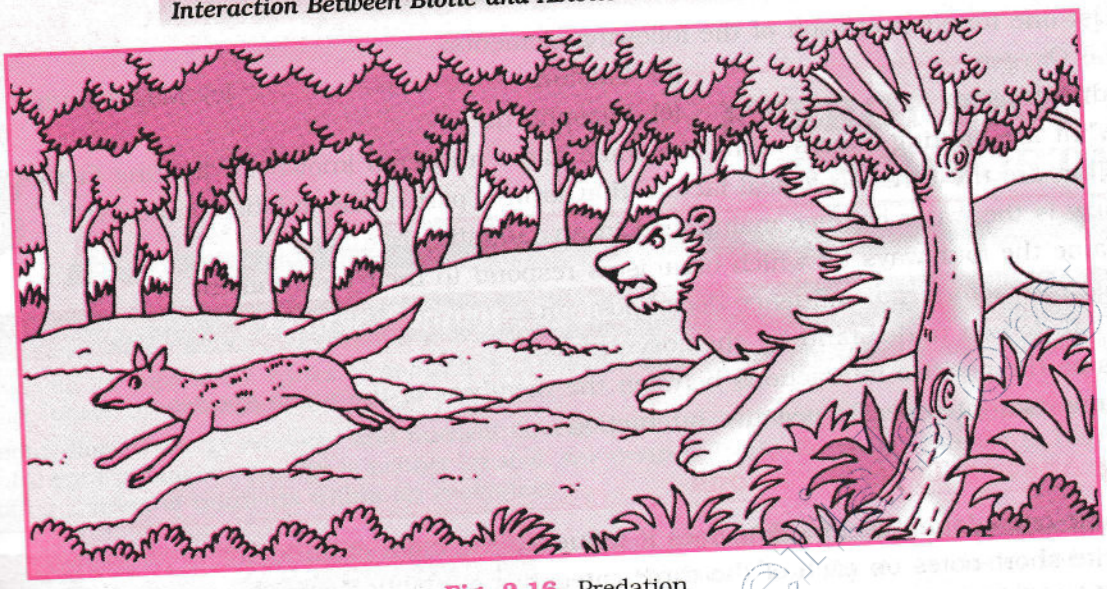


Fig. 2.16. Predation

5. Parasitism: A parasite is an organism which derives nourishment from the tissues of another large organism (called host) on or in which it lives. Parasitism is an interaction between a parasite and a host in which the former obtains benefits at the cost of the latter.

The parasite modifies itself morphologically, anatomically and physiologically to suit the conditions of the host. The parasites are of two types:

(a) Partial or temporary parasites are organisms which spend only a part of their life cycle within host. For example, Glochidium larva of mollusc has hooks over its shell to attach itself on gill filaments, fins or the tail of fishes. It remains in that condition for several weeks and then it emerges as a young one to lead life independent of the fish.

(b) Permanent parasites are organisms which spend their entire life as parasites. For example, tapeworm, hookworm, etc., which, once attached, remain with the host for the rest of the life cycle. Other examples are fleas, lice, ticks, plasmodium (malarial parasite), etc.

INTERACTIONS IN BIOTIC COMMUNITY

Positive	Negative
• Mutualism • Proto-cooperation • Commensalism • Colonisation	• Competition • Predation • Parasitism • Antibiosis

Parasitism	Predation
• Parasite does not cause death to the host. • The weak feeds on the strong.	• Predator kills the prey. • The strong feeds on the weak.

MPCC) (PPA)

EXERCISES

A. Short Answer Type Questions

1. With the help of an example show how the abiotic component can influence the biotic component.
2. Name the categories of abiotic components in a forest ecosystem.
3. Define with examples :
   (a) Micronutrients
   (b) Macronutrients.

CHAPTER 3

ENERGY FLOW AND ITS IMPORTANCE

Course Content—Syllabus and Scope

Energy flow and its importance, cycles of nutrients in terrestrial and aquatic (fresh water and marine) ecosystems, nature's mechanism in maintaining balance.

Understanding flow of energy as linear and nutrient flow as cyclic. Flow of energy to be explained by linking with the laws of thermodynamics—'Energy is neither created, nor destroyed' and 'No energy transfer is 100% efficient'. Concept of circulation of nutrients within an ecosystem.

INTRODUCTION

Energy is the ability to do work. When work is done, energy is used, or converted from one form to another. Living things get their energy from food, it is called *chemical energy*.

Some machines get their energy in chemical form from fuels such as petrol or gas. There are other forms of energy such as heat, light, sound, nuclear and electrical energy.

The earth gets huge amounts of energy from the sun. The sun is an important *non-polluting* and *renewable* source of energy. Green plants make their own food in the presence of sunlight by a process called *photosynthesis*.

During this process plants collect energy from sunlight. They use this energy to turn water and carbon dioxide into a simple sugar called glucose. Plants use glucose to make starch and cellulose. Plants are also known as the producers.

The various functions performed by the structural components of an ecosystem ensure that the ecosystem persists. By functions we mean the various activities undertaken to ensure existence of the ecosystem. For example, roots of plants perform the function of absorbing nutrients from the soil and green leaves function as sites of food production. Herbivores consume some part of the plant food production. On their part, they too serve as food for carnivores. Decomposers recycle materials by breaking down complex organic materials into simpler inorganic products, which can be reused by the producers. Inorganic products are absorbed as nutrients by plants. Thus the cycle goes on in the universe.

The various functions in the ecosystem are carried out through balanced and controlled processes through photosynthesis; the process of consumption is carried out by eating and being eaten, and the process of decomposition.

The core functions of the ecosystem are:

(i) *Production*: It is the conversion of solar energy into bound chemical energy or potential energy.

(ii) *Consumption*: It is the transfer of bound chemical energy and material through the process of eating and being eaten.

(iii) *Decomposition*: It is the breaking down of organic matter to recycle the material to release nutrients and energy in the form of heat.

The main functional aspects of the ecosystem are:

(i) Energy flow;

(ii) Cycle of nutrients.

The overall reaction of Photosynthesis may be represented as:

$$6CO_2 + 6H_2O + \text{Light energy} \longrightarrow C_6H_{12}O_6 + 6O_2$$

CO_2 from Atmosphere; Water from Soil; Sugar in plant cell; Oxygen released in the Atmosphere

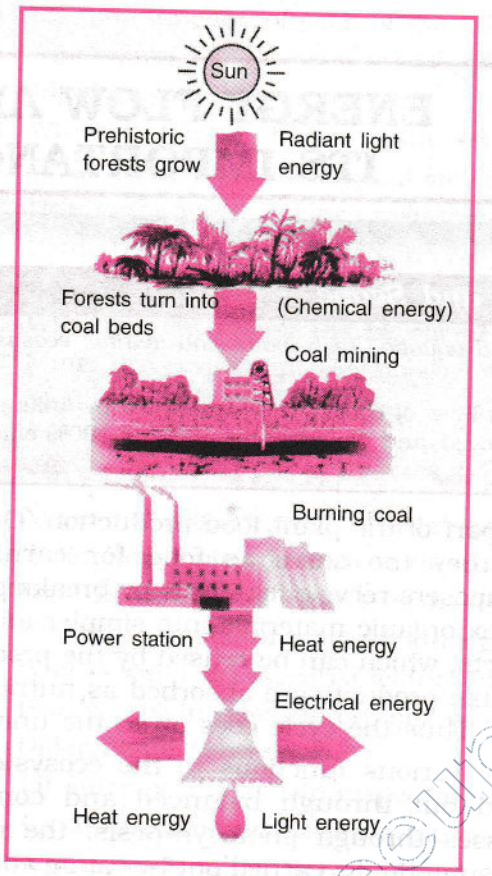


Fig. 3.1. Energy Flow Chart

ENERGY FLOW AND ITS IMPORTANCE

Energy is the capacity to do work. The sun is the source of all energy; so the energy that sustains living systems on the earth is the solar energy. Only a small fraction of the energy in the form of sun's radiation is trapped. The solar energy is turned into chemical or potential energy by green plants through photosynthesis. The total amount of solar energy as well as the pattern of flow of this energy limits the total amount of life on the earth. The energy once fixed does not circulate endlessly through the ecosystem. Some energy may pass through the ecosystem more than once before it is totally dissipated.

Photosynthesis traps solar energy to give carbohydrate such as sugar (glucose). The sugar is used in several ways:

1. It can be stored by being converted to a relatively inert energy-rich organic substance such as starch.
2. It can form specialised carbohydrates (like cellulose) by combining with other sugar molecules. These specialised carbohydrates are used by the plants for different purposes like support.
3. It can be combined with substances such as nitrogen, phosphorus and sulphur, to build complex molecules like proteins, nucleic acids, pigments and hormones.

All energy that is required by living organisms is provided by oxidation of sugar or any other organic molecule through a process called *respiration*. The energy released by respiration is lost permanently to the ecosystem.

Thus, ecosystems function with energy flowing in one direction from the sun, and through nutrients, which are continuously recycled. Solar energy is used by plants, which by the process of photosynthesis, convert it to chemical energy in the form of carbohydrates and other carbon compounds. This energy is then transferred through the ecosystem by a series of steps that involve eating and being eaten.

UNIDIRECTIONAL FLOW OF ENERGY

Producers obtain energy from the sun, which once trapped by chlorophyll, cannot retrace its path back to the sun.

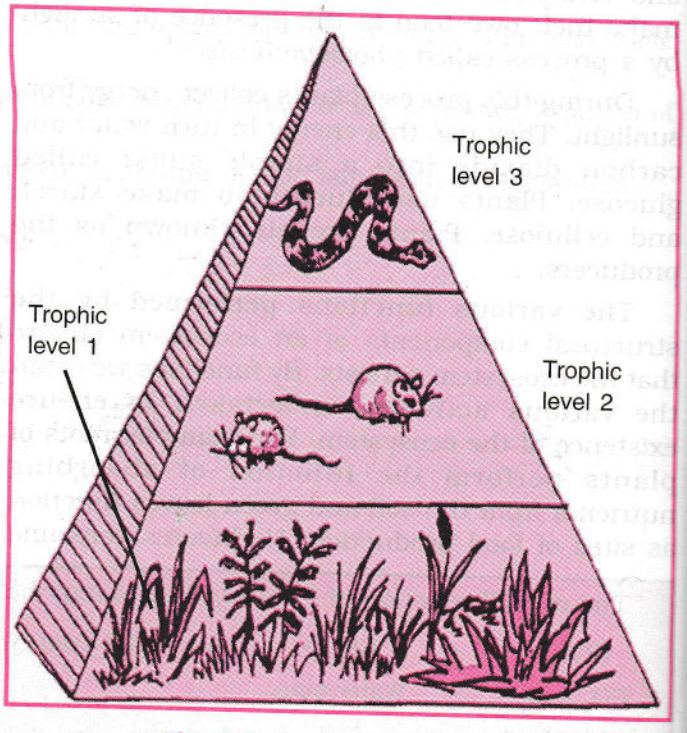


Fig. 3.2. A pyramid of energy

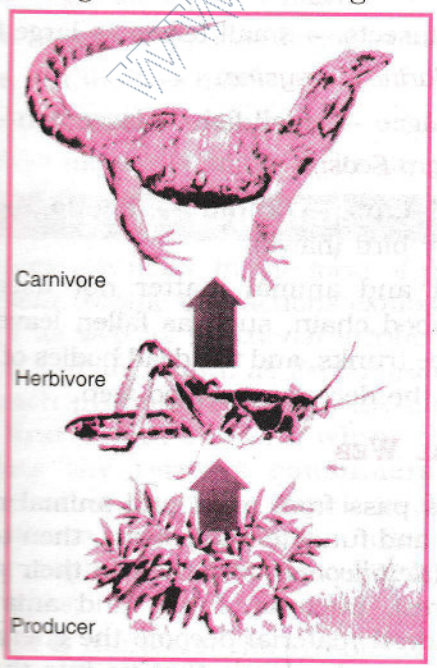
Two basic laws of thermodynamics determine the energy flow in the ecosystem.

1. **First Law of Thermodynamics:** Energy is neither created nor destroyed, but can be transferred from one component to another, or transformed from one state to another. Energy for an ecosystem comes from the sun. It is absorbed by plants, wherein it is converted to stored chemical energy.
2. **Second Law of Thermodynamics:** This law states that whenever energy is transformed, there is a loss of energy through the release of heat. It happens when energy is transferred between trophic levels and results in loss of energy in the form of heat as it moves from producers to consumers. The transfer of food energy from one organism to another loses a major portion of food energy as heat due to metabolic activities. Only a small portion is stored in living tissues or biomass.

FOOD CHAIN

We have studied that the food prepared by green plants through photosynthesis is consumed by consumers (herbivores and carnivores). Finally, all consumers are decomposed by decomposers in nature.

The transfer of food energy from its source in plants through a series of organisms with



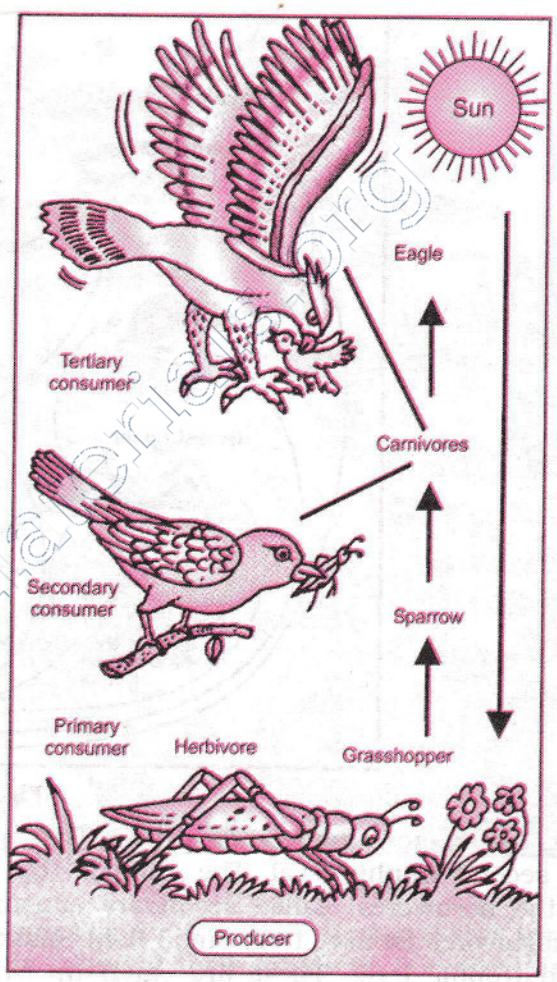


Fig. 3.4. Flow of Energy in a Food Chain

repeated eating and being eaten is referred to as a *food chain*. At each transfer a lot of energy (80-90 %) from food is lost as heat. Thus, each trophic level contains less energy than the preceeding level. For example, deer (herbivores) are more abundant than tigers (carnivores). Therefore, the number of steps in any food chain is limited to four or five. The nearer the organism is to the beginning of the food chain, the greater is the available energy. A simple generalised food chain may be presented as

producers ⟶ herbivores ⟶ carnivores.

The successive levels of energy flow constituting the links of the food chain are called *trophic levels*.

The green plants (autotrophs or the producers) constitute the first tropic level. They trap the solar energy through photosynthesis and transfer it to consumers through food. Herbivores make

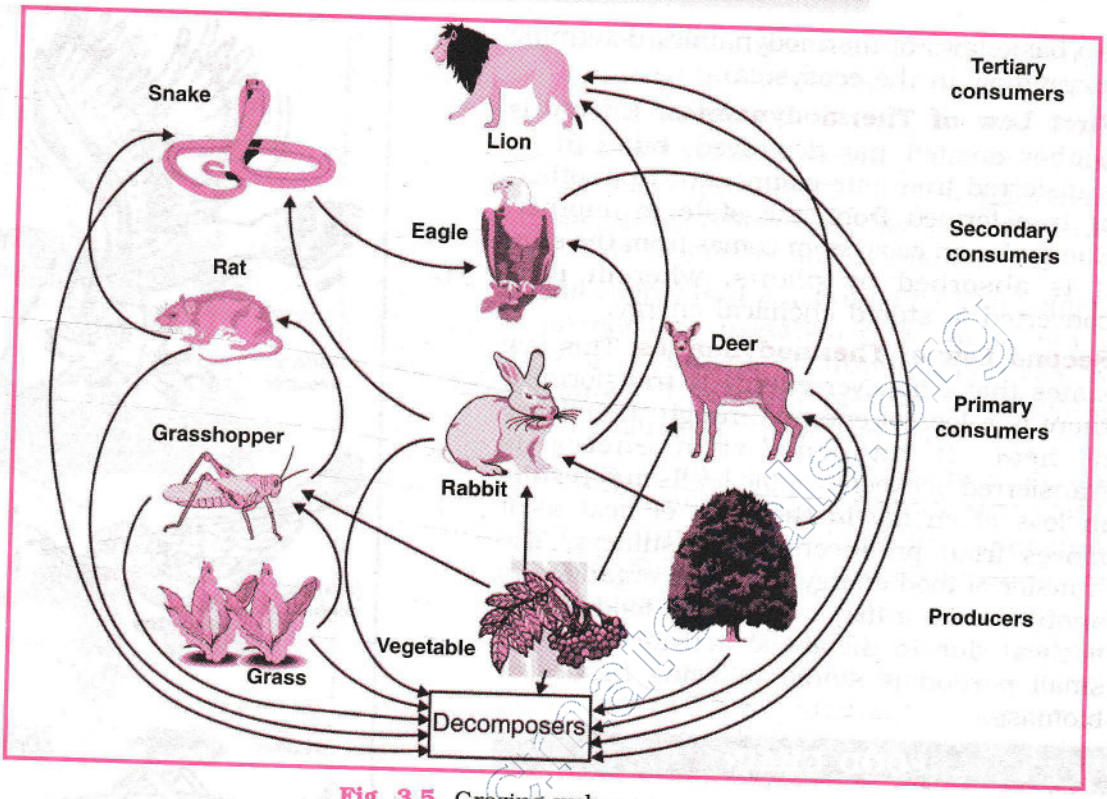


Fig. 3.5. Grazing web

deer, cattle, etc.) who feed on plants. They are at the second trophic level. The animals that feed on the herbivores, called secondary consumers or carnivores (snake, frog, small fish), make the third trophic level. These are eaten up by still larger carnivores, tertiary consumers, (hawk, lion or tiger), which make the fourth trophic level.

There exists inter-relationship among different organisms and they are linked through different food chains. In nature, simple food chains rarely occur. An organism may be the food i.e., may operate in different food chains of several other organisms or may operate at more than one trophic level. Thus, in a given ecosystem various food chains are linked together and form a complex network called *food web* by which energy and materials circulate within an ecosystem. In nature, real food webs have hundreds of species interlinked by their feeding habits. The food chain is divided into two broad categories.

Grazing Web

(a) *Marsh Community*

Green plants → butterfly → dragonfly → frog → snake → hawk.

(b) *Forest Community*

Green plants → ungulates → tigers.

(c) *Grassland Ecosystem*

Grasses → grasshopper → frog → snake → hawk.

(d) *Pond Ecosystem*

Aquatic insects → small fishes → large fishes.

(e) *Marine Ecosystem*

Marine algae → small fish → large fish → shark.

(f) *Agro Ecosystem*

Mustard crop → aphid → beetle → bird → predatory bird (hawk).

Plant and animal matter not used in the grazing food chain, such as fallen leaves, twigs, roots, tree trunks, and the dead bodies of animals, support the decomposer food web.

Detrital Web

Materials pass from plant and animal matter to bacteria and fungi (*decomposers*), then to detrital feeders (*detritivores*), and then to their predators (*carnivores*). Bacteria, fungi, and animals that feed on dead material become the energy source for higher trophic levels that tie into the grazing

food web. In this way nature makes maximum use of energy originally fixed by plants. For example:

Mangrove leaves → detritus (by micro-organism) → crabs and shrimps → small fishes → large fishes.

There also exists a parasitic food chain which goes from large organisms to smaller ones without outright killing as in the case of predator.

Plant → man → entamoeba.

Generally, many interconnections exist in food webs. For example, the fungi that decompose matter in a detrital web may sprout mushrooms that are consumed by squirrels and mice, in a grazing web. Crows are omnivores, that is, consumers of both plants and animals, and thus are in both detrital and grazing webs. Crows typically feed on earthworms, which are detritivores that feed upon decaying leaves.

Various food chains are interlinked together in the form of a food web. The food web stands for many pathways of energy flow, as shown below:

Energy flow, for example, in the path are: grass is eaten by the grasshopper which is eaten by the lizard, which is eaten by the hawk, etc. The various food chains in the food web are given as under:

Grass → grasshopper → hawk

Grass → grasshopper → lizard → hawk

Grass → rabbit → hawk

Grass → mouse → hawk

Grass → mouse → snake → hawk.

FOOD PYRAMIDS

Food Chains are made in the form of pyramids. They present trophic interactions exhibiting both structural as well as functional attributes of an ecosystem and are known as *Food Pyramids*. The base of each pyramid represents the autotrophs or the first trophic level, while the apex represents the tertiary consumers or top carnivores; other consumer trophic levels occupy their positions in a hierarchic order of their respective trophic levels. Ecological Pyramids are of three types:

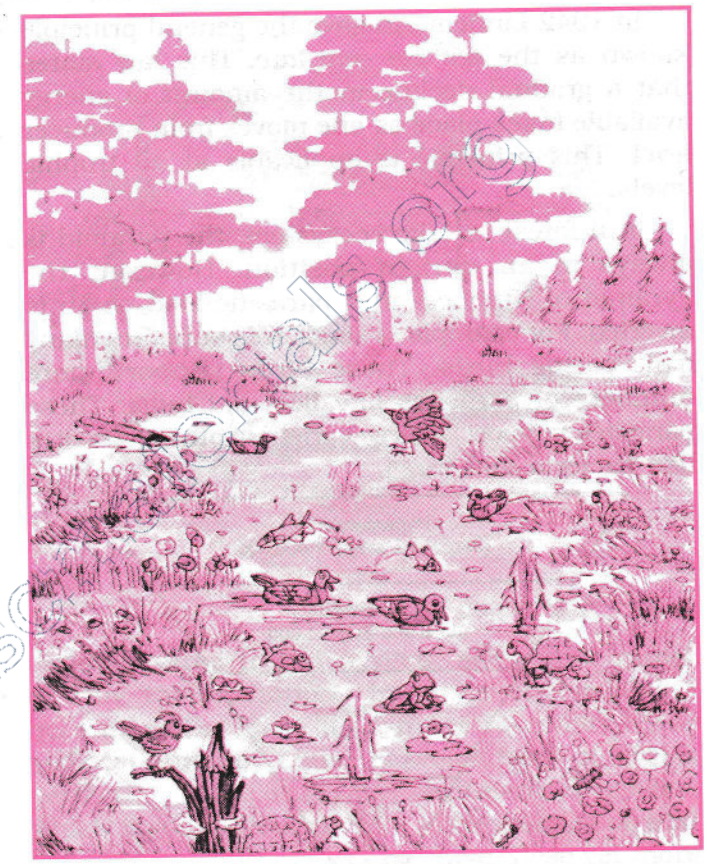
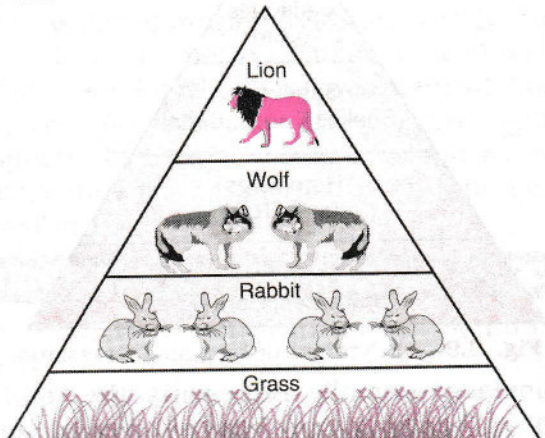


Fig. 3.6. A pond ecosystem

herbivores and carnivores at successive trophic level in terms of their numbers. For example, in a grassland, the producers are grasses which are maximum in number. This number decreases towards the higher trophic levels. The herbivores (rabbits) are lesser than grasses: the secondary consumers (wolves) are lesser than the deer and finally the tertiary consumers (lions) are still lesser than the wolves.



In 1942 Lindemann gave the general principle known as the *ten per cent law*. This law states that a gradual decline in the amount of energy available takes place as one moves from producer level. This principle is applicable at all trophic levels.

In a forest or lake ecosystem, the pyramid is always in an upright position. However, the Pyramid of Numbers in a parasitic food chain is inverted. For example, a single tree supports many fruit eating birds. These birds support more numbers of parasites like lice and bugs. These parasites support a large variety of other parasites like bacteria and fungi.

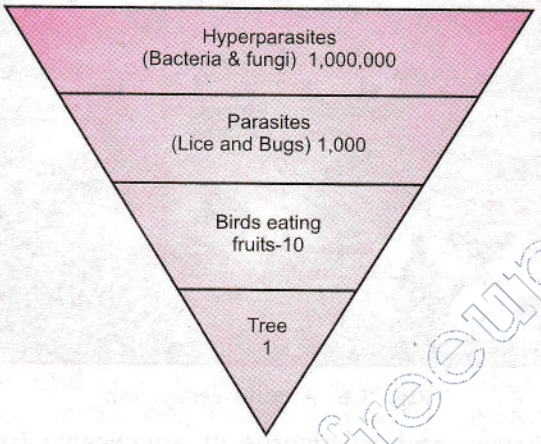


Fig. 3.8. Inverted pyramid of numbers in a parasitic food chain

2. Pyramid of Biomass: Pyramid of Biomass is the one in which the total dry weight, colour value or other measure of living material are depicted.

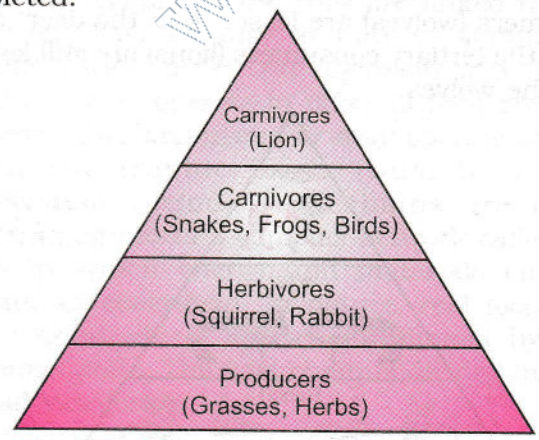


Fig. 3.9. (a) Pyramid of biomass (Grassland)

Biomass normally represents the total dry weight of the living organisms of different species constituting each trophic level at a particular time.

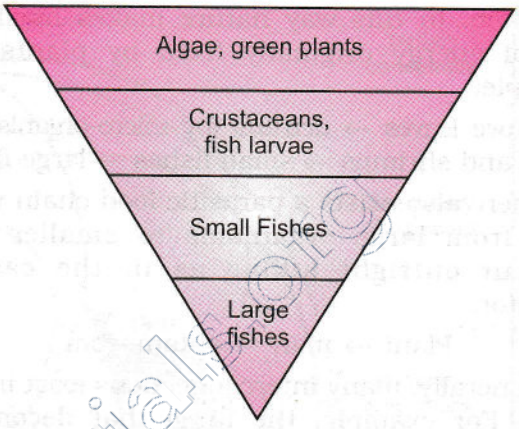


Fig. 3.9. (b) Pyramid of biomass in a pond

The biomass of the sample is known as standing crop or standing biomass. In many ecosystems, such as in forests, the biomass of producers is much greater than that of the herbivores, which in turn outweigh the carnivores and so on. Thus, we experience a gradual decline in the biomass of organisms at each hierarchic trophic level. These pyramids are in upright position. However, in a pond ecosystem, producers are small organisms, so their biomass is also less. But the primary and secondary consumers are bigger, so their biomass is more. Therefore, the value of biomass shows gradual increase, making it an inverted pyramid.

3. Pyramid of Energy: Pyramid of Energy is the one in which the energy flow of an ecosystem is depicted. It represents the number of calories

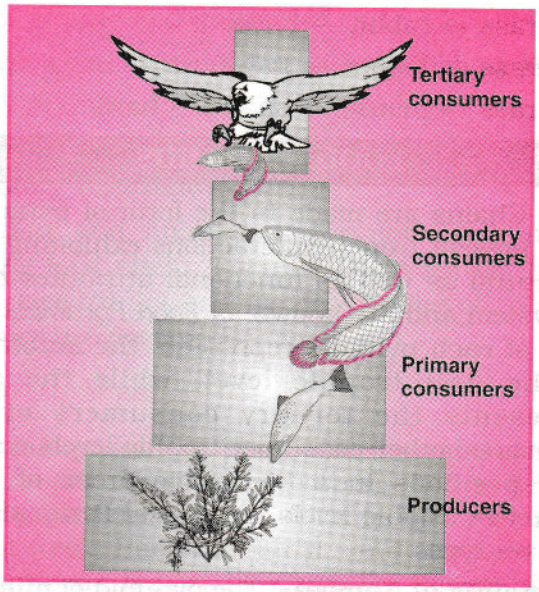


Fig. 3.10. Pyramid of energy

transferred from one trophic level to the next. Generally it is about 10-15% efficient from herbivores to carnivores.

The trophic level at the base denotes the position of the highest amount of energy whereas the amount of energy at the trophic level situated at the apex is the lowest at pyramid of energy.

CYCLES OF NUTRIENTS

The cyclic flow of nutrients between non-living environment (soil, rocks, air, water) and living organisms is known as *biogeochemical cycle*. Such movement of elements and inorganic compounds essential for life are called mineral or nutrient cycles. Out of more than 100 elements known, about 40 are present in living organisms. The major nutrient elements, are carbon, hydrogen, oxygen and nitrogen, which forms about 95% mass of the living organisms. They are cycled again and again between living and non-living components of the ecosystem.

We have already learnt that energy flows through ecosystems enabling the organisms to perform their vital activities and ultimately is lost as heat, being no longer available for utilisation. Nutrient materials, in contrast, never get used up, but are cycled and recycled repeatedly for an indefinite period of time. Thus, nutrient cycles are perfect. However, energy transfer is not so because there is a loss of some energy at every trophic level but there is no such loss of nutrients. The mineral nutrients move from the non-living to living and then back to the non-living components of the ecosystem in a circular manner. Roots of the plants absorb nutrients from soil and green leaves produce food to form complex organic compounds. Animals consume this directly or indirectly. When the dead animal body or plant is subjected to decomposition by decomposers, the nutrients are released to the environment. There they are again available for reuse and for recycling.

The functioning of nutrient cycles depends on the flow of energy. The energy moves from one trophic level to another in the food chains along with matter containing minerals and tend to circulate after the death and decomposition of organisms. However, the energy is lost as heat into the environment.

Some nutrient cycles, such as those involving

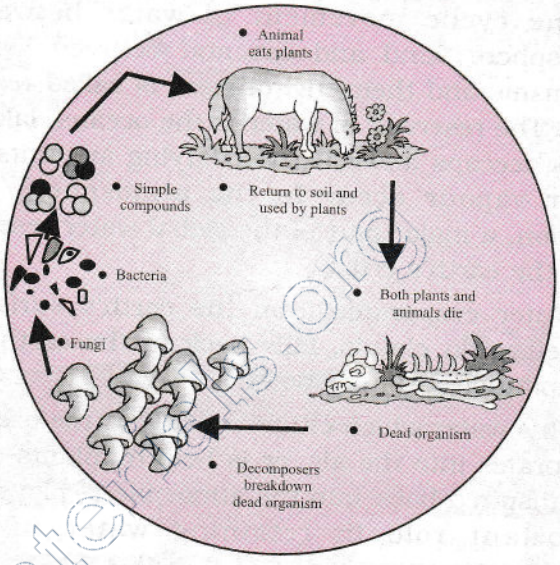


Fig. 3.11. Cyclic flow of nutrients

carbon, nitrogen and oxygen, self-adjust rather quickly to fluctuations in terms of availability because of the large atmosphere reservoir. These self-adjustments make gaseous type of cycles perfect. On the contrary, sedimentary cycles, which involve elements like phosphorous or iron are often called imperfect because these get more easily disrupted by local fluctuations because most of the material is in a relatively inactive and immobile reservoir in the earth's crust.

A given element may exist in combination with other elements forming different compounds and organisms may not be able to derive the essential nutrients from all these compounds. For example plants are incapable of utilizing nitrogen unless it is available in the form soluble nitrates (NO_3^-) or ammonium (NH_4^+) salts.

The cycling of nutrients is often closely related to the flow of energy. These characteristic pathways are known as *Biogeochemical Cycles*. The term *Bio* indicates living, *geo* signifies lithosphere, hydrosphere and atmosphere, while *chemical* means the elements and processes involved in these cycles.

HYDROLOGICAL CYCLE OR WATER CYCLE

Water (H_2O) is the most important non-organic component of an ecosystem. It constitutes more than 90% of the protoplasm. Moreover, it is directly involved in photosynthesis as one of the two chemical participants, the other being carbon dioxide.

The cyclic movement of water between tmosphere, land and sea and between living rganisms and their environment is called *water ycle*. The reservoir of water is the oceans, lakes, vers, icecaps and glaciers. Varying amounts of ater vapour occur in the atmosphere. In ddition, a major part of the global water reserve in the earth's crust.

Water evaporates from the earth's surface, ndenses in clouds, falls back to the earth as ecipitation (rain or snow).

This water which either runs off to the ocean, aporates into the air, or is held by plants and transpired back into the atmosphere, plays an nportant role in retaining water in an osystem.

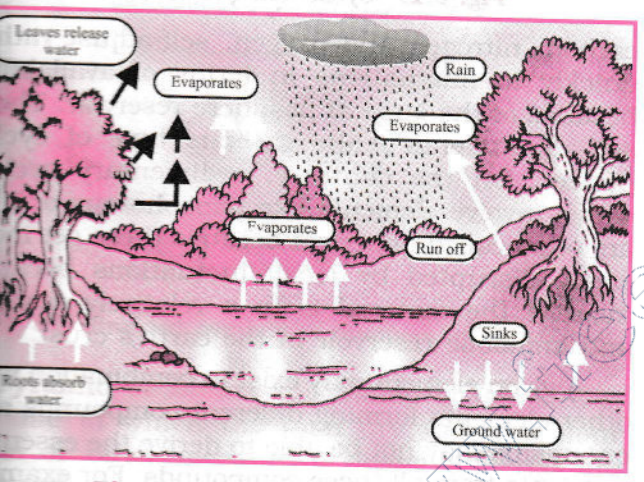


Fig. 3.12. Water cycle in a forest

Transition of water through the ecosystem stly occurs by the physical process such as poration, transpiration and precipitation. Most he rain water goes back to the ocean through rs and streams. Some of the rain water also evaporated back to the atmosphere and some trates into the soil. The plants return a part the water absorbed by them through nspiration. The water consumed by animals is rned to the atmosphere through respiration. s, there is a continuous cycling of water in ecosystem.

CARBON CYCLE

bon is the most significant element as it is building block of all organic molecules. Carbon

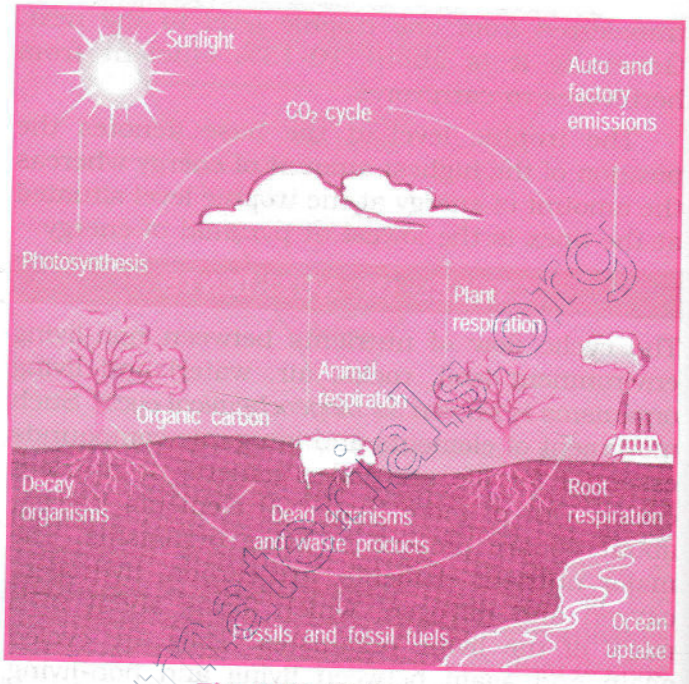


Fig. 3.13. Carbon cycle

Cycle is based on the creation and absorption of CO_2 (carbon dioxide).

The major reservoir of carbon is the atmosphere where it exist, as carbon dioxide (CO_2). Apart from this, huge reserves of carbon occur as carbonate rocks and fossil fuels, though these are not accessible to plants and animals. Soils and land vegetation constitute sub-units of terrestrial components and are often considered separately when accounting for global carbon flux. The carbon cycle depends both on the relative amounts of carbon present in each pool and on the rates of flux among these pools.

The carbon cycle functions in the following manner:

(i) Green plants manufacture their own food in the presence of sunlight and chlorophyll and CO_2 from the air and water is absorbed by the roots. During this process CO_2 is fixed as starch by plants.

(ii) From the plants, carbon moves along the food chain through consumers at different trophic levels. After the death of plants and animals, the carbon present in their bodies is decomposed and absorbed as food by saprophytic bacteria and fungi.

(iii) When plants die and get buried in the soil, they undergo slow degradation and

compaction. This results in the formation of coal and oil containing huge amounts of carbon. The carbon content in animal parts like shells also undergo compaction and lead to the formation of rocks containing carbonates.

(iv) Carbon dioxide is released into the atmosphere through oxidation by various groups of bacteria and fungi.

(v) During respiration, plants, animals and humans, use atmospheric oxygen and release carbon dioxide back into the atmosphere.

(vi) The burning of carbon containing fuels also results in the release of CO_2 in the atmosphere.

Thus, carbon from CO_2 taken by green plants from the environment through photosynthesis is returned to the environment through respiration, decomposition and through burning of fuels. This cyclic movement of carbon from the atmosphere to the organisms and from organisms to the atmosphere is known as *carbon cycle*. The carbon cycle helps in maintaining carbon balance in nature.

CO_2 In Aquatic Ecosystems

Atmospheric air contains 0.03 percent of CO_2, but in water CO_2 concentration is much higher than that of O_2 because CO_2 is much more soluble in water than O_2. In aquatic medium CO_2 can exist in free state as dissolved CO_2 or in combination with calcium in the form of bicarbonates and carbonates.

The whole aquatic system operates in a balanced way and maintains the CO_2 content of air at a steady state. If there is an increase of CO_2 content of air, more CO_2 dissolves in water forming bicarbonates and carbonates; on the other hand, if there is a decrease in the atmospheric CO_2 level the reverse reaction ensues so that the level of CO_2 in air is restored. Materials that are deposited in the sediment, however, returns to the system slowly through geological processes and weathering of limestone.

NITROGEN CYCLE

Nitrogen, the living blocks of all living cells, is one of the core components of proteins. It is also an essential component of the enzymes that regulate the reactions of carbon and other

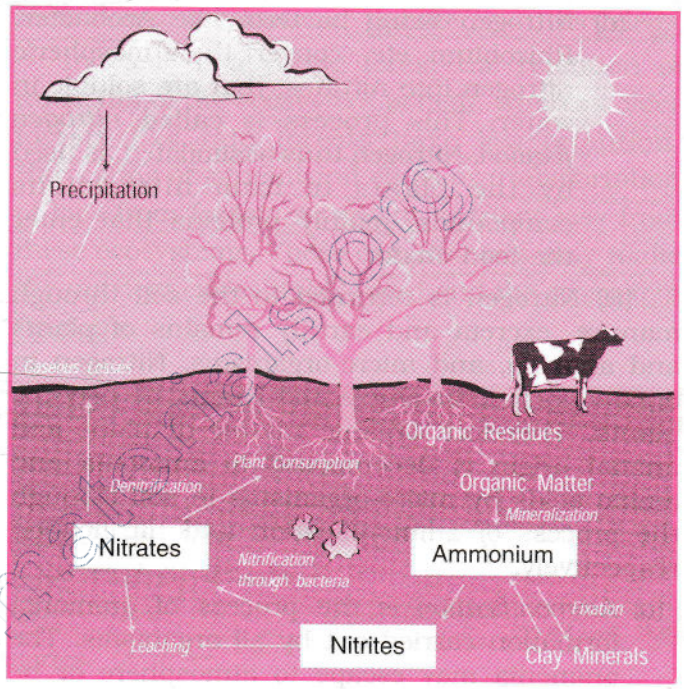


Fig. 3.14. Nitrogen cycle

elements in organisms. Thus, nitrogen plays an important role in the biochemical process that takes place in living beings. It limits the rate of production in ecosystems.

Atmosphere is the largest reservoir (78% approximately) of free nitrogen. The nitrogen in this form cannot be used by the living systems. It has to be converted into nitrates through a process known as nitrogen fixation and then it is available for use by plants.

(i) Plants take nitrogen in the form of nitrates from the soil and animals obtain nitrogen by eating plants or animals which eat plants.

(ii) The atmospheric nitrogen enters the soil in the following ways:

(a) Nitrogen and oxygen in the air combine to form nitric oxide. This nitric oxide is then converted into nitrogen dioxide by the oxygen of the atmosphere.

(b) Nitrogen oxide along with oxygen dissolves in rain water forming nitric acid. $O_2 + 4NO_2 + 2H_2O \rightarrow 4HNO_3$

(c) Nitric acid is washed down by rain water into the soil. In the soil, this nitric acid reacts with minerals like calcium carbonate to form calcium nitrate and is absorbed by the roots of the plants.

(d) Nitrogen fixing bacteria like Azobacter, Rhizobium, etc., convert the atmospheric nitrogen into nitrates, that are soluble in water. This process is called *nitrogen fixation*. Nitrogen thus assimilated, is used by the plants to form nitrogenous compounds, mainly proteins that enter the food chain.

(*iii*) Nitrogen is returned to the soil through manure, excreta and earthly remains of plants and animals, and micro-organisms. Nitrogen in organic form is insoluble and cannot be used by plants. Therefore organic matter of plant and animal origin is decomposed to ammonia and amino acids by micro-organisms in soil through the process of ammonification and nitrification respectively.

(*a*) *Ammonification* is the process of ammonia formation carried out by all organisms. The ammonia may escape to atmosphere or be retained in the soil, and is sometimes oxidised to nitrates.

(*b*) *Nitrification* is the process of conversion of ammonia to nitrates by the bacteria, (Nitrosomonas in soil and Nitrosococcus in marine systems).

(*c*) *Denitrification* is the process by which some other bacteria (decomposers) reduce nitrates back to nitrogen or to ammonia or to some other oxides. Free nitrogen returns to atmospheric pool and oxides are taken up by plants.

OXYGEN CYCLE

Living things take in oxygen from the atmosphere. They use it to release energy from the food they eat. Oxygen is also used together with carbon, hydrogen and nitrogen to build new molecules in their bodies. Oxygen is released back into the atmosphere by green plants during photosynthesis and by plants and animals as part of carbon dioxide.

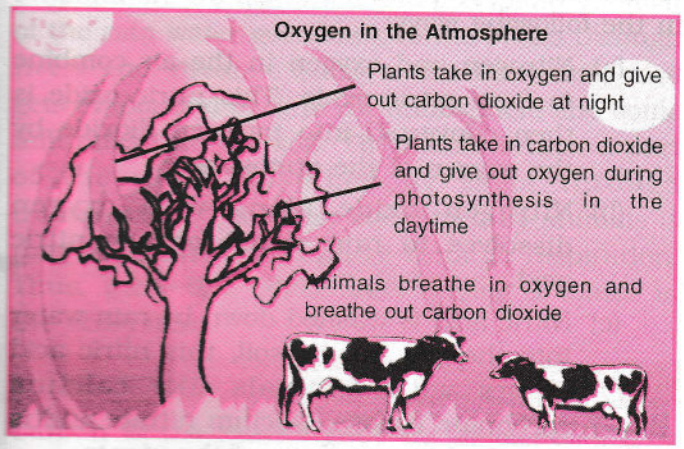


Fig. 3.15. Oxygen cycle

PHOSPHORUS CYCLE

Phosphorous Cycle is an example of sedimentary type of cycle having its main reservoir not in the air but in rocks and other deposits formed during geological ages. This cycle is simpler than the Nitrogen Cycle.

The requirement for phosphorus is critical because it is a major constituent of nucleic acid, cell membrane, cellular energy transfer systems (ATP, ADP, etc), bones and teeth.

In nature phosphorus occurs in phosphate rocks which contain phosphate ions combined with calcium and magnesium. The weathering of such rocks supplies phosphates to the soil. These soluble phosphates are absorbed by plants and incorporated in organic compounds.

Phosphatising bacteria maintain supply of phosphate ions by converting organic phosphorus contained in detritus. Absorption of phosphorus by the higher plants is promoted by the presence of mycorrhizae.

Phosphates enter marine deposits through leaching and become fixed in relatively insoluble form. Fishes and marine birds convert these deposits to phosphate rocks. As such, only a small amount of phosphorus returns to land from ocean through fishes and guano birds.

Nature's Mechanism of Maintaining Balance

Plants absorb varying amounts of nutrients from the soil to manufacture food that enters the food chain. Decomposition of dead organic matter continuously regenerate and store nutrients in soil in forms available to the plant. A dynamic state exists in soil with nutrient regeneration and absorption occurring simultaneously.

In an undisturbed ecosystem, (i.e., an

ecosystem in which human activities are absent or nearly so) the input of nutrients may approximately equal the output of nutrients rendering the nutrient cycles more or less balanced.

Uptake: It is the uptake of nutrients from soil to plants by the process of nutrient absorption.

Recycled: It refers to the nutrients brought back to the soil from vegetation, animal remains and faecal matter.

Retention of nutrients = Uptake + Recycled.

In case of a young forest the retention of nutrients of the ecosystem is high, whereas older forests like rain forests have low retention. Harvesting of agricultural crops or transportation of logs from forests represent nutrient loss from these ecosystems. These disturbances may make the nutrient cycles unbalanced and the ecosystem unstable.

EXERCISES

A. Short Answer Type Questions

1. What are the main functional aspects of the ecosystem? Prod^n, Cons^n, Decomp^n
2. How is solar energy changed to chemical energy? Photosynthesis
3. What are trophic levels in a food chain? Nutrition level
4. What is a food web? Name its two broad categories. Complex food chains Relationships, Grazing, Detrital
5. What does the Pyramid of Numbers indicate?
6. Why is Pyramid of Energy broader at the base and narrower at the top? Unidirectional energy flow
7. Which types of cycles are perfect? Nutrient
8. Give an example of nitrogen fixing bacteria. Azobacter

B. Long Answer Type Questions

1. How is the sugar obtained from photosynthesis used?
2. List the two laws of thermodynamics that influence flow of energy in an ecosystem, explaining each one briefly.
3. Explain the various trophic levels in a food chain.
4. The food web is divided into two categories. Name the two categories and subdivisions in each along with relevant examples.
5. What do the following pyramids indicate?
   (a) Pyramid of Numbers; (b) Pyramid of Biomass;
   (c) Pyramid of Energy.
6. Explain the following cycles in brief:
   (a) Water (b) Carbon (c) Nitrogen (d) Phosphorus
7. Distinguish between the following:
   (a) Food Chain and Food Web (b) Ammonification and Denitrification
8. How does nature maintain balance?

C. Project/Activities

1. Make a flowchart showing a food chain comprising primary consumers and secondary consumers.
2. Visit a pond or lake and see for yourself the food chains that exist there. Make a chart representing this ecosystem.

CHAPTER 5

IMPACT OF ECOSYSTEM DESTRUCTION

Course Content—Syllabus and Scope

Impact of ecosystem destruction—loss of habitat, stress on resources.

Change in climatic conditions, reduced rainfall, drying up of rivers, depletion of aquifers, floods and droughts, loss of topsoil and desertification, loss of species, loss of biomass. Impact on agricultural practices.

The pressure on ecosystem resources are caused by the increase in the human population, urban development, industry and agricultural activities. Future degradation of resources will be seen in those areas of the world where resources for conservation are limited. All forms of human activities pose threat to survival of many species of biota.

Urbanisation, industrialisation, land use change and water course alteration are forcing ecosystem destruction, physical habitat and water chemistry alteration as well as direct addition and removal of species. The impact of ecosystem destruction are given under the following headings.

LOSS OF HABITAT

Humans cause the majority of threats to species, sites and habitats. These threats are often interconnected. Habitat destruction and land conversion for agricultural and forestry activities and the associated degradation and fragmentation are the biggest problems.

The drainage of wetlands for agriculture, dam construction and the flooding of valleys for power generation, the use of pesticides, the development of wilderness areas, and toxic contamination of soils have all been associated with unintended species extinction due to habitat destruction.

Habitat deterioration and destruction is the main cause of threat to many wild plant species and plant communities. Habitat destruction could be caused as a result of:

1. Clearing of forest areas for settlement or agricultural expansion, commercial lodgings, large hydel schemes, fire, human and livestock pressure, etc.

2. Pollution (both air and water) stresses ecosystem, mismanagement of industrial and agriculture wastes threaten both terrestrial and aquatic ecosystem.

3. Over exploitation, mainly for commercial purposes like meat, fur, hides, body organs, medicine, etc.

4. Accidental or deliberate introduction of exotic species which can threaten native flora and fauna directly by predation or by competition and also indirectly by altering the natural habitat or introducing diseases.

5. Fragmentation of forests into subdivisions destroys habitat for wildlife, including rare species such as the Florida black bear and the red-cockade woodpecker. Some wild animals like

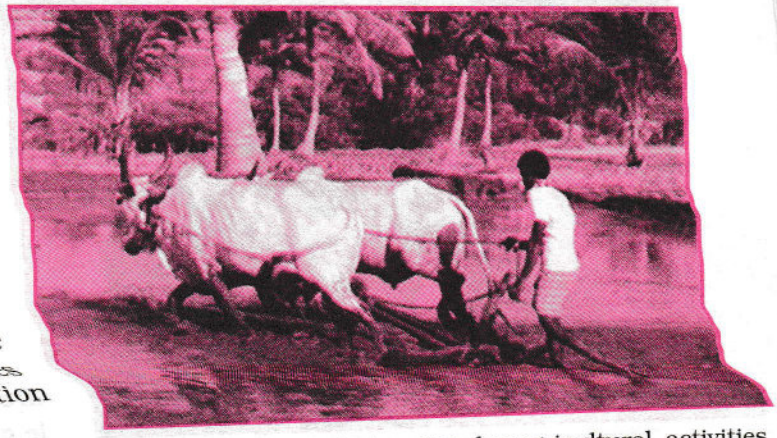


Fig. 5.1. Habitat destruction by agricultural activities

bears, bobcats and foxes are unable to adapt to changes in the forest.

6. Critical natural habitat and its associated biodiversity are diminished in wars around the world. Similarly, actions such as deforestation, habitat destruction and degraded human waste disposal—all associated with war and its aftermath—can affect other key ecosystem services such as erosion control, water quality and food production.

7. Destruction of habitats is caused on account of land being taken by new roads. This prevents free movement of animals or birds from their habitats either in search of food or for the purpose of migration from one place to another.

8. Wounding and killing of animals hit by motor vehicles and trains, or victims from drowning when falling into steep-sided canals.

9. Fish are also affected. Salmon, for instance, are frequently indirectly affected by roads. Impervious edges to roads, such as concrete, increase the flow of water from the road into streams, leading to a build up of sediment, increased water temperature and pollution. Water running off from roads is the biggest hazard, as salmon are very sensitive to these irregular "flash flows".

10. Roads also fragment habitats and divide large populations of animals into smaller and less viable units. This can lead to inbreeding and population instability, and frequently results in local extinctions.

11. Disturbance to animals arising from noise, light, movement and human activity. For example, to breed successfully, songbirds require a noiseless atmosphere. Woodland-dwelling songbirds can rarely live within 350 meters of a main road; when roads run through grasslands, few songbirds nest within 1,000 metres. The noise could interfere with their hearing and their communication, and raise their stress levels. The vibrations caused by passing cars stop earthworms from surfacing and leads to an abundance of crows, which are able to dig out worms at deeper depths.

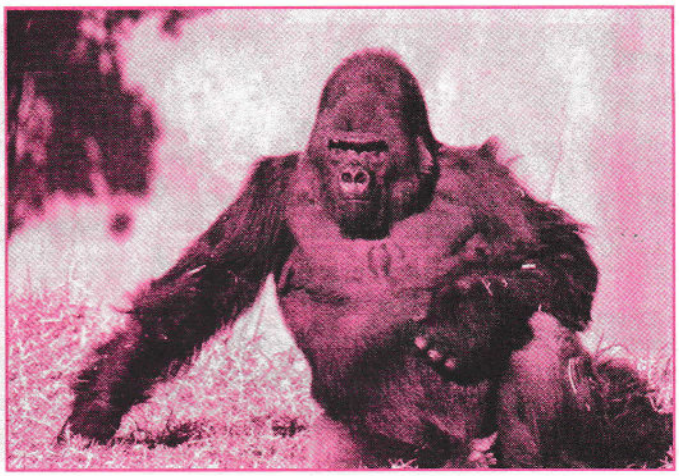


Fig. 5.2. Habitat Destruction

Fig. 5.3. Deforestation

Human activities cause nearly all of the threats that directly impact wildlife species as well as the sites and habitats in which they live. Habitat destruction and degradation currently impact 1,045 Globally Threatened Birds(GTBs), 86% of the total. Over-exploitation (mainly hunting for food and trapping for the cage-bird trade) and the effects of alien invasive species (especially predators) each directly threaten over 300 GTBs (nearly 30%).

Other factors include human disturbance (e.g. to congregatory birds), incidental mortality (notably the drowning of seabirds in commercial longline fisheries) and environmental pollution (on land, in wetlands and seas, and in the air). At least 40 percent of GTBs are threatened by two of these threats. Some of these threats can be reversed given enough resources. However, there is an increased risk of extinction in cases of small species population from threats such as natural disasters (e.g. volcanoes, cyclones and drought) or changes in native species dynamics (e.g. increases in competition) that are difficult to combat. Other factors that reduce populations

(e.g. inbreeding, limited dispersal, skewed sex-ratios) can significantly increase extinction risk.

STRESS ON RESOURCES

An ever increasing population puts greater demand on the use of limited resources of a country because people must generate better facilities for themselves. In fact, industrial expansion, urban growth, agricultural development, increase in means of transport and communication etc. are the outcome of population growth. The development of scientific techniques and advanced technologies has to be made to protect humans from hunger and natural calamity and disaster. As a result the rate of exploitation of natural resources increases more rapidly than the rate of population growth. This causes depletion and exhaustion of certain valuable non-renewable resources.

The population of India has increased fourfolds from 1901 to 2001 which means pressure on natural resources has increased four times. This has led to:

1. An increase in the net sown area from 118.75 million hectares (1950 - 51) to 142.81 million hectares (1994 - 95).
2. Decrease in forest cover.
3. Increase in irrigation facilities and irrigated areas.
4. Increase in use of agro chemicals (nitrogen, phosphorus and potash from 1.1million tones (1951 - 52) to 14.31 million tones in 1996-97.
5. Increase in use of pesticides, fungicides and herbicides. These control crop disease but they also pollute acids, water and food chains.

More people need more water, food and energy resources. But the earth's supply of fresh water is essentially fixed - only about 2.5 percent of all water on the planet is fresh water - and only about 0.5 percent is accessible ground water or surface water.

70 years, but water use has grown six-folds because of industrial development and increased irrigation.

While 60,000 villages and 1.25 lakh urban colonies in India do not have potable water. The industrial sector's water use has increased by 50 per cent in the last 25 years.

Also land area of a country is fixed, it cannot be extended and a disproportionate increase in population tends to bring down utilisable land area. Estimates claim that while in 1960, 0.21 hectares of land was available for every Indian, this figure had dropped to 0.10 hectares by 1999, a fall of over 50 per cent.

Changing patterns of land use due to human activities such as urbanisation, industrial and agricultural development and water course alterations (construction of dams) have negative impacts on the biosphere. These effects are manifested through a range of forcing factors, such as ecosystem destruction or fragmentation, physical and chemical alterations in water bodies or biotic change through extinction of exotic species.

OTHER SIGNIFICANT IMPACTS OF ECOSYSTEM DESTRUCTION

Human activities like deforestation and burning of fossil fuels are the major factors that have induced climatic changes and resultant effects.

Change in Climatic Conditions: When a forest is cut and burned to establish cropland and pastures, the carbon that is stored in the tree trunks joins with oxygen and is released into the atmosphere as CO_2. Burning of fossil fuels (coal, oil and gas) also release CO_2 in the atmosphere. Releasing CO_2 into the atmosphere enhances the greenhouse effect and contributes to an increase in global temperatures.

Deforestation also affects the local climate of an area by reducing the evaporative cooling that takes place from both soil and plant life. Evaporation and evapo-transpiration processes from the trees and plants return large quantities of water to the atmosphere, promoting cloud formation and rains. Less evaporation means that more of the sun's energy is used to warm the surface and consequently, the air above, leading to a rise in temperature.

Drying up of Rivers and Acquifers: Increasing amount of forest removal also result in decreasing amount of rainfall. Decreased rainfall reduces the percolation of water in the underground and consequently lowers the levels of underground water-table. All this leads to drying up of rivers, streams, lakes and aquifers.

Floods and Droughts: The increase in CO_2 in the atmosphere and the resultant increase in temperatures also lead to floods and droughts. Because of excessive heat, water evaporates quickly. The soil affected with erosion and devoid of vegetative covers cannot retain moisture for long. Hence, this causes droughts.

The rise in temperature lead to the melting of glaciers which form natural lakes between the mounds of debris and rocks that are left behind by the sliding glaciers. These result in an imbalance in the outflow of water. This means that the glacial lakes will be fed with water from the melting ice at a rate faster than the rate at which they can be drained, thus, making glacier lakes flood more frequently.

Removal of Topsoil and Desertification: Loss of vegetative cover also leads the rainwater to runoff rapidly over the surface causing floods. Floods wash away the top soil cover, devoiding the soil of its nutrients and thereby, its fertility. Loss of soil productivity by erosion of topsoil results in the formation of deserts.

Fig. 5.5. Too many people too few goods

Loss of Species and Biomass: As stated earlier, human activities cause the majority of threats to species, sites and habitats. Habitat destruction and land conversion for agricultural and forestry activities and associate degradation and fragmentation result in the loss of bio-species and loss of biomass.

Impact on Agriculture

Ecosystem destruction has a major impact on agricultural practices. A substantial part of agricultural land is lost or becomes unfit for cultivation due to various reasons like soil erosion, desertification, floods and drought, conversion of land for construction of houses, highways, railways, commercial complexes, factories, offices, etc. Water logging and salinisation also damage irrigated lands. Over-grazing and use of synthetic fertilisers, insecticides and pesticides turn agricultural land into wastelands.

According to an estimate, there are between 4.9 and 9.9 billion acres of cultivable land on earth. If the population continues to grow at the present rate and the yield continues to decrease, the population will quickly outstrip its food supply. As such, in future food supply and security will pose a big challenge to the mankind.

CHAPTER 6

CONSERVATION OF ECOSYSTEM

Course Content—Syllabus and Scope

Conservation of ecosystem—alternative practices including indigenous conservation practices, planning for proper land use.

Understanding indigenous conservation practices like those of Bishnois in Rajasthan.

After studying the importance of ecosystems and the impact of destruction of ecosystems we need to pay attention to the conservation of ecosystems. 'Conservation' of Ecosystem refers to activities that not only provide individual or commercial benefits of the resources but also prevent their excessive use leading to environmental degradation. This can be carried out through proper land use, planning for demands of population growth and sustainability of delicate ecosystems. There is a growing need to strengthen conservation measures based on the traditional knowledge and value system. We have to follow the system with which the tribal communities can identify, e.g. the revival of the sacred grove concept based on cultural tradition, which enabled each village to have a protected forest area.

INDIGENOUS CONSERVATION PRACTICES

Natural resources have to be conserved so that they can be used by the present and future generations. This means that a sustainable yield of renewable natural resouces has to be ensured. Besides this, a continuous protection to non-renewable resources for their prolonged existence on the earth has to be ensured. Conservation of resources was done in ancient times through indigenous practices which were followed from generation to generation. Some of these practices are followed even today.

In their day-to-day interaction with nature, the tribal people followed practices which revealed a deliberate restraint on the use of natural resources. These practices included the complete exclusion of grazing pressure during certain periods within fodder reserves, and its limited

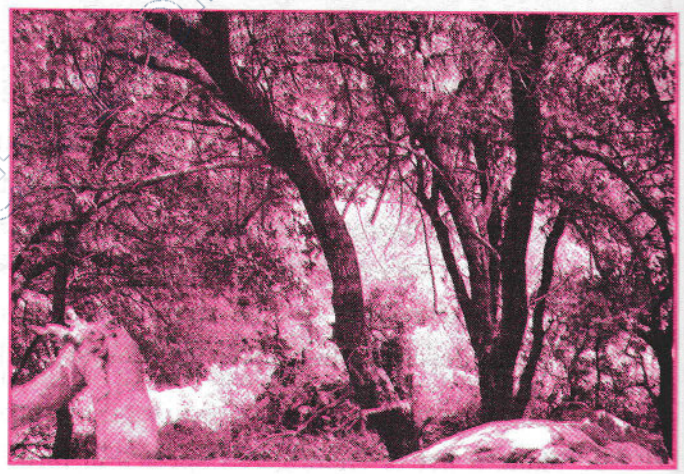


Fig. 6.1. Conservation — A Sacred Grove

use during other periods in terms of the kind and number of animals permitted for grazing—as for example in the system of *ahmias* around Taif in Saudi Arabia. In tribal society, land was considered as a living entity. It too needed rest to recover its fertility. So the land was kept fallow for sometime after cultivating two or three crops. The other notable practices are the use of water harvesting techniques, crop rotation, herbs for medicines, etc.

Some of the indigenous conservation practices included the following:

1. Water Conservation: Water has been harvested in India from ancient times. Each of our ancestors have perfected the art of water management. Many water harvesting structures and water conserving mechanisms were followed in each region of the country.

- People harvested rainwater. From rooftops, they collected water and stored it in tanks built in their

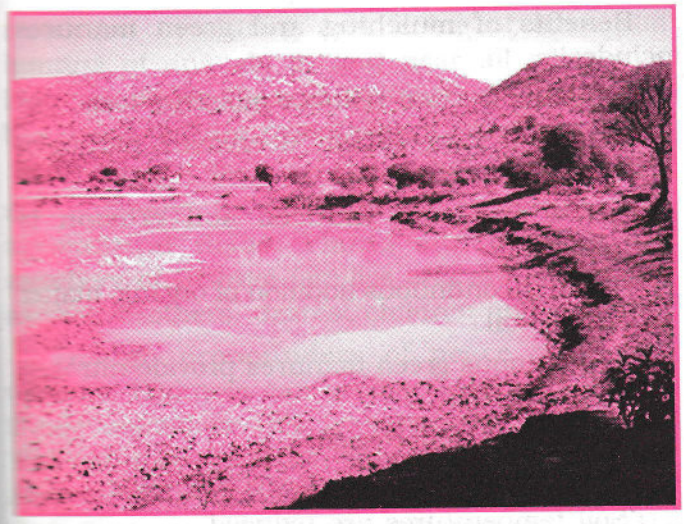


Fig. 6.2. A Johad

community lands, they collected the rainwater and stored it in artificial wells.

- They harvested rainwater runoff by capturing water from swollen streams during the monsoon season and by storing it in water bodies.
- They harvested water from flooded rivers.

The storing mechanisms or the water receptacle was known by different names in different areas. They were called *Khatri* or *Kuhl* in Western Himalayas, *Baolis* or *Dighis* in the Gangetic plains, *Johads* in Central India, *Bhandaras* or *Kere* in the Deccan Plateau, *Surangam* in Western Ghats, *Kurambu* in Eastern Ghats and *Zing* in Ladakh. These indigenous systems of water conservation ensured high water table as well as water supply during dry periods.

2. Forest Conservation: Trees and groves have been worshipped by man since time immemorial. In ancient days, man used to rever anything and everything that he either did not understand or that provided him with some useful products. Since the forests provided him with 'anna', 'aarogya' and 'aasra' (food, well-being and security) he developed an intimate relationship with them. As such, forests became central to all his customs and traditions. The tribals had the belief that if they destroy the forests, natural calamities were bound to occur. That is why, they maintained an area within the forest as a protected or sacred one with all its flora and fauna. This sacred tract of forest also had a resident God and was known by different names in different areas. Some of the tribal communities have continued this old tradition of maintaining the 'sacred groves'.

Some times the forests were referred to as *Banadevi* that is the goddess of the forest. They were also said to be *Devasthan*, the abode of gods. In many tribal areas of India, there is a popular belief that the souls of their fore-fathers might live in some of the trees. Naturally, the *adivasis* (tribals) themselves do not dare to enter some areas in the forests nor do they permit anyone to enter it. As a result, the biodiversity of the forests is preserved as it is.

3. Agricultural Practices: Some of the indigenous agricultural practices are:

Mixed Subsistence: Traditional farmers can often be characterised as managing mixed subsistence economies; employing several cropping systems simultaneously. This includes having plots under continuous cultivation, some in shifting cultivation and also raising animals. This allows for a larger diversity of outputs, greater flexibility and increased system stability.

Inter-Cropping: Inter-cropping involves growing different crops simultaneously within the same area of land. For example, in Java small-scale farmers have up to 607 crop species in their farms, equivalent to the species diversity of a deciduous tropical forest. This may seem to produce unwanted competition between the plants. Actually, it increase yields as the plants grow at different heights and have different root and leaf structures. This allows maximum utilisation of abiotic inputs. This extremely efficient use of available light, nutrients and water by plants with different heights, root and leaf structures is one of the primary reasons why traditional systems are highly efficient. This system actually increases the productivity of the land and tropical farmers claim yield improvements, as the major advantage of inter-cropping. For example, in northern India mustard is planted together with wheat. In fruit orchards, leguminous crop is planted to increase the yield of the land. In south India, coconut trees are planted on the borders of rice fields.

Genetic Diversity Within Crop Species: Traditional farming is also characterised by a high degree of genetic diversity within each crop

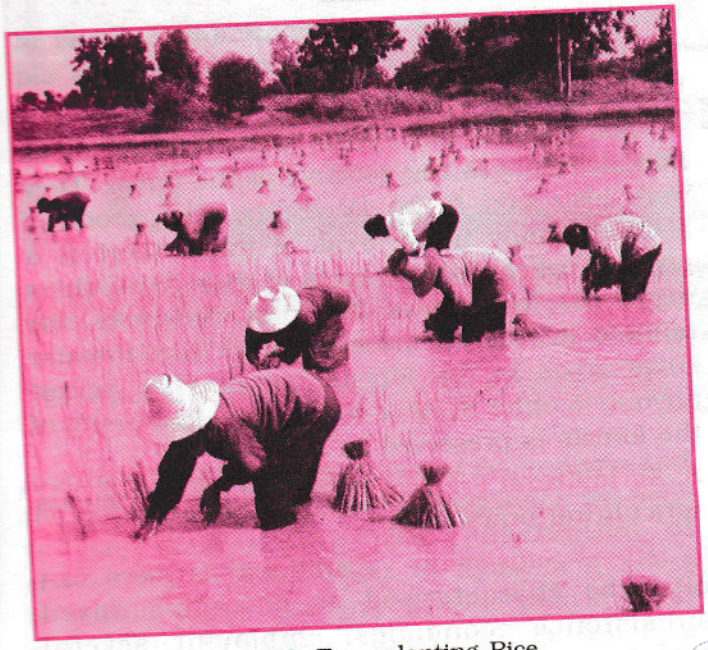


Fig. 6.3. Transplanting Rice

species. Traditional Sri Lankan farmers planted 280 varieties of rice, Andean (South America) farmers planted as many as 50 different varieties of potato in the same year and in the Philippines farmers used more than 300 traditional rice varieties.

This practice reduces the threat of crop loss due to a strain of pathogen that is adapted to a specific plant; some of the varieties are sure to be resistant. The diversity is also an insurance against losses due to unpredictable weather or changing climatic conditions. If some varieties are susceptible to mildew in wet years, others will surely thrive in those conditions. The genetic diversity within crops provides a steady harvest as different varieties mature at different rates. This ensures the harvest is a continuous process distributing labour demands over a longer period and providing relatively constant food supplies.

Mulching and Use of Green Manure: Traditional farmers often employ a system of continuous vegetative cover on the soils as either green manures or mulches. The green manures are generally leguminous plants, grown to be ploughed into the soil prior to planting crops. Alternatively, crops can be planted concurrently with green manures with minimal soil disturbance. Mulches are generally waste plant materials, such as leaf

Benefits of mulching and green manures include:

- Shading the soil reduces moisture loss.
- Reduced rain splash decreases pathogen dispersal.
- Wind and rain induced soil erosion is reduced.
- There is continuous addition of organic matter to the soil.
- Leguminous green manures provide nitrogen to the plants.
- Weeds are suppressed.
- Cover protects crops at seedling stage.
- Soil temperatures are reduced.

The Bishnois of Rajasthan

The Bishnois, a tribal race of Rajasthan are considered as the first environmentalists in the world. They have over centuries made a unique blend of ecological sense and religious sensibility their faith's cornerstone.

The word *Bishnoi* has been derived from 'Bish' which means twenty in Hindi and 'Noi' means nine. Jamboji, who is supposed to be the founder of a sect in Hindu religion called 'Bishnoi' in 1542 AD, gave a set of 29 tenets to his followers. Living in harmony with all creatures of nature was the basic theme of the sect. Bishnois are vegetarian. Of the 29 tenets eight tenets are dedicated to the preservation of biodiversity and animal husbandry without killing. Felling of trees have been prohibited. Bishnois remove living insects from firewood before burning. They never cut trees and wait for trees to die on their own or fall down during storms. They are non-violent with self control and their dead bodies are buried in the woods despite being Hindu, so as to ensure that mineralisation of the organic matter provides nutrition to growing trees.

Bishnois believe that the God is present everywhere in the nature. It is said that in 1737 AD, Amritadevi, a Bisonoi lady and her three minor daughters laid down their life by hugging a 'Khejri' tree during its felling by the King of Jodhpur State. Altogether 363 people were put to death for protesting against the felling of the trees. deeply moved and lamented for his

restriction in cutting and felling of trees and hunting of animals in and near all villages of Bishnois. Since then no member of royal family has dared to hunt near Bishnoi villages.

All wildlife like chinkaras, blackbucks, etc., move freely in Bishnoi settlements and agricultural fields. Plants and animals are members of Bishnoi families and are considered as their brothers, dearest children and relatives.

Though propounders of peace and non-violence, Bishnois can become extremely violent if any animal or tree is harmed in their area. This ruthless protection of animals is part of the Bishnoi culture. An extremely aggressive race, they fight for wildlife and environment with a vengeance.

Patience, actually, is the catchword in this simple and dedicated community. They have only four months of farming and the rest of the year they just sit around and hope the food will last. To add to that, herds of deer end up eating much of the standing crop. But not a stick is raised to chase away the animals. They willingly go hungry to feed the animals as they believe in the co-existence of life. For the Bishnois animals are the avatars of divinity, that is why, in the water-starved desert, each Bishnoi family creates a tank in their field to provide water for animals in the arid summer months.

The Bishnois have contributed a lot to nature and wildlife protection. They have learnt, with time and hardships, how to nurture nature and grow with it instead of exploiting it.

ALTERNATIVE CONSERVATION PRACTICES

Conservation does not mean preservation, but it means utilisation of natural resources in such a way that they are not destroyed completely and can be further utilised by future generations. With a rapid increase in population, the demand for natural resources has increased *manifold. Consequently,* resources are depleting at a rate faster than their growth and thereby, causing an imbalance in the ecosystem. Therefore, besides the indigenous conservation practices, we need to adopt alternative or modern conservation measures.

Modern conservation measures have three main objectives:

(i) To preserve biological diversity;

(ii) To maintain essential ecological processes and life support systems; and

(iii) To ensure a sustainable utilisation of species and ecosystems.

Though India has an ancient tradition of conservation, the modern concept of conservation was developed in 1952 with the establishment of Indian Board of Wildlife. Since then, several measures have been taken to conserve wildlife.

The following two strategies are used for conservation of biodiversity and wildlife:

(a) In-situ conservation, (b) Ex-situ conservation.

IN-SITU CONSERVATION

The in-situ conservation means conservation of wildlife in its natural habitat. It emphasises protection of the ecosystems of the original habitats or natural environment. The in-situ approach includes protection of a typical ecosystem through a network of protected areas on land or sea. These are managed through state or other effective agencies. India has 381 protected areas, covering about 4.7 per cent of the land surface. The biosphere reserves, national parks and wildlife sanctuaries are included in the protected areas.

OBJECTIVES OF NATIONAL PARKS, WILDLIFE SANCTUARIES AND BIOSPHERE RESERVES

The basic objectives of national parks, wildlife sanctuaries and biosphere reserves are:

- Protection of natural habitats through controlled, limited use of species.
- Maintenance of the viable number of species in protected areas.
- Establishment and protection of areas through legislation for the conservation of wildlife.
- Educating the public for wildlife protection.
- Conducting research in specific areas of wildlife.

(1) NATIONAL PARKS

A national park is an area which is strictly reserved for the betterment of the wildlife and where human activities like forestry, grazing or cultivation are not permitted. The examples of national parks are:

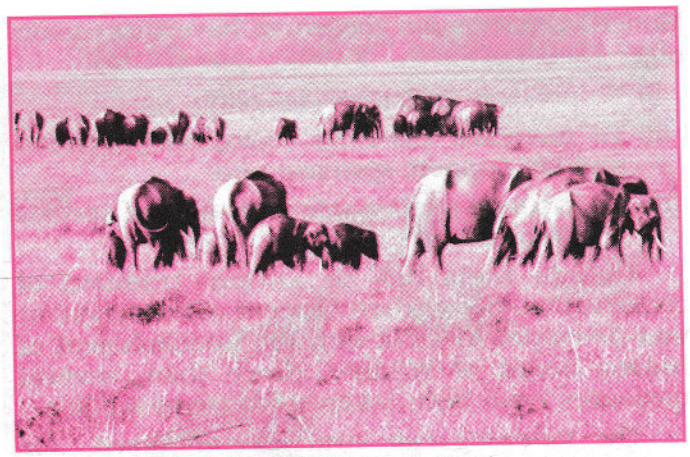


Fig. 6.4. National Park

1. Jim Corbett (It is the first National Park of India.)
2. Sunderbans (West Bengal)
3. Dudhva (Uttar Pradesh)
4. Tadoba (Maharashtra).

(2) Wildlife Sanctuaries

A wildlife sanctuary is a protected area that is reserved for the conservation only of wildlife—animals and plant species. Human activities like harvesting or timber collection of minor forest products and private ownership rights are allowed. The examples are:

1. Periyar (Kerala)
2. Ranipur (Uttar Pradesh)
3. Chilka Lake (Orissa)
4. Sariska (Rajasthan).

Wildlife Conservation Projects

Many projects are being carried out in India to prevent the extinction of some endangered wild animal species. Some of them are as follows:

(i) Project Tiger: 'Project Tiger' was launched by the Central Government in April 1973, to save the tiger from extinction in India.

(ii) Gir Lion Project: This project is being carried on at Gir forest in the Saurashtra peninsula of Gujarat to save lions in the region.

(iii) Crocodile Project: This project aims at conservation and management of crocodiles, through incubation of eggs and rearing. It is being conducted in certain sanctuaries of Orissa, Andhra Pradesh, Rajasthan, Uttar Pradesh and Madhya Pradesh.

(iv) Project Elephant: The aim of this project is to preserve a number of elephants and to identify elephant reserves to protect them.

(3) Biosphere Reserves

A biosphere reserve is a special area of land or coastal environment in which multiple use of land is permitted by dividing it into certain zones. The natural or core zone consists of an undisturbed and legally protected ecosystem. The buffer zone surrounds the core area, and is managed to accommodate a greater variety of resource use strategies. The transition zone, the outermost part of the biosphere reserve, is an area of active cooperation between the

National Park, Wildlife Sanctuary and Biosphere Reserve – a comparison

S. No.	National Park	Sanctuary	Biosphere Reserve
1.	It is associated with the habitat of wild animal species like rhino, tiger, lion, etc.	It is species oriented as pitcher plant, Great Indian Bustard.	It takes into consideration the entire ecosystem.
2.	Its boundaries are marked by legislation.	Its boundaries are not sacrosanct.	Its boundaries are marked by legislation.
3.	Disturbance only limited to buffer zone.	Limited disturbance.	Disturbance only limited to buffer zone.
4.	Tourism is allowed.	Tourism is allowed.	Tourism generally not allowed.
5.	Scientific Management is lacking.	Scientific Management is lacking.	Scientifically Managed.
6.	No attention is paid to gene pool conservation.	No attention is paid to gene pool conservation.	Attention is paid to gene pool conservation.

management and the local people. India has 13 Biosphere reserves. They are: Nilgiri, Nanda Devi (Valley of Flowers), Nokrek, Great Nicobar, Gulf of Mannar, Manas, Sunderbans, Similipal, Dibru Saikhowa, Dehang Debang, Panchmarhi, Kanchenjunga and Agasthyamalai. Out of these 13, three have been recognised on World Network of Biosphere Reserves by UNESCO, namely, Nilgiri, Sunderbans and Gulf of Mannar.

Ex-situ Conservation

Ex-situ conservation means conservation of wildlife outside its natural habitat. The conservation takes place in captivity under man's supervision. Some times, the populations of species may decline or may become extinct due to genetic or environmental factors such as inbreeding, habitat loss, disease and over-exploitation. In such cases, in-situ conservation may not prove to be effective and a species can be protected from becoming extinct only through maintaining individuals in artificial conditions under human care. Such measures are included under ex-situ conservation. Generally, botanical gardens, zoos, aquariums, parks, agricultural research centres, forest research centres, etc., are the artificial habitats for ex-situ conservation.

In order to protect global biodiversity and encourage the study and management of endangered species, the International Union for the Conservation of Nature and Natural Resources (IUCN) and the World Conservation Monitoring Centre (WCMC) maintain a global list of endangered and vulnerable animal species called the *Red List*.

LAND USE PLANNING

Land use planning determines how the country's urban areas expand, how they affect the surrounding landscape. Large-scale conservation plans can be incorporated into the land use planning process.

The main purpose of Land Use Planning is to avoid land degradation, misuse and abusive use and to maintain and enhance land quality. This can only be achieved through co-ordinated participation of all stakeholders in land resources management at all levels such as national sectors (ministries, non-governmental organisations, companies), regions, districts and villages.

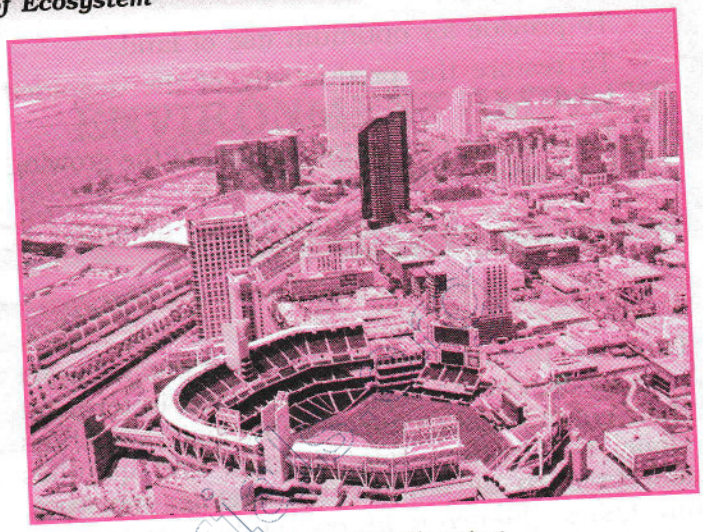


Fig. 6.5. City Planning

Objectives of Land Use Planning in India

The National Land use and Conservation Board (NLCB) at national level was set up to look after the aspects concerning land use. The main objectives of this board are:

- To prevent further deterioration of land resources.
- To allocate land for different uses based on land capability.

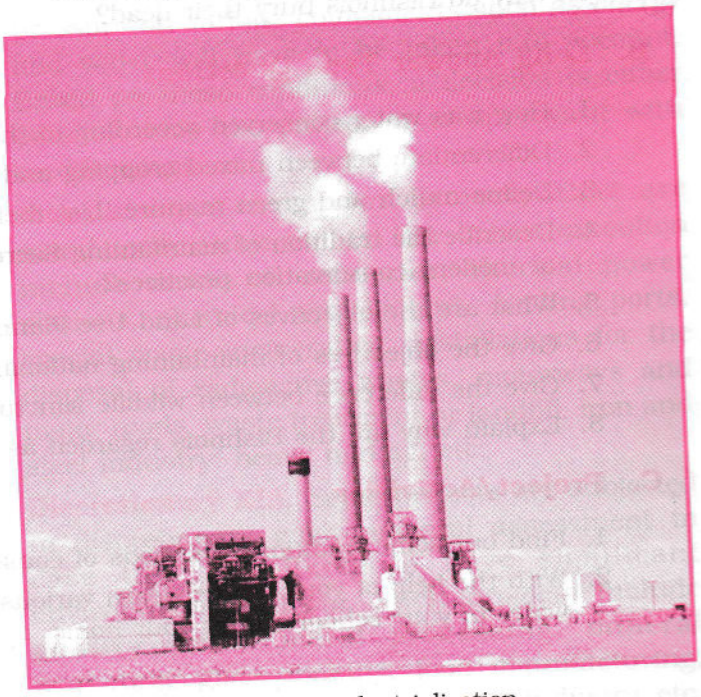


Fig. 6.6. Industrialisation

- To provide for optimum use of land.
- To restore the productivity of the degraded land.
- To meet the consumption need of the growing population.
- To involve the community for adoption of appropriate land use.

Zoning

Land use planning involves division of land units into zones. Zoning defines land units in terms of their characteristics (measurable factors such as slope, soil texture; rainfall, etc.), and qualities (effects such as temperature regime, moisture, availability, which result from a combination of characteristics). Zoning also matches land with potential uses and then rates the land in terms of suitability for the use.

Process

Strategic land use planning is a process for determining how our land will be used, ensuring greatest sustainable benefits. It involves the designing of infrastructure such as transport facilities, industrial plants, storage of produce, power generation, and facilities for towns and other human settlements. Land use planning is carried out in taking into account population increase and socio-economic development.

EXERCISES

A. Short Answer Type Questions

1. Why is it necessary to conserve ecosystem?
2. How will you define inter-cropping?
3. How do traditional farmers provide a cover to the soil?
4. What is the main purpose of land use planning?
5. What is sustainable development?
6. What are the advantages of traditional farming methods?
7. What is the basic tenet of Bishnois?
8. Why do Bishnois bury their dead?

B. Long Answer Type Questions

1. How was water conserved according to the traditional method?
2. Differentiate between mixed cropping and inter-cropping.
3. Define mulch and green manure. List their advantages.
4. Describe the tradition of maintaining Sacred Groves. What is the need of undertaking alternative or modern conservation practices?
5. What are the objectives of Land Use Planning in India.
6. Give the objectives of maintaining national parks.
7. Give the difference between wildlife sancturies and biosphere reserves.
8. Explain why are the Bishnois regarded as the first environmentalists in the world.

C. Project/Activities

1. Find out some traditional methods of conservation of ecosystems.
2. With the help of your teacher learn various rain harvesting techniques and use them to harness water in your school and at your home.

CHAPTER 7

ENVIRONMENT IMPACT ASSESSMENT (EIA)

Course Content—Syllabus and Scope

Role of Environmental Impact Assessment (EIA) in maintaining the quality of the environment.

Meaning of EIA, aims and advantages of EIA, Broad steps in EIA.

In order to have sustainable development, we need to make changes in our environment. But these changes have to be bearable and favourable to sustain life-supporting systems. Therefore, before we embark on a project, we have to assess the effects of its development on the environment. Such an assessment is known as the *Environmental Impact Assessment (EIA)*. This is done to evaluate the present conditions of the proposed projects, their suitability and future impact on the environment.

Environmental Impact Assessment is defined as an activity that has been designed to identify, predict and interpret the impact of an action on human health, including the well-being of ecosystems on which the survival of human beings depends.

There are two stages in this assessment:

(A) Initial Environmental Assessment means preliminary analysis done to know whether there are significant adverse impacts to warrant a complete EIA. In a number of nations, initial environmental assessment is done for 'screening' the proposed projects.

(B) Environmental Assessment Process means the systematic analysis of the potential effects of a proposed action and its reasonable alternatives on the physical, biological, cultural and socio-economic qualities of a particular geographical area.

AIMS OF EIA

EIA is an important management plan. It makes sure that the best use is made of natural resources for sustainable development. It is used to test the compatibility of environment before taking a decision to establish projects and industries, which could adversely effect our natural resources. It takes into consideration consequences for the natural environment.

EIA also aims at predicting and taking precautions against undesirable environmental effects of man's activities. It takes into consideration long-term planning and its effects. In undertaking an assessment, planners consider the side-effects of their proposal and also the various alternatives available. For examle, when a factory has to be started, it is not just the requirements of raw materials, but the sum total of all actions including transportation, all types of resources demanded by the system, pressure on various components such as energy and water will have to be taken into account. Based on these conditions, a decision is either taken to stop the project or to approve it with modifications.

Mandatory EIA: Major projects that are mandatorily subjected to EIA before execution include crude oil refineries, thermal power stations, chemical installations, trading ports, special waste incineration, installations for the disposal of radioactive wastes, motorways and major roads, waste treatment or landfill, iron and steel industry, heavy mining, etc.

Discretionary EIA: Some projects are subjected to discretionary environmental assessment in case they are likely to have significant environmental effects. Such projects include poultry units, metal processing, mineral extracting, glass making, food manufacturing, holiday resorts, tanneries, paper industry etc.

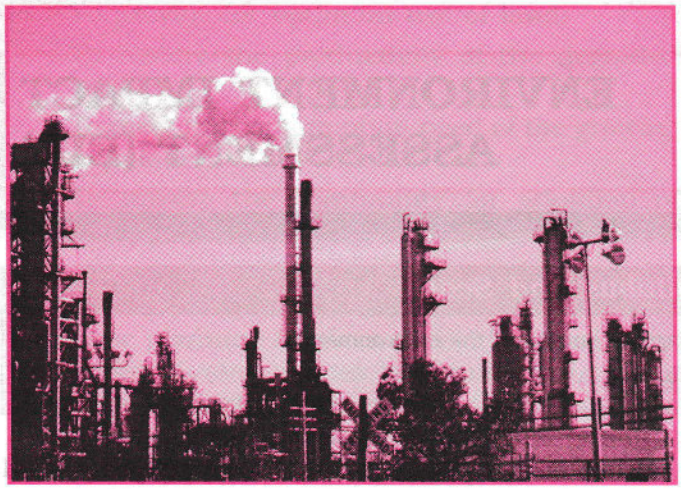


Fig. 7.1. Refinery – A Project Requiring Mandatory EIA

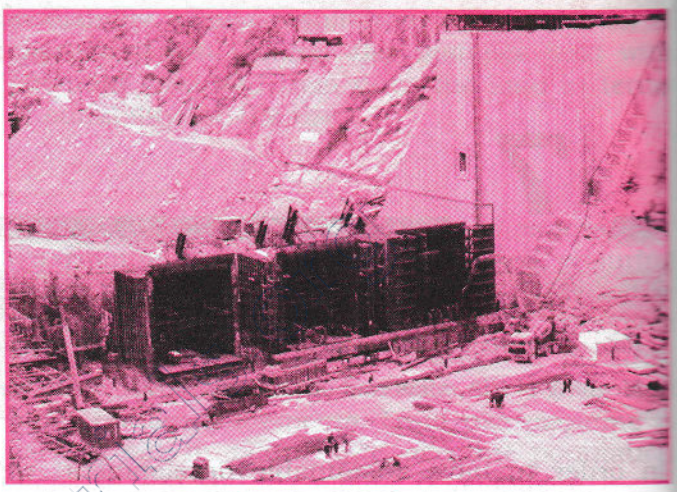


Fig. 7.2. Dam Construction

Three general criteria have been suggested to identify a project that is likely to have 'significant' effects. These are:

(*a*) **Size of the Project**—whether it transcends the 'local' significance;

(*b*) **Location of the Project**—distance from Biosphere Reserves, National Parks, Wildlife, Sanctuaries, seashore, site of scientific interest, human habitation, important monuments, etc.

(*c*) **Adverse Impact**—pollution and other adverse impacts of the project on the environment.

STEPS IN ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

EIA is a systematic process that includes a number of steps aimed at providing information to decision makers for ensuring that environmental considerations are a part of decision making. These steps are the following:

1. Clarity of Objectives: In EIA, the objectives of a particular project are assessed. To formulate objectives clearly, one has to keep in mind, the existing environmental quality standards imposed by the Government or other agencies. What is to be achieved and at what level and at what costs has to be ascertained.

2. Survey and Analysis: An effective survey is conducted of the existing environmental conditions by using checklists. The suitability of land area, availability of water, provision for waste disposal, labour, capital, etc., are kept in mind while conducting the survey.

3. Data Gathering: Data gathering is an important task of EIA as it can help in proper planning and assessment. Suppose you want to establish a colony at a short distance from the town. You may formulate a questionairre to gather information using the following points:

- The distance between the existing colony and the proposed colony.
- Details of any rare plant/animal species that will be affected.
- Source of energy demands.
- Loss of green cover.
- Afforestation plans under social forestry and kitchen gardens.
- Any major public utility such as metro station/bus terminus.
- Design for disposal of domestic wastes.
- Any schools, colleges or hospitals in the area.
- Plans for rooftop harvesting of rain water collectively or in individual units and technology requirements for the same.
- Any public entertainment system such as movie hall, theatre, etc.

After conducting the survey and collecting the data, the future environmental conditions are considered. Such predictions depend on the

Fig. 7.3. Public Participation

Fig. 7.4. Data Analysis

quality of the economic conditions and population forecasts for an area. The forecasts should reveal the expected industrial outputs, changes in the distribution of activities, resource use, waste disposal, etc.

4. **Alternative Plans:** Besides having a simple plan, alternative plans with proper objectives to enable the assessors to have a viable alternative are taken into consideration. When many plans are considered, a comparison can be made on their respective advantages and disadvantages. The project plans are later presented to the public for their opinion.

5. **Decision, Implementation and Monitoring:** Once the decision has been taken, guidelines are given for the project implementation and its monitoring. Here one can take the help of experts and get their valuable suggestions.

6. **Public Participation:** It is necessary to involve the public while making the Environment Impact Assessment. The planning reports and the projected environmental impacts are presented to the public. This is done by interacting with the community representatives or with a small group of people at the local level.

Guidelines for Public Participation

Public participation could be enhanced by taking the following steps:

- Detailed procedures for public participation.
- Everybody has the right to participate.
- Publicity of the proposed action in the press, and other media. Further information from the competent authority could be given.
- A detailed discussion among the Government agencies could be carried out.
- Proper time-frame for the submission of comments.
- Comments of the public to be compiled and included in the EIA.
- The reaction of the competent authority on the comments made by the public.

Environmental Statement

The outcome of EIA is represented in the EIA Report, which is also called the *Environmental Statement*. An Environmental Statement should comprise:

- information describing the EIA process;
- information describing the site of the proposed project and the current state of environment;
- assessment of the effects of the proposed project;
- measures of mitigating the adversities and their likely effectiveness; and
- risk of accidents, if any.

Role of Environmental Impact Assessment

If the EIA system is followed, it can play a major role in maintaining sustainable development. It plays an important role in the following ways:

1. With the EIA implementation, future projects can be carried out with least harm to the environment.

2. Wastage of natural resources as well as money can be taken care of with proper projection.
3. If the project is not feasible, alternative plans can be drawn.
4. Wastage due to inadequate methods can be checked. For examples, only 20 per cent of irrigation water is utilised by the plants, the rest is wasted during transport.

ADVANTAGES AND DISADVANTAGES OF EIA

ADVANTAGES

Environment Impact Assessment has the following advantages:

- It provides better understanding of the impacts of a project.
- It identifies the issues that are contentious and helps in resolving those issues.
- It ensures cooperation of the local people and transparency for the implementation of the project.
- It helps in identifying alternative sites, designs etc.
- It reduces disputes and confrontation.
- It creates a sense of local ownership among the people residing in and around the project area.

DISADVANTAGES

- Time consuming.
- Illiteracy among people.
- Communication problem.
- Time and cost involved to deal with these difficulties may be high.
- Lack of suitable experts.

EIA in India

EIA was introduced in India in 1978. EIA covers the following projects:

(i) Development projects such as (a) mining (b) thermal power plants (c) river valley (d) communication projects (e) ports and harbours (f) rail, road, highways, bridges, etc, and (g) airports.

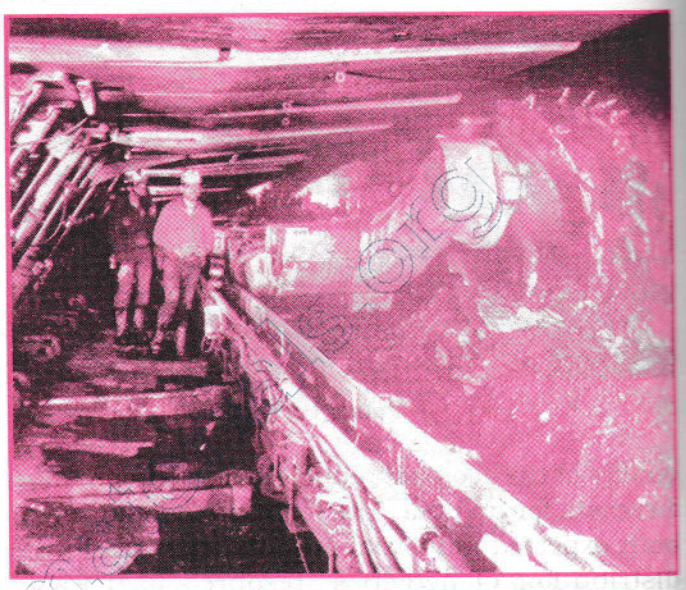


Fig. 7.5. Mining

(ii) Those which are sensistive and located in environmentally degraded areas.

(iii) Public Sector Undertakings (PSUs) of the Centre where the project cost is more than Rs. 50 crore.

(iv) Those which require the approval of the Public Investment Board/Planning Commission/ Central Electricity Authority.

(v) Other sectors such as irrigation, power, transport, tourism, communications, etc.

THE PROCEDURE

Once an application for environmental clearance is submitted together with the requisite documents, the proposal is examined by the Ministry. The expert committees assess the likely environmental impacts of the project.

They may visit sites. The committees make recommendations for approval or rejection of the proposal. The application is then processed in the Ministry for approval or rejection.

In case of projects involving sites such as mining, river valley, ports and harbours, etc, a two-stage clearance is needed.

This is to ensure that ecologically and environmentally sensitive areas are protected while locating the projects.

In case of projects, which are submitted with required documentation, a decision is taken within 90 days.

If the application is rejected, a new application may be submitted after making the suggested modifications in the project.

Thus, the main objective of EIA is to maximise the positive environmental impacts and minimise the adverse impacts.

EXERCISES

A. Short Answer Type Questions

1. What is Environmental Impact Assessment?
2. What is the use of Environmental Impact Assessment?
3. Name two projects for which Environmental Impact Assessment is mandatory.
4. Why is it advisable to have alternative plans before designing a project?
5. What is the main objective of Environmental Impact Assessment?
6. What is the importance of the Environmental Assessment Process?
7. When was Environmental Impact Assessment introduced in India?

B. Long Answer Type Questions

1. Explain the two stages of Environmental Impact Assessment.
2. Explain the process involved in Environmental Impact Assessment.
3. Why is public participation necessary for EIA? What steps should be taken to enhance public participation?
4. What is an Environmental Statement? What are its different components?
5. Explain how Environmental Impact Assessment is an important management plan.
6. What are the advantages and disadvantages of Environmental Impact Assessment?
7. Name the projects covered under Environmental Impact Assessment in India.
8. Explain the procedure for environmental clearance of a project in India.

C. Project/Activities

1. Suppose there is a pond in your locality and you want to convert it to a swimming pool. Evaluate the project using Environmental Impact Assessment.
2. Prepare a project report using Environmental Impact Assessment for a power project in your state. Conclude if the project is viable or not.

UNIT 2 – DEPLETION OF RESOURCES

CHAPTER 8

NATURAL RESOURCES

Course Content—Syllabus and Scope

Natural resources—air, water, soil, metals, minerals, forests and fuels.

Importance of these resources in our daily.

The word *resource* is used to describe the materials present in large quantities and held in reserve for future use. If these resources occur in nature, they are called *natural resources*.

A resource should satisfy any of the two following basic conditions.

1. There must be a demand for the physical substance, either in human society or in any part of the biological kingdom.
2. There should be the knowledge and technical abilities for extraction and utilisation of the physical substance.

Types of Natural Sources

(a) On the basis of renewability, the natural resources are divided into:

Renewable Natural Resources: These are those resources which have the capacity to replenish or renew by themselves. This may be through reproduction, recycling or replacement. Water, soil, and living organisms are some examples of renewable resources.

Non-renewable Natural Resources: Those resources which cannot be renewed or take a very long time to renew are called non-renewable resources. Coal, petroleum, minerals, ores, etc., are examples of non-renewable resources on earth. Such resources must be used judiciously as they will not be available once their supply is exhausted.

If the rate of use of renewable resources exceeds the rate at which they are renewed, then even these resources become non-renewable. If you cut trees regularly in a short period, the forest resources will be exhausted, because saplings will take years to grow as mature trees.

Therefore, whether the resource is renewable or non-renewable, it must be used in a judicious manner.

(b) On the basis of availability, natural resources are divided into:

Exhaustible Natural Resources: Those resources which exist in limited quantities and can be exhausted through continuous or excessive use are known as Exhaustible natural resources. Some of these are: trees, animals, coal, petroleum, minerals, ores, etc.

Inexhaustible Natural Resources: Those resources which cannot get exhausted by man's consumption; such as wind, sunlight, air, etc.

Fig. 8.1. Natural Resources

AIR

Air is the gaseous envelope that surrounds our Earth. It is also called the atmosphere. The atmosphere extends up to 400 km above Earth's surface. Living organisms cannot live without air.

Composition of Air

The main gases in the atmosphere are Nitrogen (about 78 per cent), Oxygen (about 21 per cent) and remaining 1 per cent contains Carbon dioxide (0.03 per cent), Ammonia, Ozone, Argon, Helium, water vapour and dust particles.

Importance of Air

Air is the basic necessity of human beings. Man can live for sometime without food and water, but he cannot live without air for more than a few minutes. The major components of air are used in the growth, development and survival of all organisms.

(i) Oxygen in the atmosphere is essential for the processes of respiration and metabolism. These processes are the means by which all the living organisms including human beings, derive energy needed to sustain their existence on this planet.

(ii) In the upper layers of atmosphere, oxygen gets converted into ozone. This ozone present in the stratosphere is extremely beneficial to human beings and other living organisms, as it absorbs the harmful ultra-violet rays present in the sunlight. The exposure to these rays can cause skin cancer.

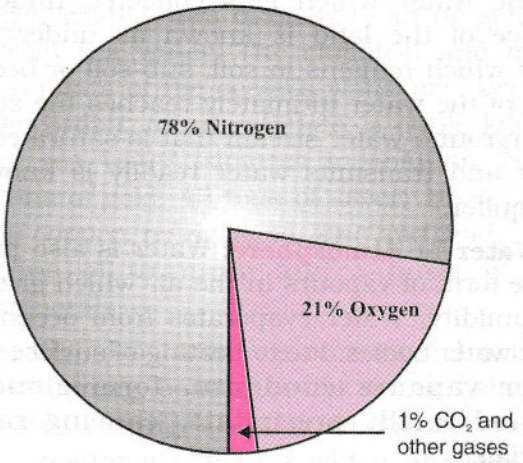


Fig. 8.2. Components of Air

Fig. 8.3. Air Around us

(iii) Nitrogen is the most abundant gas in the atmosphere. It plays an important role in slowing the rate of burning and controlling the combustion in respiration and other biological and physical processes.

(iv) Nitrogen is largely used as nitrogen fertilizers in agriculture. Nitrogen fertilizers are manufactured on a large scale from the nitrogen contained in the atmosphere.

(v) Carbon dioxide present in the air absorbs the infrared rays and keeps the earth warm. If carbon dioxide is absent in the air, these infrared rays would escape into the atmosphere and the earth would cool down very rapidly to a very low temperature.

(vi) Carbon dioxide, the quantity of which is small in the atmosphere is important for plants. Plants use carbon dioxide as a raw material for the manufacture of food by the process of photosynthesis and release oxygen as a by-product.

(vii) Moisture in the air is known as *humidity*. The more moisture the air contains, higher is the humidity. If the air becomes cold enough, the water vapour begins to change to tiny water droplets or ice crystals. This process is called *condensation*. The temperature at which water vapour begins to condense is called the *dewpoint*. If the temperature is lowered further water vapour will begin to condense and form clouds, fog or dew and falls down on earth as rain or snow. It forms the major source of water on the earth.

r is needed to hear sound. We cannot hear ıy sound in the vacuum. Most of the sounds e hear travel through air. So, without air ıman life will be soundless.

ır has weight. This weight enables balloons lled with a light gas or heated air to rise igh above the ground.

ir is used to fill tyres used in different ehicles. Without air, it would not be possible o use most of the vehicles and man would ave to walk miles together like prehistoric nen.

CHANGES DUE TO POLLUTION

ollution is defined as the contamination of y polutants like dust, smoke and harmful which cause adverse effects on human s, plants, animals and the environment.

ır pollution is also caused by the gaseous volatile hydrocarbons such as Methane, ylene and Terpenes. Some hydrocarbons like lene, which undergo chemical reactions in presence of sunlight and nitrogen oxide from tochemical oxidants (like Ozone) are harmful utants. Automobile exhausts, Methane gas Chlorofluorocarbons (CFCs) pollute the air ch cause ozone layer depletion, global ming, climate change, greehouse effect, acid ıs and health problems like lung cancer, nchitis, respiratory tract infection, skin ases, etc.

Vehicles are mainly responsible for more than per cent of total air pollution in cities and ustrial areas. The major pollutants released n automobiles, locomotives, aircrafts, etc., lude carbon monoxide (CO), unburnt lrocarbons and nitrogen monoxide. In the or metropolitan cities like Delhi, Mumbai and kata, vehicular exhaust accounts for per cent of all CO, 45 per cent of all lrocarbons, 40 per cent of all oxides and 30 cent of all suspended particulate matter.

Industries such as chemical industries, paper pulp mills, cotton mills, petroleum refineries, create a menace. The SPM levels in areas of stone crushing are more than five times the industrial safety limits. The smoke coming out from the factories has small particles of dust, carbon, metals, other solids, liquids and radioactive materials which get mixed in smoke and pollute the air. The burning of sulphur present in coal or heavy oil in thermal power plants releases SO_2 in the air.

WATER

The main sources of water on the earth are the following:

(a) Ocean Water: About 97 per cent of the earth's water supply is in the ocean which is unfit for human consumption and other uses due to high salt content. Of the remaining 3 per cent, 2.3 per cent is locked in the polar ice caps. The balance 0.7 per cent is available as fresh water but 0.66 per cent, is ground water and the rest 0.03 per cent is available to us as fresh water in rivers, lakes and streams. Thus, we see that we have a very limited stock of usable water, 0.03 per cent surface water (rivers, streams and ponds) and 0.66 per cent ground water.

(b) Water on Land: Water on land is the result of precipitation or seepage from underground which forms streams and rivers flowing on land and finally joining the sea.

(c) Underground Water: The water from precipitation, that is from rain or snow flows on the surface. Some of the water evaporates and the rest sinks into the soil.

The water which gets collected under the surface of the land is known as underground water which remains in soil, sub-soil or bedrock. Most of the water ultimately reaches the sea. An underground water stream that is saturated with water and transmits water readily is known as an aquifer.

(d) Water in Atmosphere: Water is also present in the form of vapours in the air which gives rise to humidity. Water evaporates from oceans and other water bodies due to heating of surface water.

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IMPORTANCE O

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(v) Water

hydrosphere and lithosphere is called *Hydrological Cycle*. Water cannot be created, nor it can be destroyed. It can only be transformed into different states.

Importance of Water

Water is extremely essential for life to exist on the earth.

(i) Water is required to meet our basic needs in day-to-day life, i.e., for cooking, drinking, bathing, washing, disposal of sewage, irrigation, generation of electricity and the disposal of wastes.

(ii) Water has the capacity to store a lot of heat without rapid increase in temperature. This property of water results in moderating the climate of the earth. It also has many industrial applications due to this property. The excessive heat generated during nuclear reactions is absorbed by water. Industrial processes in which heat is produced, power plants and car engines are cooled by using water.

(iii) Water is a good medium for transport. Ships and boats carry men and materials to far away places. Transporting cargo by ships is cheaper and convenient. Rivers too are used to transport man and logs of wood.

(iv) Ocean waters are replete with abundant resources. At present man extracts 65,000,000 tons of food from the ocean annually by fishing. About 200,000,000 megawatt hours of energy can be generated from sea water. The chemical and mineral contents of the ocean's water are very large. According to an estimate, a cubic kilometre of sea water contains in solution upto 25 tons of gold; 45 tons of silver; 10 to 30 tons of copper, manganese, zinc and lead; several tons of uranium and a horst of other minerals.

(v) Water also facilitates recreational activities. Swimming, boating, water skiing, fishing and river rafting are the important outdoor

Reduction in Water Resources

1. Water resources are degraded due to pollution. Global warming makes the ice caps melt and due to continuous melting of ice caps water will not be stored in the ice caps for future use. Thus, the shrinking ice caps will not have much water to supply to our rivers and streams.
2. Deforestation and lack of forest cover make the rain water drain into the seas or oceans. The water does not soak into the soil to raise the underground water table.
3. Big dams collect water in one place, without giving a chance for the large river surroundings to seep water underground.
4. Excessive drawing of underground water has emptied the ground water from the aquifers. It will take a long time to replenish them.
5. The watersheds are degraded. They do not store enough water for streams. We have failed to maintain them.
6. Rainwater is not harvested; neither the traditional water conservation methods are followed. The consequences are lack of fresh water on earth.

Lack of Access to Safe Water

Clean drinking water is necessary to prevent diseases and to maintain good health. For many of the world's poorest people, one of the greatest threats to health is lack of access to safe water. In 2002 the United Nations estimated that at least 1.1 billion people lacked access to safe drinking water. As populations grow, agriculture and industry compete for scarce water supplies. Water shortages are expected to become more severe in the near future.

Groundwater is being withdrawn from aquifers faster than natural recharge can replace it. Excessive pumping for irrigation has removed so much water that wells have dried up in many places. Recharging such aquifers will take thousands of years.

According to the United Nations estimates, at

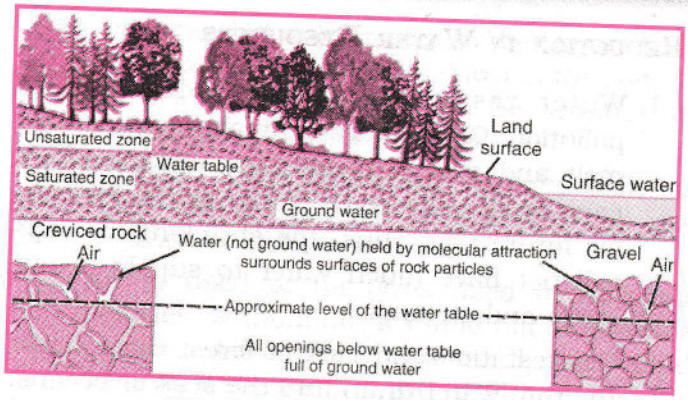


Fig. 8.4. Underground water

safe drinking water and 2.4 billion do not have adequate sanitation facilities. Increasing population and expanding development would further increase the demand for water. It is estimated that by 2024, two-thirds of the world population would be suffering from acute water shortage.

In India, the land of rivers and lakes, ironically, the problem of water scarity is more acute. The demand for water in the 35 cities, that were surveyed, is expected to double as the population of these cities rises from 10.7 crore in 2006 to 20.2 crore in 2021, while the availability of water remains at 2006 level. As a result 20 crore people are vulnerable to water wars.

Water scarity is not just an urban problem, rural India is no different. According to the Ministry of Water Resources, eight out of 20 river basins are water deficit. Of the available water, 90 per cent is consumed by the agricultural sector. Further, ground water levels have plunged in 206 out of 591 districts in India because of the use of tube-wells and hand-pumps to draw water. Nine States, namely, Rajasthan, Maharashtra, Gujarat, Haryana, Karnataka and Punjab are facing major water deficits where demands exceed supply with 1.5 million hand-pumps and 56 lakh tube-wells in operation.

Thus, India faces an impending water crisis not only because of scarcity of water but also because of unequal distribution of water resources. This is partly due to uneven distribution of rainfall, with the average ranging from 100 mm in the west to 1,170 mm in the east. Besides, while the rainfall takes place in just 100 hours spread over 100 days, the requirement is throughout the year. Consequently, every summer on an average 91 districts are hit by drought and every monsoon 40 million hectares are submerged in flood waters. So, it has been rightly observed that the next wars will probably be fought over water in water scarce regions, as most of the fresh water in the arid regions come from the shared river basins.

SOIL

The word 'soil' is derived from the Latin word 'solum', meaning the upper crust of the earth. It is the uppermost layer of the earth which is capable of supporting plant life. Soil occupies an important place in the biosphere as it is the life zone of the earth.

The soil is a mixture of solid, liquid and gaseous substances which is formed at the top of weathered layer of the earth's crust. Since it has air and water, it supports, together with the Sun's energy, all living beings on the earth.

Basically, the soil consists of the following five categories of components.

1. Basic mineral matter accumulated due to the weathering of rocks.
2. Humus, which is the soil's organic matter consists of dead plant and animal matter.
3. Soil water is the water contained in soil together with dissolved solids, liquids and gases.
4. Soil atmosphere occupies the pore space between soil particles.
5. Biological system consists of flora and fauna of bacteria, fungi, algae, protozoa, nematodes, etc.

Importance of Soil

(i) All land vegetation grows on soil. Soil provides water, nutrients and support for crops, grassland and trees which, in turn, provide us with food, fuel, fibre and timber. Thus, it becomes a necessary substance for the survival of living beings.

(ii) Soil is a medium for purification of water by filtering it. Soil helps in recycling water by absorbing it, allowing it to join the seas as

Fig. 8.5. Soil

Fig. 8.6. Erosion of Topsoil

well as making it available for human use and finally the water is evaporated and it completes its cycle through condensation and returning to the soil through precipitation.

- Soil acts as a buffer for the flow of water and solutes between the atmosphere, ground and surface waters. It also acts as a buffer for temperature change.
- Soil provides the habitat for the decomposer organisms and plays an essential role in the cycling of carbon an mineral nutrients.
- Soil is used in building construction, brick kilns, etc.
- Soils in the alpine zone above 5000 m help in conserving perennial flow of the rivers.

Soil Erosion

Soil erosion means the wearing away of soil. Soil erosion is defined as the movement of soil components, especially surface litter and topsoil from one place to another. Soil erosion results in loss of fertility of the soil because it is the topsoil layer which is fertile. Removal of the topsoil layer is caused by two factors:

1. *Natural processes* like torrential rains, natural flow of water along slopes, run-off, wave action, melting and movement of snow and movement of winds.
2. *Human activities* like deforestation, mining, overgrazing, etc. Deforestation without reforestation, overgrazing by cattle, surface mining without land reclamation, irrigation techniques that lead to salt built-up, water-logged soil, farming on land with unsuitable terrain and soil compaction by agricultural machinery, etc. make the topsoil vulnerable to erosion.

Due to these activities topsoil is disturbed and rendered devoid of vegetation cover. Overgrazing accounts for 35 per cent of the world's soil erosion while deforestation is responsible for 30 per cent of the earth's seriously eroded lands. Unsustainable methods of farming also cause 28 per cent of soil erosion.

MINERALS—METALLIC AND NON-METALLIC

A mineral is an inorganic substance that is found in Earth's crust. Most minerals have definite chemical and physical properties. A mineral in its natural unmined form is known as an ore. Minerals are a non-renewable resource. Once exhausted, they cannot be replenished easily. Minerals are used in industries and they are a basic natural resource for development.

Minerals are classified into three groups on the basis of their use metallic, non-metallic and fuels. Coals, oil and natural gas are fuel minerals. The important metals are iron, copper, lead, platinum, silver and gold. The non-metallic minerals are known as industrial minerals. They have more than one metal as part of their chemical formulae. Examples of such minerals are: phosphates, gypsum, salt, clay and sand. Industry uses about 80 of the known minerals.

Importance of Minerals

The economic development of a country is influenced by the availability of minerals. Minerals form the base for several large-scale industries. Agriculture, too, is influenced by the availability of minerals in the form of fertilizers.

(i) Modern farming, which is considerably dependent upon the use of minerals like potassium, phosphorus, nitrogen, etc., could not feed millions of people without their use.

(ii) Minerals play an important role in maintaining human health. Minerals are one of the food constituents. Human beings use processed small quantities of minerals like iron, zinc, copper, calcium, etc., in their dietary requirements.

(iii) Minerals are used for making arms and ammunition, nuclear bombs and missiles.

(iv) Industrialisation depends solely on the use of minerals.

(v) Steel, used in the construction of houses is obtained from a mineral containing iron. Cement is obtained from limestone.

(vi) Minerals are used for making pottery, glass enamel, ornaments, etc.

Characteristics of Mineral Wealth

(a) Exhaustible: Minerals are finite, i.e., non-renewable resources. Once they are mined, they are depleted and they cannot be replenished.

(b) Unpredictable: The location, availability, types of mineral to be found, the extent of depth and cost of mining is unpredictable.

(c) High Risk: Mining is a risky adventure. During the process of mining there are many hardships like high temperature, pressure differences, lack of drainage and ventilation. There are also many dangers like collapse of roofs and walls, explosions, fire and gas hazards.

(d) Other Factors: Mineral resources are spread over many countries. Their unequal distribution has an international competition in trade. So, there is a fluctuation in prices, availability and demand in industries.

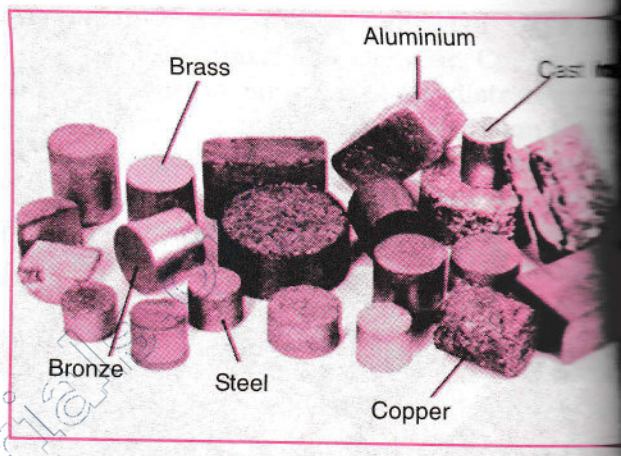


Fig. 8.7. Minerals

Use of Metallic and Non-Metallic Min

Mineral	Use
Aluminium	Air-conditioning ducts, packa of medicines and other mate cables.
Copper	Alloy in gold jewellery, silver electric wire, cooking ute etc.
Gold	Jewellery, medicine.
Iron	Structural material like components of steel.
Lead	Pipes, battery electro pigments.
Mercury	Thermometer, dental inlays.
Nickel	Metal plating, coins.
Phosphorous	Fertilizers, detergents, medic
Platinum	Jewellery.
Potassium	Fertilizers, photography, glass
Silver	Jewellery, utensils, alloys.
Sulphur	Insecticides, rubber tyres.
Tin	Cans, containers, alloys.
Uranium	Nuclear reactors, electricity.

Limited Availability of Minerals

Demand for minerals is increasing worldwi the population increases and the consum demands of individuals increase. The min the earth's natural resources is, there accelerating, and it has accompan environmental consequences.

Human wealth basically is generated three soruces – agriculture, manufacturing mineral resources. The complex modern s

built around the exploitation and use of mineral resources. But these mineral resources are limited. It has been estimated that our known supply of minerals will be used up in the third millennium. Furthermore, modern agriculture and the ability to feed an overpopulated world is dependent on mineral resources to construct the machines that till the soil, enrich it with mineral fertilizers and to transport the product.

Once a mineral is mined, the deposit gets depleted and is lost forever without any chance of replenishment. Over consumption or waste of these finite resources cannot be allowed. Some of the minerals are on the verge of extinction in coming 20-100 years. Present rates of consumption dictate minimal waste, wise use and reuse of minerals.

FORESTS

The word forest is derived from the Latin word foris, which means outside. Originally, it meant uncultivated land outside the village boundary. In India, forests form 20.55 per cent of the total land area. A forest is a natural self-sustaining community having a vertical shape created by trees. It is a natural ecosystem which has multi-species as dominant community.

Importance of Forests

Forests have the following importance in our daily life:

(i) Productive Functions: Various trees provide us with products such as fruits, leaves, roots and tubers of plants. Besides, forest animals also provide food to some of the tribes in the form of meat. Wood is used for making furniture in houses as well as industrial units. Wood and bamboo pulp are used for manufacturing paper and paper boards. Wood is used indiscriminately as a source of energy for cooking and for providing warmth.

Forest products, other than timber and firewood, include fibres, essential oils, oil seeds and edible plants. Bamboos provide a means of livelihood for the tribals who make mats, baskets, pipes, etc., using bamboo. It is also used in the manufacture of rayon (yarns and artificial silk fibres).

(ii) Protective Functions: Forests control the water flow. The thick layer of humus in the forests prevents evaporation of water. The humus acts as a natural sponge and helps to soak the rain water in the soil. The forest with its complex root system binds the soil thereby preventing soil erosion and loss of nutrients. The thick humus over the years is formed by the decay of forest litter, which increases the fertility of the soil.

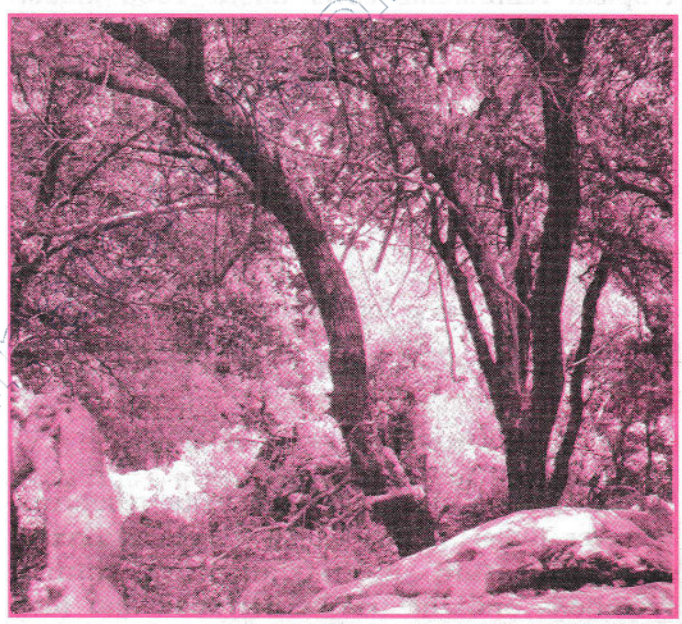


Fig. 8.8. Forests

(iii) Regulatory Functions: The trees use carbon dioxide from respiration and release oxygen during photosynthesis. The oxygen released by the trees is used by the animal world. Thus, the trees perpetuate the cycles of oxygen and carbon dioxide in the biosphere. They also regulate the water cycle. The trees absorb water from the ground, release water (during transpiration) into the atmosphere which helps to form clouds and precipitation, which brings water again into the soil, thus completing the Water Cycle.

(iv) Accessory Functions: Accessory functions of the trees means that the forests provide habitat for the wildlife. Forests also provide aesthetics and recreation to human beings through National Parks, Wildlife Sanctuaries and Biosphere Reserves.

Extent of Forest Cover in India and the World

Forests are one of the significant features of land surface. They vary greatly in composition and

density and stand in marked contrast to meadows and pastures. Twenty-one percent of the earth's land is covered by indigenous forests which account for 10 billion acres. Of these, 57 million acres of tropical forests exist in South America, 40% of moist forests in tropical Africa and 37% of moist forests remain in Asia. The Tropical Rainforests cover about 1000 million hectares of land in the world – more than a quarter of the total world forest cover, *i.e.*, 8.3 per cent of the total land area on the earth. These forests are the home of more than 13 million distinct species of plants and animals, *i.e.*, more than half of the world's total number of species.

The forest cover in India is 6,75,738 sq. km and constitutes 20.55 per cent of its geographical area. Of this, dense forests constitute 12.68 per cent and open forests 7.87 per cent.

Implications of Destruction of Forest Cover

Forests are the most important biotic resources. However, indiscriminate felling of trees as a result of urbanisation, industrialisation, mining operations and the use of fire-wood and fuel-wood is causing depletion of forests. In the last 100 years, the destruction of forests for expansion of agriculture and roads, towns, factories has increased.

According to the report of the National Biodiversity Strategy and Action Plan, India has lost over 50 per cent of its forest cover, 40 per cent of its mangroves and a significant part of its wetlands in the past two centuries. If the present rate of depletion is allowed to continue unabated, India will be heading towards the situation of zero forests in about 20 years.

The depletion of the forest cover can have serious implications. The forest cover has a great value for mankind, ensuring economic development, preserving environmental quality and maintaining the basic needs of the rural population. Forests not only provide wood, fibre, fuel and shelter, but have immense importance in the protection of the soil and maintenance of the climatic and environmental stability. So the depletion of forest cover will have the following

(i) Soil erosion due to reduction o vegetational cover.

(ii) Reduction in the oxygen liberated by plants through photosynthesis.

(iii) Habitat destruction of wild animals.

(iv) Increase in pollution due to burning o wood as fuel and due to reduction in carbon dioxide fixation by plants.

(v) Decrease in availability of forest products

(vi) Loss of cultural diversity.

(vii) Loss of biodiversity.

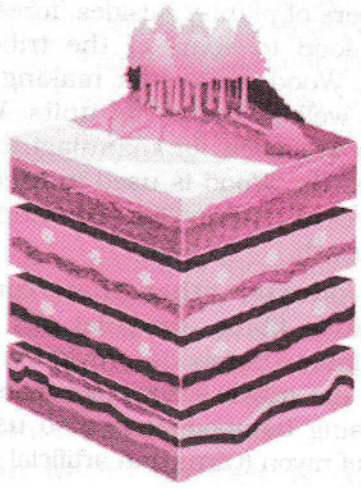
(viii) Lowering of the water table due to more run-off and thereby increased use of the underground water leading to increased frequency of droughts.

(ix) Scarcity of forest products and deterioration in economy of people residing near forests.

(x) Rise in carbon dioxide level results in increased thermal level of earth which in turn results in melting of ice caps and glaciers and consequent flooding of coastal areas.

FUELS

Fuel is a material that provides useful energy. Fuels are used to heat and cool buildings, cook food, power engines and produce electricity. Some fuels occur naturally and others are artificially created.



Natural fuels such as coal, petroleum and natural gas are obtained from underground deposits that were formed millions of years ago from the remains of plants and animals. These fuels are, therefore, called fossil fuels. Fossil fuels, account for about 90 per cent of the energy people use today.

Fossil Fuels

The energy of the fossil fuels is derived from the energy of the Sun. It is believed that solar energy was trapped in the fossils through natural processes millions of years ago. We shall discuss these coal, petroleum and natural gas.

Coal

It is found in the deeper layer of Earth. It is mined out from coal mines. It is a very useful fuel and one of India's most important natural resource.

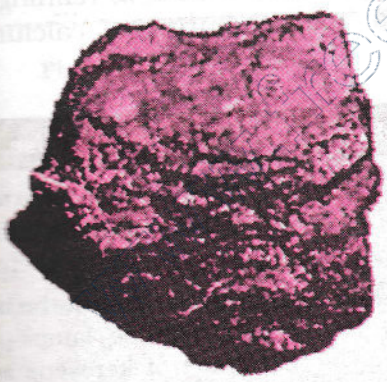


Fig. 8.10. Coal

Coal is formed from dead plants by a process of destructive distillation and carbonification.

It is believed that due to volcanic activity and earthquakes, which occurred about 300 millions of years ago, large areas of forests were buried in earth.

Over a period of several thousands of years, these trees were covered by layers of soil and rocks. Due to intense heat and pressure and absence of oxygen in the deeper layers of Earth, plants burnt incompletely and were converted into coal. This process is called *destructive distillation* or

Varieties of Coal

Coal can be divided into four varieties:

1. Anthracite Coal: It is hard coal, black in colour and is ideal for domestic use since it burns slowly without smoke. It has a high energy value (i.e., gives off a lot of heat when burned). This is the best quality of coal.

2. Bituminous Coal: It has 50 per cent to 80 per cent carbon, with a good energy value. Bituminous coal can be subdivided into
(a) coking coal, which is used in blast furnaces.
(b) gas coal, which is used for making gas, and
(c) steam coal, which is nearly smokeless and is used as household coal, and in steam powered vessels.

3. Lignite: It is brown in colour. It has 60 per cent carbon and gives off a low heat. Its use is in the production of thermal electricity.

4. Peat: It is loose in structure. It gives less heat, and leaves a lot of ash after burning.

Fig. 8.11. Peat

Importance of Coal

(i) Coal provides about 28 per cent of all commercial energy used in the world. Coal is used chiefly to produce electricity and steel. Coal also provides heat and power for many other industries.

(ii) Besides being used as fuel, coal is also used for obtaining products like *coal gas* (a mixture of hydrogen, methane and carbon monoxide), *ammonical liquor*

CHAPTER 13

CLASSIFICATION OF WASTE

Course Content—Syllabus and Scope

Classification of waste—biodegradable, non-biodegradable; toxic, non-toxic, bio-medical.
Biodegradable waste: Paper, rags, vegetable peels.
Non-biodegradable waste: Plastic, styrofoam, cans and glass.
Biomedical waste: Needles, syringes, soiled dressings, pathological waste from hospitals, medical labs.
Toxic waste: Radioactive waste, mercury, lead, DDT.
Non-toxic waste.

CLASSIFICATION OF WASTE

Demand for goods is increasing day by day at a very fast rate due to rapid industrialisation and population explosion. This, in turn, has resulted in increase in the quantity and variety of waste generated. Wastes can be classified into the following categories:

1. Biodegradable Wastes
2. Non-biodegradable Wastes
3. Toxic Wastes
4. Non-toxic Wastes
5. Biomedical Wastes
6. E-Wastes.

1. BIODEGRADABLE WASTES

Wastes that can be degraded or broken down through microbial activities of fungi and bacteria are called *biodegradable wastes*. Wastes which come from agricultural and horticultural sources are easily biodegradable. Excretory products of animal origin and dead bodies of plants and animals are decomposed by micro-organisms into simple inorganic compounds.

Fig. 13.1. Gobar Gas Plant

Biodegradable wastes can easily serve as alternate sources of energy. Gobargas (biogas) is an example of conversion of biodegradable wastes into energy.

Biodegradable wastes can be classified into:

(a) Simple Biodegradable Waste: These wastes are easily broken down by natural processes of decomposition. Leaves, vegetable peels plant remains, faecal remains, waste water, dead plants and animals all belong to this category.

(b) Complex Biodegradable Waste: The waste material that comes under this category is not easily decomposed. They are resistant to natural processes of decomposition. However, over a long period of time, they can be decomposed. For example, glass bottles take a million years to decompose, leather shoes takes 30-40 years, tin cans 50-100 years. We must be careful while disposing of waste material under this category.

2. NON-BIODEGRADABLE WASTES

Wastes which cannot be degraded or broken down through microbial activities are called *non-biodegradable wastes*. Such wastes include crude petroleum, plastics, styrofoam products, cans, glasses, polymer, synthetic pesticides, radioactive fall-out, some industrial effluents and metals like lead.

Fig. 13.2. Plastic Waste

Plastics has replaced the traditional material (paper/cloth etc.,) as packing and carry bags because of cost of convenience. But this has led to substantial growth in the consumption of plastics and increased production of plastic waste. The plastic waste is considered as environmental hazard due to the "Throw away culture". The hazards plastics pose are numerous.

The land gets littered by plastic bag garbage presenting an ugly and unhygienic seen. The "Throw away culture" results in these bags finding their way in to the city drainage system. The resulting blockage causes inconvenience and difficulty in maintaining the drainage. It also creates unhygienic environment resulting in health hazard and spreading of water borne diseases.This littering also reduces rate of rain water percolation, resulting in lowering of already low water levels in our cities. The soil fertility deteriorates as the plastic bags form part of manure and remain in the soil for years. It has been observed that the animals eating the bags sometimes die. Plastic goes into the ocean which is already a plastic infested body of water. Fish and other marine species in the water ways, misunderstanding plastic garbage as food items swallow them and die.

Another form of plastic is *styrofoam* which is a pure solid, hard with limited flexibility. It is used for making disposable cutlery, plastic models, CD and DVD cases, etc. Products made of styrofoam are available everywhere as packing materials, insulation, coffee cups, etc. They are thrown after one use and so discarded styrofoam

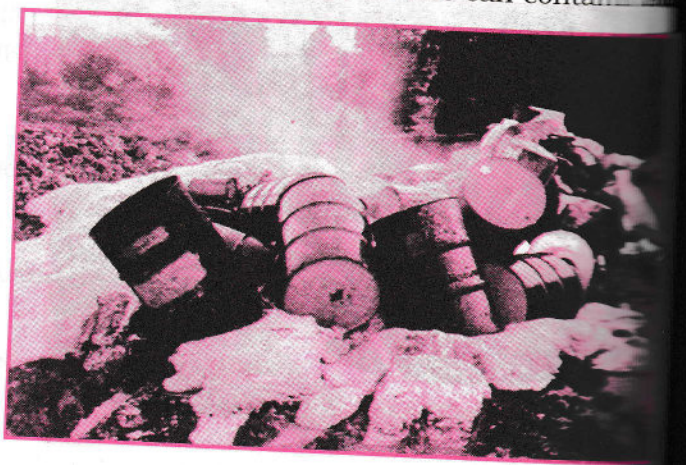
products which do not biodegrade are abundance in the outdoor environment. This because they are light in weight and can float water and blow in winds.

Rapid industrialisation during the past decades has changed our lifestyles. That is we produce more of non-biodegradable wastes such as polythene bags, empty containers plastics, etc. Non-biodegradable wastes persist in the environment for a long time. biomagnified, become toxic and cause health problems.

Scientists all over the world are trying to find out devices to degrade non-biodegradable material. Some species of bacteria have been developed that can degrade even some types of plastics. An India-born American scientist Dr. A. N. Chakraborty, has produced a genetically engineered species of bacterium *Pseudonymus* which can decompose some of the synthetic pesticides. In India, scientists are also working to develop biodegradable plastics.

3. Toxic Wastes

Certain wastes are classified as toxic wastes because they pose a serious threat to human health and the environment. These wastes result from industrial processes and products. They also include chemicals used in modern agriculture and medical waste from hospitals. The use of chemicals has increased causing health hazards to living beings. They produce toxic wastes during their manufacture. If allowed into the environment, these toxic wastes can contaminate



pollute water and enter the food chain, plants, animals and human beings. Most the pesticides sprayed on the crops fall on the as waste and enter the local water supply when this soil drains away into the rivers lakes.

Radioactive wastes are toxic. They include by-products obtained from the processing of radioactive materials, wastes from nuclear reactors, wastes generated from hospitals and industry, etc. Industries not directly connected the nuclear industry may also produce large quantities of radioactive waste, but their waste is usually low level waste, which is only slightly contaminated but still dangerous if it enters human body through ingestion, inhalation, absorption or injection.

Mercury is a heavy silvery-white metal that is liquid at room temperatures. It is commonly used in thermometers, nano-meters, and barometers, thus it is present in nearly every chemistry and physics lab. Confined in such instruments mercury itself is not likely to cause health problems, but if there is a means for mercury vapour to enter the environment, these highly toxic vapours present a health hazard.

Mercury is a powerful poison. Presence of mercury even in small amounts, is more toxic than lead, cadmium and even arsenic. Some of the most common signs and symptoms of mercury exposure include irritability, fits of anger, lack of energy, fatigue, low self-esteem, drowsiness, decline of intellect, low self-control, nervousness, memory loss, depression, anxiety, shyness/timidity and insomnia.

When mercury enters bodies of water, biological processes transform it to methyl-mercury, a highly toxic and bioaccumulative form. Fish can absorb methylmercury from their food and directly from water as it passes over their

Most people are exposed to mercury by eating fish containing mercury. There is no method of cooking or cleaning them that will reduce the amount of mercury in a meal. The first occurrence widespread mercury poisoning in humans occurred this way in Minamata, Japan, now called *Minamata disease*.

Fig. 13.4. Person affected by Minamata disease

Lead is a poisonous metal that can damage nervous connections (especially in young children) and cause blood and brain disorders. Because of its low reactivity and solubility, lead poisoning usually only occurs in cases when the lead is dispersed, like when sanding lead based paint, or long term exposure. Long term exposure to lead or its salts can cause abdominal pains.

Lead as a soil contaminant is a widespread issue, since lead is present in natural deposits and may also enter soil through (leaded) gasoline leaks from underground storage tanks or through a wastestream of lead paint or lead grindings from certain industrial operations.

Lead that is emitted into the atmosphere can be inhaled, or it can be ingested after it settles out of the air. It is rapidly absorbed into the bloodstream and is believed to have adverse effects on the central nervous system, the cardiovascular system, kidneys, and the immune system.

Some of the commercial toxic wastes are arsenic, cyanide, lead, cadmium, nickel, beryllium, uranium and mercury and their compounds, chlorinated solvents, asbestos, organo-chlorine pesticides, photographic wastes, plating sludges, pesticide residues, waste paints and lubricants. Burning produces oxides of sulphur and nitrogen which become toxic at high concentration.

Sources of Toxic Wastes

Element	Sources
Lead	Auto exhaust (from gasoline, paints, storage batteries, pipes)
Cadmium	Coal, zinc, incineration of plastic containers, refining of metals, tobacco somke.
Nickel	Combustion of coal, diesel, residual oils, tobacco smoke, chemicals and catalysts, steel and non-ferrous alloys manufacture.
Mercury	Combustion of fossil fuels, evaporation from ore mining, exhausts from metal smelters, chloroalkali cells, paints, pharmaceuticals.
Beryllium	Ceramic industry, rocket motor test facilities, coal combustion and Nuclear Power industry.
Asbestos	Vehicle brakes and asbestos industries.

Electronic waste or E-waste is another toxic waste. It refers to any broken or unwanted electrical or electronic appliance. It includes computers, entertainment electronics, mobile phones and other items that have been discarded by their original users. While there is no generally accepted definition of E-waste, in most cases E-waste consists of expensive and more or less durable products used for data processing, tele-communications or entertainment in private households and business.

This is a modern phenomenon in our civilisation where computers are used in homes, offices and other establishments. After a short while the computer becomes obsolete and its keyboard, mouse, monitor and central processing unit becomes waste products. Since these cannot be recycled, they are dumped in isolated places as E-waste. It is a point of concern considering that many components of such equipment are considered toxic.

E-waste is both valuable as source for secondary raw material and toxic if treated and discarded improperly. Due to lower environmental standards and working conditions in China and India, E-waste is being sent to these countries for processing in most cases illegally. Bangalore in India and the Guiya area in the Chaozhou region of China have E-waste processing areas. Uncontrolled burning and disposal are causing environmental problems. It is of concern largely due to the toxicity of some of the substances like lead, mercury, cadmium, etc. A typical computer monitor may contain more than six per cent lead by weight. Up to 36 separate chemical elements are incorporated into E-waste items. The unsustainability of discarded electronics and computer technology is another reason for the need to recycle or perhaps more practically, re-use E-waste.

E-waste presents difficulties for recycling due to the complexity of each item and lack of viable recycling systems. Many of the plastics used in electronic equipment contain flame retardants. These are generally halogens added to the plastic resin, making the plastic difficult to recycle.

Fig. 13.5. E-waste

4. Non-Toxic Wastes

Some of the solid wastes are generated due to domestic activities such as food-leftovers, fruit and vegetable peelings, bits of paper and other rubbish often stored in dustbins. The wastes produced by shops, offices, restaurants and schools do not pose a serious problem to the animals, plants or to the environment. Such wastes are called Non-toxic Wastes.

Non-toxic wastes are mostly biodegradable and after decomposition become a part of nature.

5. Bio-medical Wastes

Bio-medical wastes are wastes that are generated from the activities performed in hospitals. These wastes include needles, syringes, soiled dressings, pathological wastes such as blood, tissues, body parts, body fluids, human foetuses, chemicals used for pathological tests, infectious wastes like cultures and stock of infectious agents, wastes from surgery and autopsy used and discarded medical instruments such as scalpels, blades and other glass materials, empty plastic bottles, polythene bags, tubes, gloves etc. expired medicines including pills, capsules, chemicals, etc., and containers having innocuous or inert gas and aerosol from hazardous wastes.

Fig. 13.6. Bio-medical Waste

EXERCISES

A. Short Answer Type Questions

1. Name the categories into which waste can be classified.
2. Name two biodegradable and two non-biodegradable wastes.
3. What are toxic wastes? Give two examples of toxic wastes.
4. What are non-toxic wastes? Are they degradable?
5. What is bio-medical waste? Give two examples of bio-medical waste.
6. What is radioactive waste?

B. Long Answer Type Questions

1. Explain how toxic wastes pose a serious threat to human health and environment.
2. Distinguish between the following:
   (*a*) Biodegradable waste and non-biodegradable waste.
   (*b*) Toxic wastes and non-toxic wastes.
3. Explain how biodegradable wastes can be converted into sources of energy.
4. How do we produce more of non-biodegradable wastes?
5. How are non-toxic wastes less harmful than toxic wastes?
6. Explain the harmful effects of using plastics.

C. Project/Activities

1. Find out the types of waste found in and around your house. How is it disposed of?
2. Organise a debate on the topic given below:
   'Use of plastic bags should be banned.'

Fig. 14.5. Eutrophication Resulting in Death of Fish

Water pollution occurs when people put a large amount of waste into a water system, and the natural cleansing process in the water bodies cannot function properly.

Eutrophication: It is the process of depletion of oxygen from waterbodies occurring either naturally or due to human activities. The process of eutrophication takes place due to introduction of nutrients and chemicals through discharge of domestic sewage, industrial effluents and fertilizers from agricultural field. Algae and phytoplankton use carbon dioxide, inorganic nitrogen and phosphate from the water as food. They serve as food for microscopic animals (zooplankton). Small fish feed on these zooplanktons and large fish in turn consume these small fish. When nutrients become abundant due to waste accumulation, the growth of phytoplankton and algae increases. Consequently, the penetration of oxygen, light and heat into the waterbody is reduced. This causes death of most of the aquatic organisms, draining water of all its oxygen.

HEALTH HAZARDS

Spread of Disease Through Contamination

Several incidents around the world have demonstrated the potential harm of accumulation of waste to human health. People suffer and die every day from illness related to hazardous waste. Industrial wastes contaminate food and water supply posing a severe threat to public health. Lead is a harmful toxin and it can affect the development of a child's brain. Asbestos can cause asbestosis, as well as chest and lung cancer. Mercury is a highly toxic chemical which attacks the nervous system, causing brain damage and even death. Arsenic is another chemical that has been shown to cause cancer.

Effects of Toxic Particulate Materials

1. Lead: Affects blood system, behavioural disorders and can also cause death.

2. Cadmium: Cardiovascular diseases and hypertension, kidney damage.

3. Nickel: Respiratory symptoms, lung cancer.

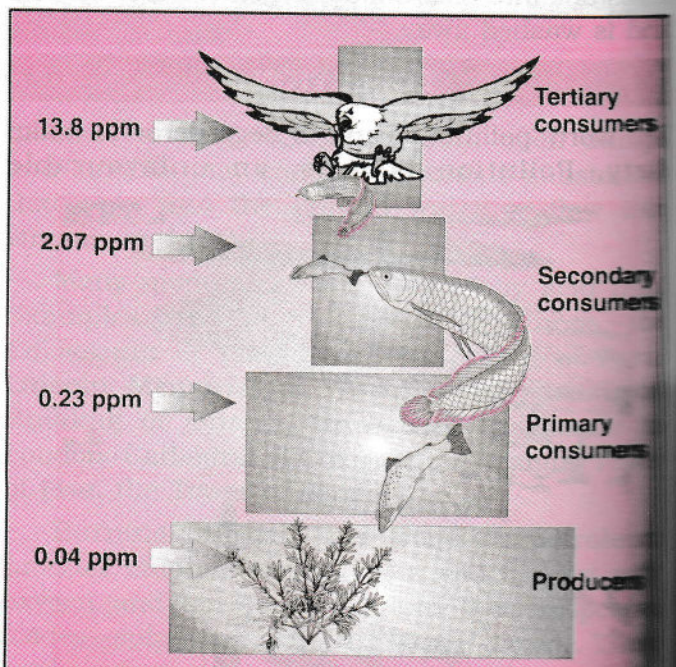
4. Mercury: Nerve and brain damage, kidney damage.

5. Beryllium: Causes berylliosis. Affects mucus membrane of eyes and lungs. Causes shortness of breath, weight loss, lung cancer and affects heart.

6. Asbestos: Causes asbestosis, shortness of breath, pleural calcification and lung cancer.

Biomagnification

The term *Biomagnification* means increasing the concentration of various toxic substances along



The numbers are representative values of the concentration in the tissues of **DDT** and its derivatives (in parts per million, ppm)

the food chain. Toxic substances at the level of primary producers get concentrated at each trophic level as they move up the food chain. The phenomenon of concentrated toxic deposition at the higher trophic level is known as *bio-accumulation*. A small amount of toxic constituent which is neither excreted nor metabolised, gets increased as the food chain moves upward from one trophic level to the next and the toxic constituents become concentrated.

An example of the phenomenon of Bio-magnification was first noticed in Illinois (USA) where elm trees were sprayed with DDT. A large number of birds like robins died near these trees. It was later discovered that these birds perished due to DDT poisoning. The lethal dose came from earthworms which they consumed. Earthworms had concentrated DDT residue by feeding on fallen elm leaves.

Radioactive waste produced by nuclear reactors and weapon factories cause a potentially serious environmental problem. Radioactive waste, although present in small quantities, remains extremely harmful to human health for many years.

EFFECT ON TERRESTRIAL LIFE

Accumulation of solid waste looks ugly, smells bad, attracts insects, rats and other animals that spread diseases. Burning of waste in the open dumpyards causes smoke and foul smelling air. In addition, rain water can drain through refuse and carry harmful substances to different places.

Fig. 14.8. Waste not, want not!

Sanitary landfills are not fit for human settlements because methane and carbon dioxide gases start coming up in the first two years. These gases are produced when solid wastes start decomposing underground.

Urban and industrial dusts have dangerous chemical properties that cause harm to terrestrial life. They cause:

(i) Different types of leaf injuries.

(ii) Decrease in transpiration.

(iii) Reduction in photosynthesis.

(iv) Reduction in biological nitrogen fixation.

(v) Increase in respiration rate.

(vi) Reduction in biomass causing loss of productivity and economic yield.

EFFECT ON AQUATIC LIFE

Untreated sewage contains disease-carrying bacteria which consume excess of algae and use up oxygen, causing aquatic life to perish.

Pesticides which destroy soil productivity can also flow into ground water or other water systems and poison aquatic life. Carelessness and the deliberate dumping of wastes and oil spills in the seas and oceans pollute wate damage beaches. Marine pollution is a threat to sea-life (plants and animals). Oil fish, birds and marine mammals, killing of them.

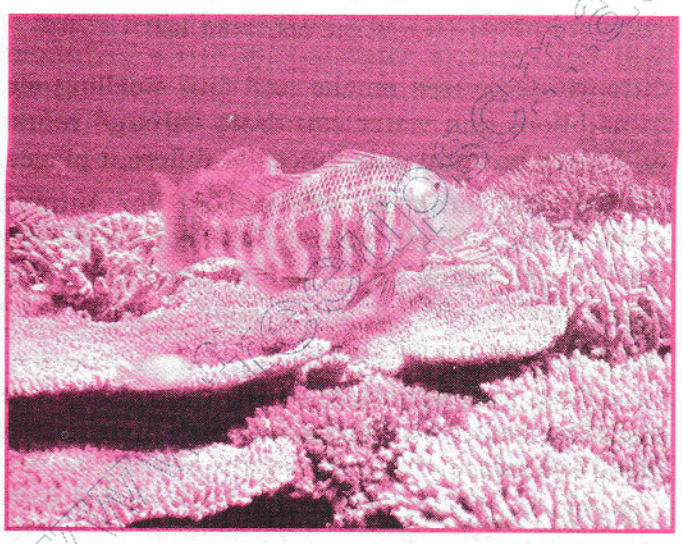
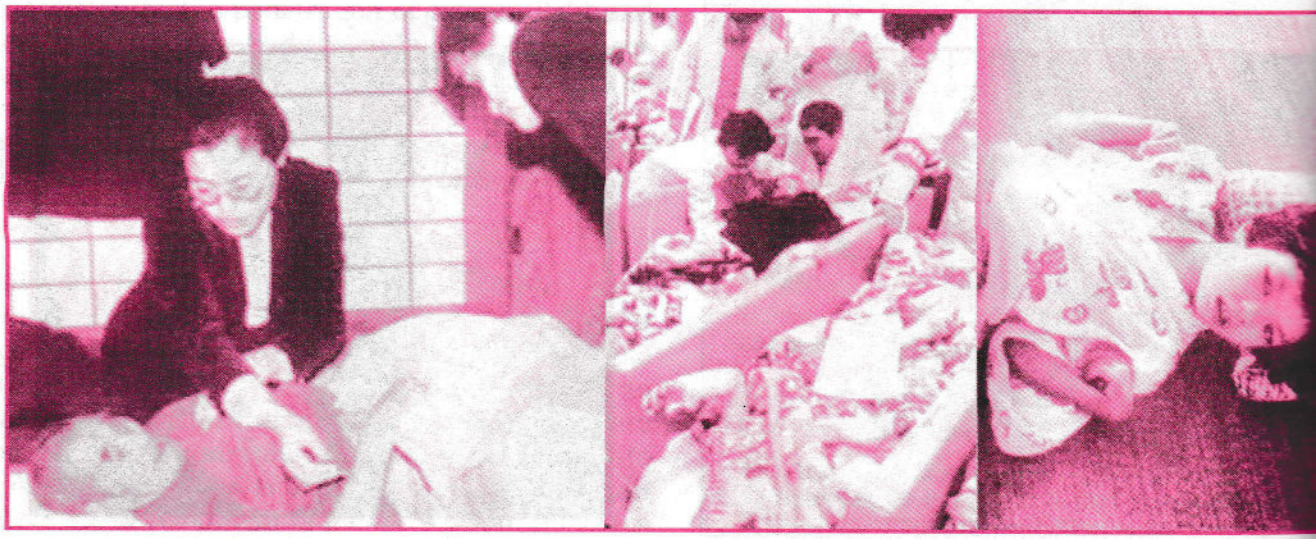


Fig. 14.9. Aquatic Life

CASE STUDY: MINAMATA TRADEDY

Minamata, a coastal town of Japan had a f of Vinyl Chloride in 1952. It used to disc effluents with methyl mercury into the Methyl mercury can break the barrier be blood cells and nerve cells. Thus, it reaches to cause progressive irreversible damage. In some fishermen fell ill in Minamata and illness was detected to be caused by consu fishes caught from the Minamata Bay. F in Minamata Bay was banned in 195 mercury was identified to be the reaso toxicity. The epidemic in Minamata is known as 'Minamata Disease'. Mercu Minamata contaminated and killed differen bird species feeding on fishes.

Mercury contamination also results wastes of other industries like paper and industry, chlorine industry, pesticide industu Pesticides with mercury add a conside proportion of mercury to natural water bod



CHAPTER 15

NEED FOR MANAGEMENT OF WASTE

Course Content—Syllabus and Scope

Need for management of waste.

Self-explanatory.

The problem with waste is that it remains in our environment. We move waste from one place to another but never get rid of it completely. Nature has recycled waste materials for millions of years. However, human population has increased so rapidly during the last century that the environment is now threatened by our activities and the wastes they produce. This damage is done to the environment by the pollution of air, degradation of soils and contamination of water sources such as rivers, lakes, etc.

Many scientists believe that if we do not learn to use our resources carefully and to reduce waste, we will not be able to survive. There is a close connection between waste, pollution and the damage to the environment. Waste causes pollution, which in turn causes the damage. Hence, there is an urgent need for management of waste.

The following dangers, posed by global pollution due to accumulation of wastes, threaten the survival of the ecosystem and call for the need to manage waste.

TRANSMISSION OF DISEASES

WASTE ON LAND: Various diseases spread on an epidemic scale due to waste accumulation on land and water bodies. Vectors like flies, mosquitoes, rodents and pet animals transmit these diseases. The waste is a breeding ground for such vectors. Hence, there is an urgent need to manage waste disposal in an effective manner. Here is a list of common diseases spread by mosquitoes, flies,

2. Sand fly: Kala-azar, sandfly fever, etc.

3. Tsetse fly: Sleeping sickness.

4. Mosquitoes: Malaria, filaria, yellow fever, dengue, encephalitis, etc.

5. Rodents: Plague, salmonellosis, encephalitis, etc.

6. Pet animals:

(a) *Dog* – Rabies, hydrated diseases, etc.

(b) *Cat* – Dermatophytosis, anthrax, etc.

WASTE IN WATER: Water without human interference is in its pure form. Industrialisation and urbanisation pollute water in the following manner.

(i) Sewage contains decomposable organic matter together with pathogenic agents.

(ii) Industrial and commercial waste has toxic agents including metal salts and complex synthetic organic chemicals.

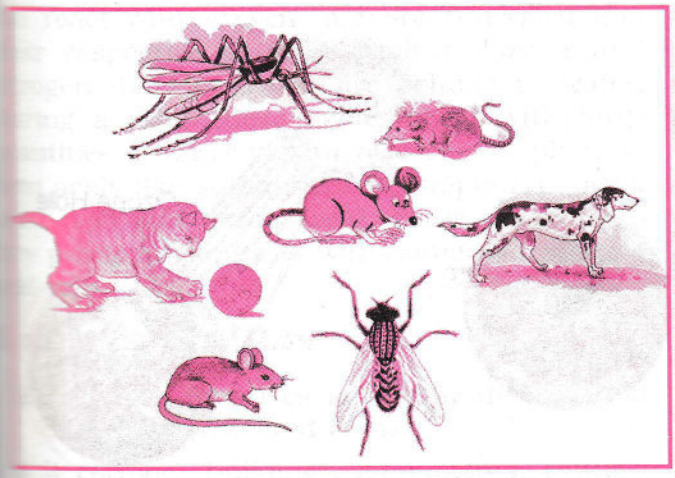


Fig. 15.2. Carriers of Disease

(iii) Agricultural practices produce pollutants such as fertilizers and pesticides.

(iv) There are also other pollutants like radioactive substances.

Human beings are affected:

(a) by drinking contaminated water,

(b) by using contaminated water for purposes of personal hygiene and recreation.

Some of the common water-borne diseases are:

(i) *Viral*: Viral hepatitis, diarrhoea, etc.

(ii) *Bacterial*: Cholera, typhoid, dysentery.

(iii) *Protozoan*: Amoebiosis, diarrhoea.

(iv) *Helminthic*: Round worm, whip worm, thread worm.

GREENHOUSE EFFECT AND GLOBAL WARMING

The rate of absorption of solar radiation by earth and its emission back into space as infra-red waves balances the heat on earth. This phenomenon plays a very important role in maintaining surface temperature of earth. The carbon dioxide and other gases form a blanket around the globe which prevents the passage of infra-red waves from earth back into space. Concentration of solar radiation produces much heat, making earth a very warm place. This phenomenon is similar to that of greenhouse in which the glass enclosed area gets heated up due to its insulation from the rest of the environment. Hence, warming of the atmosphere due to the greenhouse effect. Hence, Global Warming is also known as Greenhouse Effect.

GREENHOUSE GASES

There are five gases which are mainly responsible for the Greenhouse Effect and Global Warming. These gases are known as Greenhouse Gases. They are :

(i) Carbon dioxide (CO_2)

(ii) Methane (CH_4)

(iii) Nitrogen oxide (Nitrous oxide)

(iv) Chloroflurocarbons (CFC)

(v) Water vapour.

EFFECT OF CARBONDIOXIDE: Human activities like burning of fossil fuels increase the carbon dioxide content in the atmosphere. The increased concentration of carbon dioxide may bring about drastic changes in the world climate in the near future in the form of increased temperatures or global warming.

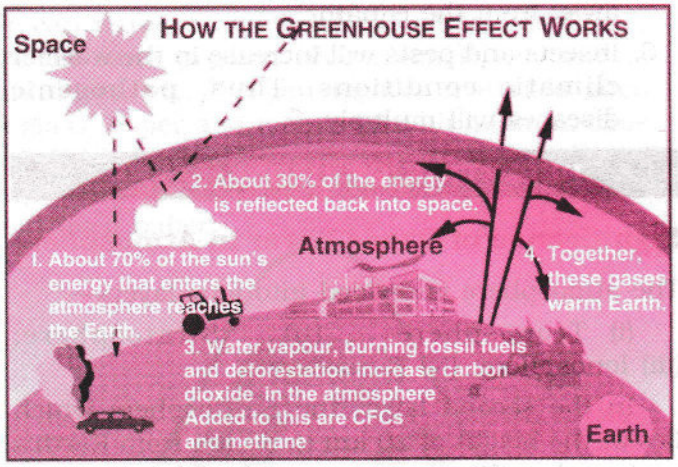


Fig. 15.3. Greenhouse Effect

If the carbon dioxide content of the atmosphere increases steadily it will result in increase in the present world temperature by about 3.6°C. It is estimated that if the earth continues to warm up, all the glaciers will recede and the ice caps in the Antarctic and the Arctic will begin to melt. Then, the sea level will rise by a few metres, and most of the cities on the seashore may be submerged and coastal eco-life will be adversely affected.

OUR FUTURE IN DANGER

Our future is in danger if we do not arrest global warming by controlling emissions into the atmosphere.

Effects of Global Warming are:

1. Global temperature is likely rise by 2 to 5°C during the next century.
2. Due to rise in temperature by 2 to 5°C, there is a chance of melting of ice caps on Earth's poles. This melting of ice will result in the rise of the sea level. Large stretches of low lying areas will submerge and many island countries will face deep encroachment by seawater. Some may disappear altogether.
3. As the increase in temperature will be uniform all over the surface of the world, there will be serious climatic changes. This will bring various changes in wind and rain pattern.
4. Higher temperature will cause rise in transpiration, which in turn, will affect the groundwater table.
5. As the climatic belts shift from equator towards pole, the vegetation would also shift away from the equator.
6. Insects and pests will increase in the warmer climatic conditions. Thus, pathogenic diseases will multiply.

DEPLETION OF OZONE LAYER

Significance of Ozone Layer in Atmosphere

The atmosphere is divided into four layers—

(i) Troposphere; (ii) Stratosphere; (iii) Ionosphere; (iv) Exosphere.

In the second layer, the Stratosphere which lies at the height of 20 km to 50 km from Earth's surface, lies the Ozone layer although its density is very low. In spite of its low density, the Ozone layer plays an important role in our life.

Due to the presence of Ozone layer, ultraviolet rays and Infra-red rays from the sun cannot reach Earth directly. Ozone layer absorbs the harmful ultra-violet rays from the sun and protects the life on Earth from their harmful effects.

Cause of Ozone Depletion and Ozone Hole

It has been revealed from different researches that when the Oxides of Nitrogen (NO and NO_2) come in contact with Ozone (O_3), their chemical reaction destroys Ozone layer. Besides this, supersonic aeroplanes move through the stratosphere and emit huge amount of Nitrogen gas which depletes the Ozone layer. Another important factor is chlorofluorocarbons (CFCs) which have strong power to damage the Ozone layer.

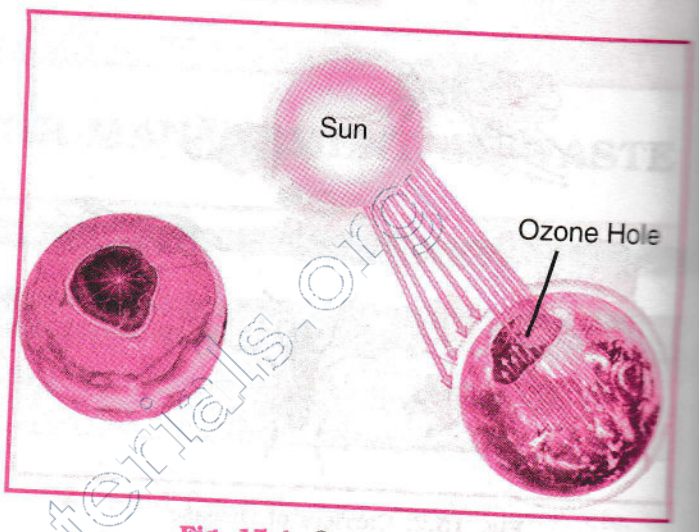


Fig. 15.4. Ozone depletion

All the developed and developing countries are using CFCs-type chemicals as refrigerants in aerosol, paints, plastics, foam; thermal insulating materials in spray and packaging industries. During the use of such materials, a lot of CFCs ultimately get dispersed into the atmosphere.

A hole has been observed in the Ozone layer in the stratosphere near Antarctica. This hole allows the ultraviolet rays of the sun to reach Earth directly without any obstacle or filtration. These ultraviolet rays cause skin cancer and cataract in eyes of the human beings.

The ultraviolet rays cause genetic disorders which ultimately affect heredity. Increased concentration of ultraviolet rays disturb ecological balance in marine ecosystem. Green algae, fish and other animals on continental shelves get affected by ultraviolet rays. Young cells and larvae of aquatic ecosystems get destroyed. Vegetables are very sensitive to the ultraviolet rays. Ultraviolet rays can damage physical and chemical properties of any complex chemical substance. Plastics become brittle when they come in contact with ultraviolet rays.

ACID RAIN

Acid Rain means the presence of excessive acids in rain water. Burning of coal, fuel wood or petroleum produces sulphur

react with oxygen and are converted into respective oxides—sulphur dioxide and gen dioxide, which are soluble in water. ring a rain, these oxides react with large tities of water vapour of the atmosphere to acids like sulphuric acid, sulphurous acid, ic acid and nitrous acid. These acids, when precipitate together with rain or snow create rain.

ECTS OF ACID RAIN

(i) Acid rain increases acidity in the soil and destroys forests and crops.

(ii) It corrodes buildings, monuments, statues, bridges, fences and railings.

(iii) It poses a serious threat to human health, since it contaminates air and water.

(iv) It affects the human nervous system by causing neurological diseases.

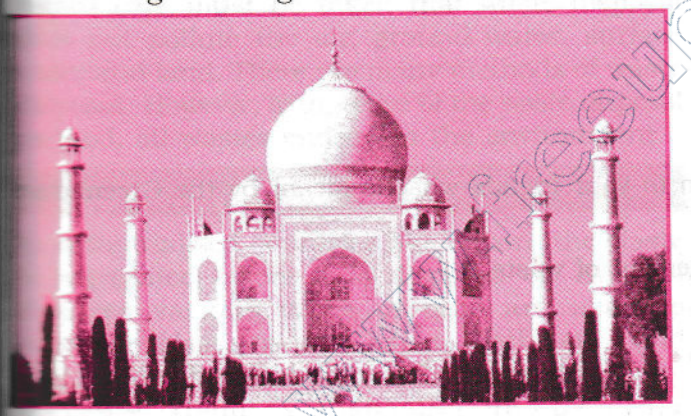


Fig. 15.5. Effect of Acid Rain

SOIL HEALTH

Soil is the foundation for a healthy biosphere. Precipitation from air as acid rain and dry deposition of pollutants on land surface contribute to soil pollution. Chemicals and minerals in the soil react with chemical pollutants. Pollutants combine with plant nutrients and are consumed by animals. Polluted soils unfavourably affect the microbial environment resulting in reduction in mineralization and decomposition processes. Transformation of sulphur, nitrogen, availability of phosphorus, biological nitrogen fixation in soil are affected by acid rain. Soil fertility and aeration are also reduced. Earthworms,

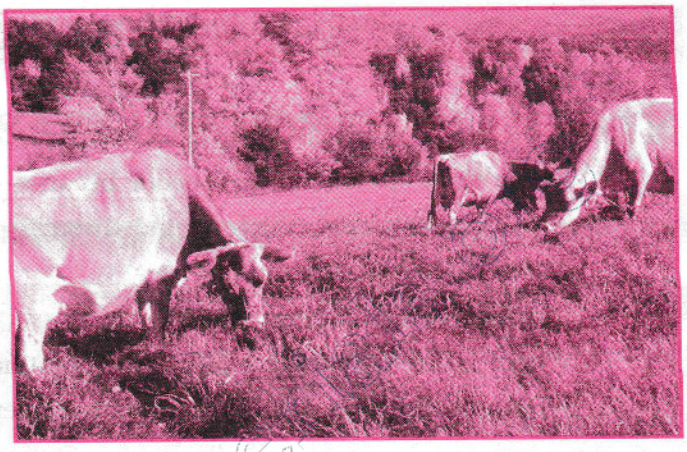


Fig. 15.6. Overgrazing reduces soil fertility

destruction of the biosphere.

WASTE MANAGEMENT

One of the easiest ways of management of waste is the '3-R' system i.e. Reduction, Reuse and Recovery. We can reduce our use of resources. We can reuse the materials for packaging that is use the same product several times, e.g. bottles, containers, etc. We can recover materials such as glass, paper and metals (like aluminium, cans and steel) from old articles. We can recycle the used items to make new material, e.g.,cardboard from used paper.

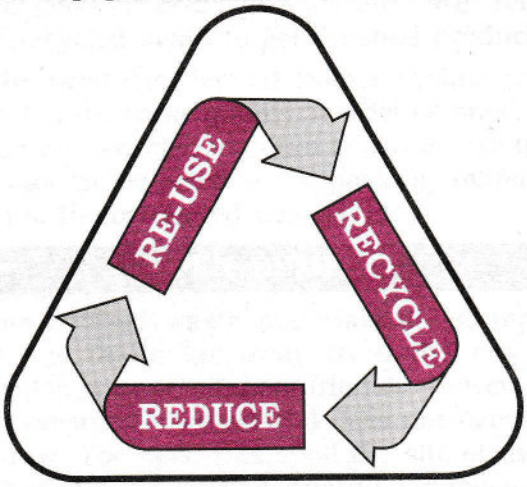


Fig. 15.7. Three R's

Public awareness of the health hazards of waste is increasing. There is a need to manage the waste properly. No doubt, waste disposal has become a big industry employing many thousands of workers but the options for its disposal are limited, the main disposal sites are the land, water

CHAPTER 16

SAFE DISPOSAL OF WASTE

Course Content—Syllabus and Scope

Methods of safe disposal of waste—segregation, dumping, composting, drainage, treatment of effluents before discharge, incineration, use of scrubbers and electrostatic precipitators.

Segregation of domestic waste into biodegradable and non-biodegradable by households; sweeping from gardens to be converted to compost, sewage treatment plants, incinerators in group housings.

Scope and limitations of incinerators. Potential and limitation of equipment like ESP, scrubbers in industries.

After segregating the waste and separating materials for reuse and recycling, the absolute waste material should be disposed of. In this regard care must be taken that waste disposal does not pollute the air, ground water, surface water and land. There are many methods of waste disposal. However, irrespective of the waste disposal method, all wastes end up in the environment.

SEGREGATION

In industrialised countries like Japan, the waste is segregated before it is disposed of. Even in colonies various types of bins are used to segregate glass, metals, paper, cloth, etc., and each type is handled separately by reusing them, recycling them or disposing in any other accepted waste disposal method. It should be the duty of each household to segregate domestic waste into different dust bins (like biodegradable and non-biodegradable) and then convert biodegradable ones into other useful products like compost or gobar gas. Urban residential colonies should undertake collective efforts for safe disposal of domestic waste.

Sorting out of the re-usable material from heaps of waste may often involve much manual labour. In a country like India, the poor garbage collectors make a living from discarded solids. In this way they do a good job by removing much of the waste from the garbage dumps. Pieces of metal, glass, rubber, plastics etc., are, removed to be recycled again to get finished products.

The products derived from recycling process are not of the same quality as original ones. Paper made from recycled material is of a coarse quality and has to be used as a packing material in cartons, in corrugated boards, etc.

OPEN DUMPING

In this method waste materials are dumped in open low lands far away from the city. This method is not environment friendly. However, this is the cheapest method and does not need much planning. The open pits spoil the site of the area and become a breeding ground for mosquitoes, flies, insects etc. that are the carriers of harmful diseases. They give out foul odour. If you burn the material in the open dumps it pollutes the air. Another danger of open dumping is that rainwater could carry the harmful substances to the nearby streams, ponds or lakes and if the water seeps down it could pollute the

Fig. 16.2. Open Dumping

MUNICIPAL WASTE MANAGEMENT

1. Collection of Municipal Solid Wastes

To prohibit littering and facilitate compliance, the following steps should be taken by the municipal authorities:

(i) Organising house-to-house collection of municipal solid wastes.

(ii) Devising collection of waste from slums and squatter areas or localities including hotels, restaurants, office complexes and commercial areas.

(iii) Bio-medical wastes and industrial wastes should not be mixed with municipal solid wastes.

(iv) Horticultural and construction or demolition wastes or debris should be separately collected and disposed of by following proper norms.

(v) Waste (garbage, dry leaves) should not be burnt.

Fig. 16.3. Storage Bins

(vi) Stray animals should not be allowed to move around waste storage facilities.

2. Storage of Municipal Solid Wastes

Following criteria shall be taken into account while establishing and maintaining storage facilities:

(i) Storage facilities shall be created and established by taking into account quantities of waste generation in a given area and the population densities. A storage facility shall be so placed that it is accessible to users;

(ii) Storage facilities shall be so designed that wastes stored are not exposed to open atmosphere and shall be aesthetically acceptable and user-friendly;

(iii) Storage facilities or 'bins' shall have 'easy to operate' design for handling, transfer and transportation of waste. Bins for storage of bio-degradable wastes shall be painted green and those for storage of recyclable wastes shall be painted black;

(iv) Manual handling of waste shall be avoided.

3. Transportation of Municipal Solid Wastes

Vehicles used for transportation of wastes shall be covered. Waste should not be visible to public, nor exposed to open environment, preventing their scattering.

4. Segregation of Municipal Solid Wastes

The municipal authorities shall undertake phased programme to ensure community participation in waste segregation.

SANITARY LANDFILL

In this method, the waste is packed and dumped at the site and is covered with earth daily to prevent insects or rodents from entering into the landfill. The waste then is subjected to bacterial decomposition. Physical, chemical and biological reactions take place generating different gases like carbon dioxide, methane, ammonia and hydrogen sulphide.

Sanitary landfill is a way of disposing refuse on land without creating

Fig. 16.4. Sanitary Landfill

to public health or safety. The waste disposal is carried out with minimal environmental damage and in areas already spoiled or in need of restoration.

The sanitary landfill system of disposing of waste is essentially a biological method. The waste undergoes the following five phases:

1. During the first phase of operation, aerobic bacteria deplete the available oxygen and as a result the temperature increases.

2. In the second phase, anaerobic conditions become established and hydrogen and carbon dioxide are evolved.

3. Phase three establishes population of bacteria and the beginning of methanogenic activity.

4. In the fourth phase the methanogenic activity becomes stabilised.

5. The fifth phase depletes the organic matter, and the system returns to aerobic state.

The advantages of sanitary landfill as opposed to open dumping are:

(i) It is free from air pollution from burning.

(ii) The health problems are minimised since flies, rats and other pests cannot breed in the landfill because of the covered wastes.

(iii) It is mostly free from fire hazards.

Plantation at Landfill Site

A vegetative cover should be provided over the landfill site in accordance with the following specifications:

(a) Locally adopted non-edible perennial plants that are resistant to drought and extreme temperatures should be planted.

(b) The plants grown should be such that their roots do not penetrate more than 30 cms. This condition shall apply till the landfill is stabilised.

(c) Selected plants should have the ability to thrive on low-nutrient soil with minimum nutrient addition.

(d) Plantation should be made in sufficient density to minimise soil erosion.

Closure of Landfill Site and Post-care

The post-closure care of landfill site should be conducted for at least 15 years and long term monitoring or care of the site shall consist of the following:

(a) Maintaining the integrity and effectiveness of final cover, making repairs and preventing run-on and run-off from eroding or otherwise damaging the final cover.

(b) Monitoring waste collection system in accordance with the requirement;

(c) Monitoring of ground water in accordance with requirements and maintaining ground water quality.

(d) Maintaining and operating the landfill gas collection system to meet the standards.

Special Provisions for Hilly Areas

Cities and towns located on hills should have location-specific methods evolved for final disposal of solid wastes by the municipal authorities with the approval of the concerned State Pollution Control Board.

Fig. 16.5. Modern Landfill

The municipal authorities should set up processing facilities for utilisation of biodegradable organic wastes. The inert and non-biodegradable waste will be used for building roads or filling-up of appropriate areas on hills. Because of constraints in finding adequate land in hilly areas, wastes not suitable for road-laying or filling up should be disposed of in specially designed landfills.

COMPOSTING

Composting of waste is an aerobic method of decomposing solid wastes. Moisture content is an important factor in aerobic composting. A moisture content of about 55 per cent is beneficial for biological breakdown of the waste. It may be necessary sometimes to add water to maintain moisture content.

The micro-organisms help to stabilise the organic matter. For example, fungi starts working in the first week after dumping of the material. Actinomycetes help in the last stages of the breakdown while bacteria is present throughout the process. The process involves decomposition of organic waste into humus known as compost which is a good fertiliser for the plants. The composting process also produces carbon dioxide and heat which can be used for various purposes like cooking.

In India, we use manual as well as mechanical methods of composting. In the ru areas composting refuse and night soil mixtu are dumped together which produce manure the fields. Layers of vegetable waste and ni soils are alternated in a shallow trench. T mixture is turned regularly for about three mont to provide air to the mixture. Then the compo is left for another month without turning for t process to take effect. This method of compostin is known as the *Indore Method.*

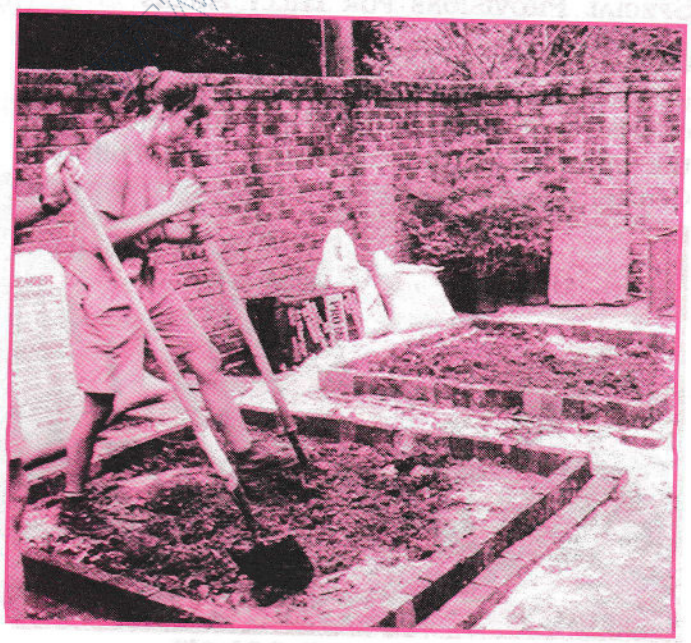


Fig. 16.6. Composting

In the mechanical process, used in Bangalo and widely adopted by other cities in the countr the waste material is placed in layers about o metre deep. The material is not turned at all b it decomposes completely in about five month This method of composting is known as th *Bangalore Method.*

ADVANTAGES OF COMPOSTING

The major benefits of composting are th following:

(i) It enhances soil nutrients and water retentio capacity of soils.

(ii) It suppresses plant diseases.

(iii) It rejuvenates poor soils by adding humus.

(iv) It absorbs odours and degrading volatil organic compounds.

(v) It helps prevent pollution by preventin pollutants in storm water run-off fro draining into water resources.

(vi) It checks soil erosion and silting o embankments.

(vii) It reduces cost through reduction in th need for excess water, fertilisers an pesticides.

TREATMENT OF EFFLUENTS BEFORE DISCHARGE

Waste water undergoes treatment depending upo the purpose for which it is treated. Therefore treatment of water has two procedures:

PRIMARY TREATMENT

When the water is disposed of into a stream, river, lake, etc. it undergoes primary treatment. The primary treatment involves removal of majo impurities. After the treatment, the water is

Primary treatment for removal of gross impurities involves four stages:

(a) *Sedimentation*: The waste water undergoes the physical treatment in which the water is first of all stored in large basins. Storing the water for a long time in reservoirs, settles gradually sand particles, clay, silt and other suspended material at the bottom.

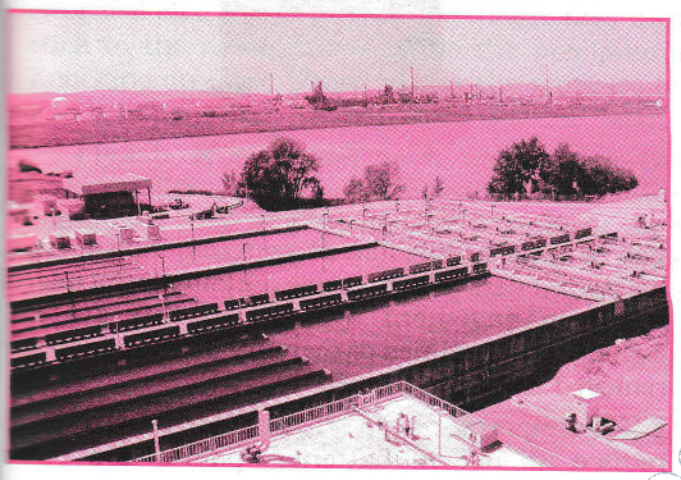


Fig. 16.7. Sedimentation

(b) *Coagulation or Flocculation*: In this process, the sedimented water is subjected to a chemical process. A coagulant such as aluminium sulphate or alum is added to the water. Fine particles are removed by promoting their agglomeration or flocculation in the presence of the coagulant. The coagulant reacts with water and forms a bulky precipitate. The agglomerated particles, known as floccules, are again separated by sedimentation or filtration.

(c) *Filtration*: It is a physico-chemical process for separating suspended and colloidal impurities from water by passing it through a barrier of sands matrix of fibrous material or coal particles. This process removes micro-organisms as well as the remaining floc particles.

(d) *Disinfection*: The water which undergoes above three processes is not totally free from micro-organisms. In order to get rid of the micro-organisms, chlorine or bleaching powder is added to the water to disinfect it. Sometimes disinfection is carried out by using ultra-violet light, ozone or silver ions.

Secondary Treatment of Water

Water treated by primary treatment is not fit for drinking. Therefore, it undergoes the process of secondary treatment. Secondary treatment has the following two steps:

(a) *Softening*: The hard water has cations of calcium and magnesium. To soften water, Lime and Soda ash are added to the water to precipitate calcium and magnesium ions as carbonates. The precipitate is then filtered out. The water so treated goes through porous cations exchanger in which water becomes cation free.

(b) *Aeration*: In order to make the water fit for drinking some amount of oxygen is forced into it. Aeration of water is carried out by forcing air through water in the form of air bubbles. This process adds oxygen and other gases and reduces the content of carbon dioxide and hydrogen sulphide in the water.

INCINERATION

In cities vacant areas for disposal sites are not very many; so incineration process is used for waste disposal by industries and municipalities. Incineration is the process of controlled high temperature oxidation of primarily organic compounds that release thermal energy and produce carbon dioxide and water. In short, incineration involves burning of wastes at a very high temperature. The waste to be burnt is fed into an incineration chamber (or kiln) and combustion consumes/destroys the organic component.

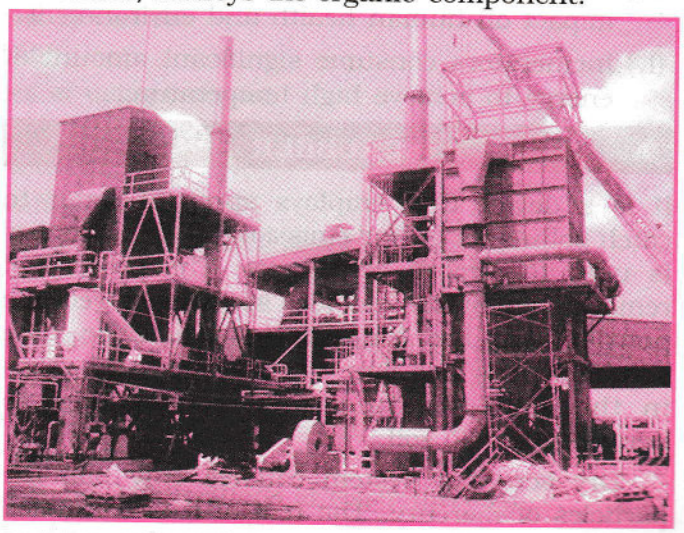


Fig. 16.8. Incineration

Advantages of Incineration

Incineration as a system of waste disposal has the following advantages:

(i) It is a useful technology to deal with large quantities of organic hazardous wastes that have high calorific value and cannot be dealt with by other methods.

(ii) Incineration kills pathogenic organisms and reduces the volume of the waste upto 50 per cent.

(iii) Incineration is useful to dispose of petroleum and plastic wastes in chemical industries.

(iv) Incineration of combustible waste produces tremendous heat that can be used to produce steam from water which in turn can be utilised to generate electricity.

Limitations of Incineration

The limitations of incineration are the following:

(i) Incineration process is quite expensive because of the installation of proper control equipment to minimise air and thermal pollution and the need for skilled operators.

(ii) Incineration equipment has high maintenance requirements.

(iii) Incineration process generates ash and combustion gases consisting of air and the products of combustion from the waste. The emission of pollutants like HCl, CO, SO_2, heavy metals and ash can have adverse impact on human health and environment.

(iv) Incinerators consume significant amount of energy to achieve high temperature.

SCRUBBER

It is a device that employs spray of water to catch pollutants during emissions. A dry scrubber is used to remove acid gases. The process of removing pollutants includes spraying of wet lime powder into the hot exhaust chamber. The scrubber uses this lime to neutralize acid gases in the same way a gardener uses lime to neutralize acidic soil.

Dry scrubber system catches only half the particles of mercury. The rest of it is controlled by blowing activated charcoal into the exhaust

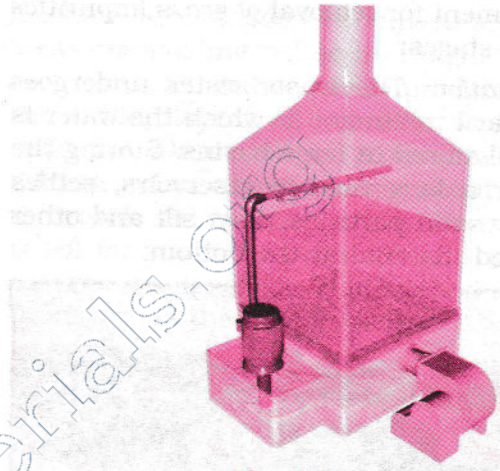


Fig. 16.9. Scrubber

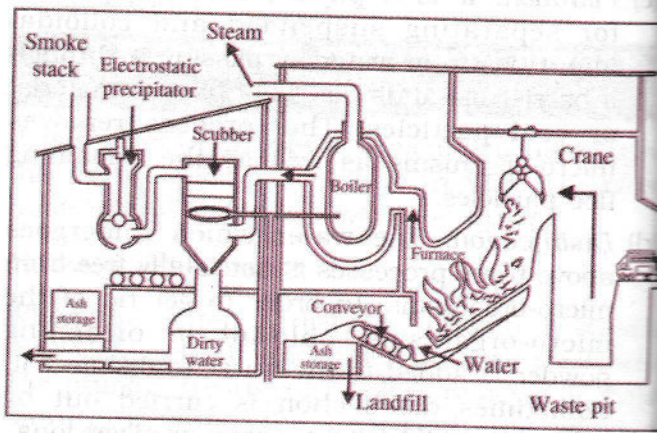
gas to form a thin film of mercury. Now-a-day waste-to-energy is the sole guiding principle waste management system. In this syste significant quantities of mercury are permanen removed from the wastes.

An important step in mercury control is reduce its use in batteries, paints and oth consumer products.

Scope and Limitations: Scrubbers are bett than dry particulate removal process because reduced explosion risk and quenching of h gases. The disadvantage of scrubber is that t particulate matter does not settle easily. Besid it is difficult to manage the wet sludge in t process.

ELECTROSTATIC PRECIPITATORS (ESPS

It is a device that helps in pollution control removing many chemicals from gas stream These chemicals include lime salts, activat charcoal, ordinary smoke and soot as well



dioxins. It also removes particles of metals like lead, cadmium and nickel that are present in many consumer products. These particles are called "flyash" because they are light and tend to fly around in hot flue gases.

Electrostatic precipitator (ESP) removes these particles from smoke after combustion takes place. In the removal process, it imparts an electrical charge to the particles that makes them stick to the metal plates inside the precipitator. Knocking on these plates makes the particles fall into a hopper tray for disposal.

Flyash is collected in a bag house that operates like a huge vacuum cleaner. This cleaner contains a large number of fabric filter bags. Some industrial units use electrically charged plates that capture tiny particles of fly ash in the same way a television screen attracts dust particles. ESPs are used in boilers, furnaces and many other units of thermal power plants, cement factories, steel plants, etc.

Advantages of ESPs

The advantages of using ESP are the following:

(i) ESPs are economical to operate.

(ii) ESPs provide high efficiencies, upto 99 per cent.

(iii) ESPs are dependable and predictable.

(iv) ESPs do not produce a moisture plume.

Limitations of ESPs

(i) ESPs cannot be used with moist flows, mists or sticky particles.

(ii) ESPs must be heated during start up and shut down to avoid corrosion from acid condensation.

(iii) ESPs are expensive.

EXERCISES

A. Short Answer Type Questions

1. What do you mean by segregation of waste?
2. What is open dumping of wastes?
3. What is a sanitary landfill?
4. For how many years post care of landfill should be conducted?
5. What is composting?
6. Name the four stages of primary treatment of water.
7. What do you mean by a scrubber?

B. Long Answer Type Questions

1. What are the dangers posed by open dumping of wastes?
2. How is waste disposed of in a sanitary landfill?
4. How is compost made? Give three advantages of using compost.
5. What is incineration? Give two advantages and two limitations of incineration.
6. Explain the stages of primary treatment of water.
7. Explain the stages involved in secondary treatment of water.
9. Explain the process of electrostatic precipitation. Give two advantages of using ESPs.

C. Project/Activities

1. Make a group-project for disposal of waste in your local area. Each one in the group deals with one aspect of the following methods of waste disposal:

   (a) Open dumping (b) Sanitary land fill (c) Composting

   (d) Incineration (e) Water-borne Waste.

2. Organise an awareness camp in your school about safe methods of waste disposal.

CHAPTER 17

REDUCE–REUSE–RECYCLE

Course Content—Syllabus and Scope

Need for reducing, reusing and recycling waste.

Methods would involve governmental, social and individual initiatives.

Governmental initiatives: not building large dams for generating hydro-electric power which leads to less land being submerged and less displacement of people. Improving efficiency of existing technologies and introducing new eco-friendly technologies.

Social initiatives: Creating awareness and building trends of sensitive use of resources and products, e.g. reduced use of electricity, etc.

Individual: Developing an ethical environmental consciousness e.g. refusing use of polybags, styrofoam containers, etc; reusing: plastic and glass containers; recycling: e.g. paper—this will reduce demand on wood and save trees.

In the modern industrial world, the waste has become an environmental and public health hazard. Waste can be effectively managed by using the following three strategies:

(i) Reducing the Waste;

(ii) Reusing the Waste; and

(iii) Recycling the Waste;

REDUCING THE WASTE

The waste can be reduced by making use of the following methods:

(a) *Change of Process*: By changing a modern method to make the best use of raw materials reduces the waste generation in industries. In zinc electroplating chlorides are used in the process instead of using the sulphate salt in order to eliminate the production of cyanides.

(b) *Waste Concentration*: By using scientific techniques such as precipitation and evaporation we can reduce the amount of liquid waste. We can also use incineration to get rid of inflammable wastes.

(c) *Segregation of Waste*: First of all, non-hazardous waste are separated from hazardous waste rather than dumping them together. Then we can treat the small amount of hazardous waste. We can dispose of a large amount of non-hazardous waste in the traditional ways.

Fig. 17.1 Three Rs of Waste Management

REUSING THE WASTE

In our houses and in industries many materials are discarded as wastes. These materials have some value, for instance glass, metal pieces, rubber, wood fibre and paper products.

In developing countries like India, some of the waste materials like old glass bottles, steel tyres, tin cans are reused. For example, shoes or chappals are made from old tyres, water bags are made from leather, lamps are made from tin cans, etc. Many waste collectors roam about in

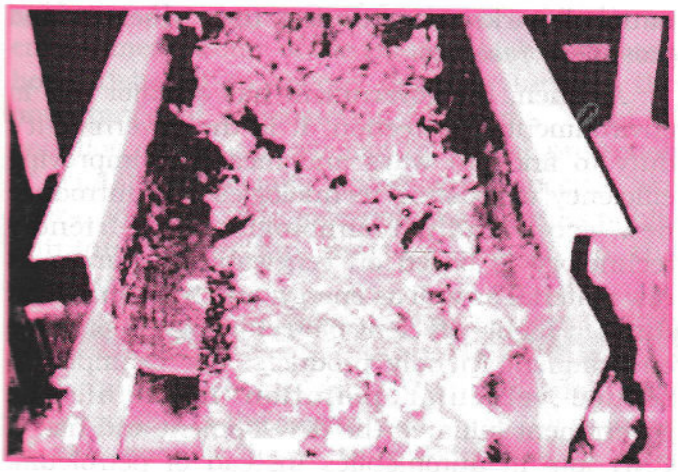


Fig. 17.2. Reusing the Waste

residential areas and industrial units to collect the solid waste. They segregate them and supply them to specialised artisans who make utility articles from such materials and make a living from their skill. For example, a very beautiful garden has been created by Nek Chand in Chandigarh using waste products like tin cans, bottles, broken pieces of crockery etc. Waste collectors, thus, help in making new production processes. Thus, they reduce the burden of waste disposal.

Some solid wastes from the industry can be utilised directly. Flyash from power plants is used as a cement substitute. Bricks are made from flyash. Flyash is also used in making of the roads and filling up low-lying areas.

RECYCLING OF WASTE

Besides reuse of the materials by using physical processes, we also use recycling process by treating the waste before it is used in a manufacturing process. In India, we have tonnes of bagasse from sugarcane during a particular season. Bagasse can be used in the manufacture of paper pulp. This would save trees which are normally used for making paper pulp. Bagasse is also used for making packaging material of dairy products and eggs. Paper industry recycles wood, cloth and used paper.

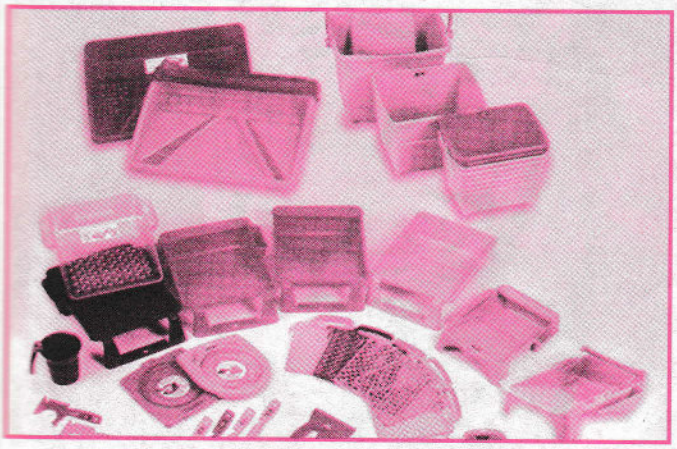


Fig. 17.3. Plastic Products

Plastics are recycled by plastic manufacturers. About 80 per cent of the plastic waste is recycled in India, which is about 0.75 million tonnes a year. Plastic is non-biodegradable. The bonds of carbon in plastic are impossible to break down through a physical or chemical process. They have to be incinerated, recycled or burried in land fills. The plastic bags which are extensively used in India are made from recycled plastic. The recycled plastic bags are harmful because the melting of plastic and plastic products breaks some polymer chains into smaller units which are harmful.

AN EXAMPLE: PAPER

The paper industry segregates waste paper from a huge discarded dump. Waste paper has grit, sand, ink, tar, paper clips, plastic coatings, rubber bands, etc. These are separated. Most of the used paper is made into cardboard, paperboard, insulation, paper bags, etc. Recycled paper is used for printing only a few times because with each recycle the fibres become weak. The recycled product is weaker than similar product made from fresh fibres.

Waste paper is fed on to a conveyor belt. The conveyor belt feeds the paper to a hydropulper where it is smashed in water at about 38°C. The

Fig. 17.4. Recycled Paper Products

force in the hydropulper is so great that the sheets of paper are rapidly broken down to a slurry. The fibres in the paper are retained and unacceptable materials are drained off. The pulp of waste paper is passed over a riffer system. It is then fed into another unit for the removal of dirt and tar. The paper slurry is thickened before it is fed into the paperboard machines.

GOVERNMENT INITIATIVES

The Central and State Governments own, control and develop a country's forests, dams, major irrigation systems, power stations, industries, means of transportation, railways, roads, ports, etc. The Government is not just the protector of the country's environment but also has a major responsibility for sustaining environmental conscience.

In India, the Ministry of Environment and Forests is the main nodal agency for generating environment consciousness and making and implementing schemes for environmental protection. The Government's environmental policy focuses on the following areas:

(i) To check degradation of land and water through Wasteland Management and Restoration of river water quality programmes;

(ii) To provide for conservation of natural resources by direct action such as declaration of reserved forests, biosphere reserves, wetlands, mangroves and protection of endangered species;

(iii) To monitor development through Environmental Impact Assessment Studies of major project proposals; and

(iv) To make laws and acts for environment protection and to initiate penal measures against those who violate these laws.

The Environment Protection Act (1986) empowers the Central government to coordinate actions of State Governments, plan and execute a nationwide programme for the prevention, control and abatement of environmental pollution, lay down standards for the quality of environment in its various aspects and for emission or discharge of environmental national parks, sanctuaries, tiger reserves and biosphere reserves.

As such, the government has a major role in environmental protection. It is the government's duty to find out ways and means of improving efficiency of existing technologies and introduce new eco-friendly technologies. Eco-friendly technology is based on renewable resources as raw material as well as energy; and transformation through highly efficient biotechnology to produce environment friendly products. For example, to reduce vehicular pollution in Delhi, the government initiated the development and use of CNG kits in automobiles instead of petroleum. This has reduced air pollution in Delhi to a considerable extent.

In India, the concept of cleaner technology has also been applied in the area of liquid waste management, the technologies for the gaseous and solid materials are available with National Environmental Enginering Research Institute (NEERI), Nagpur, Central Pollution Control Board (CPCB), New Delhi and Cleaner Technology Centre, New Delhi.

In order to minimise the adverse impact of a number of developmental projects on the environment, the government ensures that an Environmental Impact Assessment is carried out before such a project is started. Environmental clearance is granted to them only after stipulating appropriate environment management plans. These plans are also strictly monitored for compliance. The government sets up various committees under the charge of experts to

evaluate the impact of various projects on environment. Some of the issues which have been hotly debated in recent decades include the importance of constructing big dams, effect of pollution on monuments like Taj Mahal, protection of wildlife, especially endangered species like tigers, lions, etc. The government also seeks public opinion on certain matters related to the environment.

SOCIAL INITIATIVES

Environmental protection is not the responsibility of the government alone. All sections of the society have to participate in this endeavour. It is ultimately the society that suffers due to environmental degradation. Therefore, the society has to play an important role in maintaining environmental standards in the following ways:

(i) If air and water resources in an area are unfit and do not meet the acceptable standard, the people of the area can organise themselves and force the responsible agencies to take necessary action.

(ii) If suitable action is not forthcoming they can, under the laws of the land, file a Public Interest Litigation (PIL) and get their problems solved.

(iii) Society is made of individuals together. So it is the duty of each individual to see that his/her actions do not pollute the environment.

(iv) Groups of individuals together can make a huge difference in maintaining environmental standards. For example, group housing societies can initiate steps for waste management by making provisions for segregating wastes, taking measures for recycling wastes like making compost pits, etc. They can also take measures for reducing the use of electricity and finding alternative sources of energy.

(v) Air pollution, specially vehicular pollution can be minimised by adopting car pool method. This will also save huge amounts of money spent on importing petroleum from other countries.

(vi) Society can play a significant role in environmental protection by creating awareness and educating people about the need to conserve and manage natural resources.

INDIVIDUAL INITIATIVES

The role of every individual in environmental protection is of great importance because if every individual contributes substantially, the effect will be visible not only at the community, city, state or national level but also at the global level. It is the responsibility of each individual to protect the Earth and provide conducive environment for itself and innumerable other species which evolved on this earth.

Each individual should change his or her life style in such a way as to reduce environmental pollution. It can be done by following ways:

1. Use carry bags made of paper or cloth instead of polythene.
2. Help more in pollution prevention than pollution control.
3. Use eco-friendly products.
4. Cut down the use of chlorofluorocarbons (CFCs) as they destroy the ozone layer. Do not use polystyrene cups that have chlorofluorocarbon (CFC) molecules in them which destroy ozone layer.
5. Use the chemicals derived from peaches and plums to clean computer chips and circuit boards instead of CFCs.
6. Use CFC free refrigerators.
7. Save electricity by not wasting it when not

Fig. 17.7. Individual Initiatives – Sunderlal Bahuguna

electricity generated without polluting the environment. For example, put on warm clothes rather than switching on a heater.

8. Adopt and popularise renewable energy sources.
9. Promote reuse and recycling wherever possible and reduce the production of waste.
10. Use mass transport system. For short-visits use bicycle or go on foot. Decrease the use of automobiles.
11. Use rechargeable batteries. Rechargeable batteries will reduce metal pollution.
12. Use low phosphate, phosphate-free or biodegradable dish washing liquid, laundry detergent and shampoo. This will reduce eutrophication of water bodies.
13. Use organic manure instead of commercial inorganic fertilizers.
14. Plant more trees, as trees can absorb many toxic gases and can purify the air by releasing oxygen.
15. Check population growth so that demand of materials is kept under control.

EXERCISES

A. Short Answer Type Questions

1. What are the three R's of waste management?
2. Name the processes involved in reducing the waste.
3. Give one example of reusing of waste.
4. What do you mean by recycling of waste?
5. Why are recycled plastic bags considered harmful for the environment?

B. Long Answer Type Questions

1. Explain clearly how the waste can be reduced by changing the process of production.
2. Explain how recycling of waste to produce paper can reduce deforestation.
3. Explain the role of government in waste management.
4. Give three examples to show how social initiatives can help minimise the use of resources.
5. Explain the role of an individual in maintaining environmental standards.

C. Project/Activities

1. Visit the site where waste paper is recycled. Observe carefully the method adopted and find out if you can take similar steps to recycle waste paper.
2. Go around your school compound and make a detailed plan for safe disposal of waste in the campus. You may suggest ways of disposal of waste under the following heads:
   (a) Reduce (b) Reuse (c) Recycle
3. Organise a debate on the topic — "Should we ban the use of plastics?"

CHAPTER 18

LEGAL PROVISIONS FOR HANDLING AND MANAGEMENT OF WASTE

Course Content—Syllabus and Scope

Legal provisions for handling and management of waste.

Need for legal provisions. Limitations of Legal provisions for managing wastes.

Need For Legal Provisions

Environmental degradation has assumed alarming proportions, threatening the very existence of life on the earth. This dangerous situation is largely the result of human activities. The process of population explosion, heavy industrialisation and growing urbanisation has resulted in acute environmental problems in respect of air, water and noise pollution; soil erosion; water depletion; land degradation and degradation of forests; enhanced greenhouse effect and global warming, etc. Laws, in this regard, are the vital tools for protection, conservation and judicious use of resources.

In India, all the components of the environment have been considered as life support systems right from ancient times and their protection has been of great importance. In ancient days, population was limited and the life of the people was quite simple. However, gradually the population increased and consequently the demands of the people increased manifold. This has led to a strain on natural resources and devastating effects on the environment. Moreover, with the growth of commercialisation and due to man's greed, over-exploitation of environment has become a common feature. This can be checked only through legal provisions.

At present, the life of an individual depends on the activities and performance of many other individuals. Careless maintenance of a nuclear reactor or a chemical plant, can take toll of hundreds or thousands of lives, not only in and around the accident site, but also at a considerable distance. Similarly, a mass casualty or environmental destruction can happen due to carelessness while transporting hazardous wastes. Therefore, there must be some legal provisions so that such instances of negligence can be reduced, if not totally avoided.

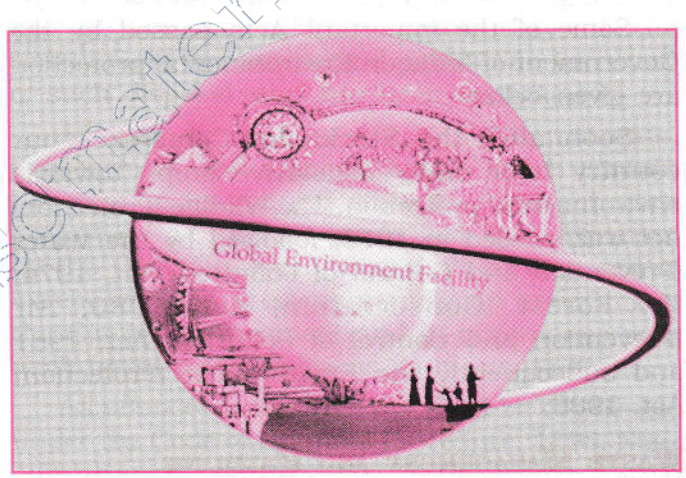


Fig. 18.1. Global Environment

Legal Provisions in India

Legal provisions to control environmental pollution were existing in India even before independence. But these provisions were inadequate and did not play a significant role in protecting the environment. At the close of the 1970s, growth in environmental consciousness all over the world, led to the development of new Central laws to restore and maintain the quality of the environment.

Constitutional Provisions: The provisions for environmental protection in the Constitution of India were made within four years of Stockholm Conference, in 1976, through two amendments as follows:

Article 48-A of the Constitution provides: "The state shall endeavour to protect and improve the environment and to safeguard forests and wildlife of the country." (Directive Principles of State Policy).

Article 51A(g) provides: "It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures" (Fundamental Duties of a citizen). Thus, our Constitution includes environmental protection and conservation as one of our fundamental duties.

Some of the important Acts passed by the Government of India on Environmental protection are given below:

Soon after the Stockholm Conference our country took many legislative steps towards environmental protection. The Wildlife (Protection) Act was passed in 1972, followed by the Water (Prevention and Control of Pollution) Act, 1974, the Forest (Conservation) Act, 1980, Air (Prevention and Control of Pollution) Act, 1981 and subsequently the Environment (Protection) Act, 1986.

Waste Management and Handling

According to the Environment (Protection) Act 1986, the Central Government has made the following rules relating to the disposal of hazardous wastes.

Radio-active wastes are covered under the provision of The Atomic Energy Act, 1962.

Categories of Hazardous Wastes

- Mercury, Arsenic, Thallium and Cadmium bearing wastes.
- Wastes from paints, pigments, glue, varnish and printing ink.
- Wastes from dyes containing inorganic chemical compounds.
- Waste oil and oil emulsions.
- Wastes from manufacturing of pesticides and herbicides as well as residues from pesticides and herbicides formulation units.
- Discarded containers and containers lining

Fig. 18.2. Paint

The Hazardous Waste (Management and Handling) Rules

Conditions

- Occupiers generating hazardous wastes given in the list shall take all practical steps to ensure that such wastes are properly handled, i.e. collection, reception, treatment, storage, and disposal of wastes without any adverse effects to human health and environment.
- Such occupier shall apply for authorisation in prescribed format to the *State Pollution Control.*

The Municipal Solid Wastes (Management and Handling) Rules, 2000

The *Municipal Solid Wastes (Management and Handling) Rules, 2000,* which came into effect from January 2004 apply to all municipal authorities responsible for collection, segregation, storage, transportation, processing and disposal of municipal solid wastes.

These rules lay down the responsibility of management of solid waste disposal and various standards for disposal of treated leachate (liquid that seeped through solid waste and other medium and has extracted dissolved or suspended material from it). They also define terms like "anaerobic digestion", "biodegradable digestion", "composting". "leachate", "vasode water", "vermicomposting", etc. The management of a solid waste has been made the responsibility of municipal authority. The District Magistrate, Deputy Commissioner shall have the over all responsibility for the enforcement of the

State Boards

- After appropriate and satisfactory verification of facilities, the authorization may be granted for managining hazardous wastes for a period of two years. State Pollution Control Boards have power to cancel the authorization or suspend it, if it is found that the occupier is not following the Provisions of Rules.

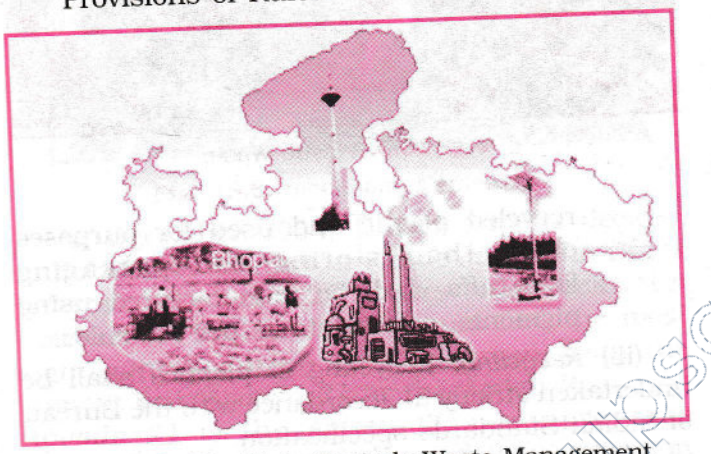


Fig. 18.3. The State Controls Waste Management

- State government shall maintain the inventory of disposal sites.
- The occupier shall maintain records of all operations and report to the State Boards.
- Dealing in the hazardous waste shall not be permitted in respect of dumping or disposal from other country except to those wastes which are examined and approved by the State Pollution Control Boards. However, such permission shall be communicated to the Central Government, Ministry of Environment and Forest.

Statutory Authorities

(a) Ministry of Environment and Forests

Ministry of Environment and Forests (MoEF) remains in overall charge of implementation of the Rules at the national level, while the State Pollution Control Boards are responsible for implementation at the State level. The MoEF has also retained with itself the power to decide on identification of hazardous wastes.

(b) Central Pollution Control Board (CPCB)

The CPCB has now been assigned a specific role

(c) State Pollution Control Boards (SPCB)

SPCBs have been made responsible for review of matters relating to identification and notification of disposal sites.

(d) State Governments

The responsibility of the State Government to identify hazardous waste disposal sites is a shared responsibility between industry and the Government. Once a site has been identified, it must be subjected to the EIA process. The Government then notifies the site, invites objections and conducts a public hearing if there are objections. The responsibility of the Government to compile and publish an inventory of such disposal sites has been maintained.

Atomic Energy Act 1962: No minerals, concentrates and other materials which contain uranium in its natural state in excess of such proportion as may be prescribed by notification by the Central Government shall be disposed of except with the previous permission in writing of the Central Government and in accordance with such terms and conditions as it may impose.

All offences under this Act shall be cognizable under the Code of Criminal Procedure, 1898. Non-compliance shall be punishable with imprisonment for a term which may extend to (a) one year (for an individual) and (b) five years (for a company), or with fine, or with both.

BIOMEDICAL WASTES

Biomedical Waste (Management and Handling) Rules, 1998

With a view to control the indiscriminate disposal of hospital waste/biomedical waste, the Ministry of Environment and Forest, Government of India has issued a notification on Biomedical Waste Management under the Environment (Protection) Act. Government of NCT of Delhi in its notification dated July 6, 1999 has authorised Delhi Pollution Control Committee (DPCC) for the purpose of granting authorisation for collection, reception, storage, treatment and disposal of biomedical waste to implement the Biomedical Waste Management Rules, 1998. The salient features of this Act are the following:

1. Biomedical waste shall not be mixed with other wastes.

(ii) Critical issues such as industry responsibility, a pattern to enable sustainable recycling of waste and to catalyse waste reduction through, say better packing, have not been touched upon in these legislations.

(iii) The rules and regulations for waste management do not have provisions for any public participation, despite the fact that most of these rules have been an outcome of public pressure and the immense work done by the NGOs and community groups.

(iv) These rules are inadequate both in terms of addressing impact of waste on environment and its social and economic implications.

(v) In most of the cases, the legal provisions do not mention the penalties for non-compliance. Even if they do so, the penalties are minor, most of the time small monetary fines.

(vi) Most of the people are unaware of the legal provisions for waste management. This results in lack of public awareness, motivation and poor response from the citizens.

In the last two decades, a trend has been seen in our cities of shifting the traditional municipal responsibility to private sector. But the laws do not contain the rules in case the responsibility shifts from municipality to private sector. Besides, excessive reliance is being placed on technologies many of which are expensive and with negative environment and economic consequences. For example installing an incinerator, before the economics of incineration are understood, [illegible] policy document on waste management, should include a cradle-to-grave approach with responsibility being shared by many stakeholders, including product manufacturers, consumers and communities, the recycling industry, trade and the municipalities.

EXERCISES

A. Short Answer Type Questions

1. Where and when was environment conservation first discussed at an international forum?
2. When is the World Environment Day celebrated ?
3. When were the provisions relating to environmental protection introduced in India?
4. Why do we need legal provisions to protect the environment?
5. What do the Directive Principles of State Policy say about the protection of the environment?
6. State the Fundamental Duty of an Indian citizen regarding environment.
7. What is *Agenda 21*?

B. Long Answer Type Questions

1. Mention the provisions for environmental protection provided in the Constitution of India.
2. Name four conditions which apply to the hazardous waste management.
3. Name the rules related with biomedical waste.
4. What does the Atomic Energy Act, 1962 state about the disposal of used Uranium?
5. Give three provisions of the Recycled Plastic Manufacture and Usage Rules (1999).
6. What are the key objectives of Basel Convention on transboundary movement of hazardous waste?
7. What are the major limitations of the legal provisions for managing waste?

C. Project/Activities

1. Collect information on various international environmental conferences.
2. Make a project showing how waste can be effectively utilised.

UNIT 4 – ENVIRONMENTAL VALUES AND ETHICS

CHAPTER 19

HUMAN RIGHTS, FUNDAMENTAL DUTIES AND VALUE EDUCATION

Course Content—Syllabus and Scope

Human rights, fundamental duties and value education.

Human rights, fundamental duties: Self-explanatory.

The environmentally conscious may choose to carry cloth bags, use organic manure. Apart from one's own home, also make effort to see that the surroundings are cleaned, e.g.: the neighbourhood—plant more trees, respect for other people's things; this will evoke respect for their colony, city and country.

Ethics refer to moral principles that control or influence a person's behaviour. The morality of recognising the right of every living creature to survive in this world is the basic demand of environmental ethics for all human beings. Man is a part of the environment and he must live in harmony with other forms of life and available resources on Earth.

International Union for the Conservation of Nature and Natural Resources (IUCN) has provided the following ethical principles for preserving biodiversity.

1. This world is an interdependent whole composed of human beings and natural communities. The well-being and health of any one community is dependent on the well-being and health of the other portion.
2. Human beings are a part of nature and are covered under the ecological laws.
3. All life-forms on Earth depend on the uninterrupted functioning of natural systems that ensure the energy flow and supply of nutrients.
4. Human beings must recognise the right of other life-forms or species to permanently and freely exist in nature.
5. Man should consider sustainability as the basic principle for any social and economic development.
6. Human rights (with the dimension of moral ethics) must be ensured to all men and women.

HUMAN RIGHTS AND FUNDAMENTAL DUTIES

These have been derived from the principle of Natural Law. This law claims that the society must recognise the human rights and provide these to the individuals. These are certain rights which must be provided to an individual because one is born as a human being and there are certain rights and privileges that one must enjoy.

Human Rights were first certified by Britain in the Magna Carta in 1215. The Universal declaration of Human Rights by the United Nations on December 10, 1948 provides comprehensive protection to all against all forms of injustice and human rights violations. It also defines specific rights—civil, political, economic, social and cultural. Although human rights are

Fig. 19.1. Making the surroundings clean

considered to be universal, a wide disparity exists between their implementation in the developed and the developing countries.

The Constitution of India grants to its people civil, political, economic and social rights for improving their life through the provisions of Fundamental Rights and Directive Principles of State Policy. It also lays down Fundamental Duties for all citizens of the country.

Human Rights

Human Rights are the basic rights of every human being. The essence of human rights, is to protect the weak against the strong, to provide each individual equality of treatment and opportunity, to ensure sufficiency of information to everybody for enabling correct decision making, to fulfil for everybody the basic human need for food, clothing, shelter, health, education, work and social security.

Human rights are classified into some distinct categories. These are as follows:

- **First Generation Rights:** This can be identified as the right to liberty and are represented by civil and political rights, i.e., the rights of individuals to remain free from arbitrary interference by the State.
- **Second Generation Rights:** This is for equality, relating to the protection of economic, cultural and social rights, such as "the right to the creation of conditions by the State that will enable all individuals to develop their maximum potential."
- **Third Generation Rights:** This is for solidarity of a human being, to ensure an international legal and economic order "to guarantee the right to development, to disaster relief assistance, to peace and to a good environment". Such rights can only be ensured by international cooperation and not by national constitutional measures.

Human Rights and Ecological Balance

Human beings have a right to a clean and healthy environment. Therefore, any act of creating pollution, depleting natural resources, and any act leading to the destruction of ozone layer are considered as a human rights violation is in tune with the violation of animal rights for a clean habitat.

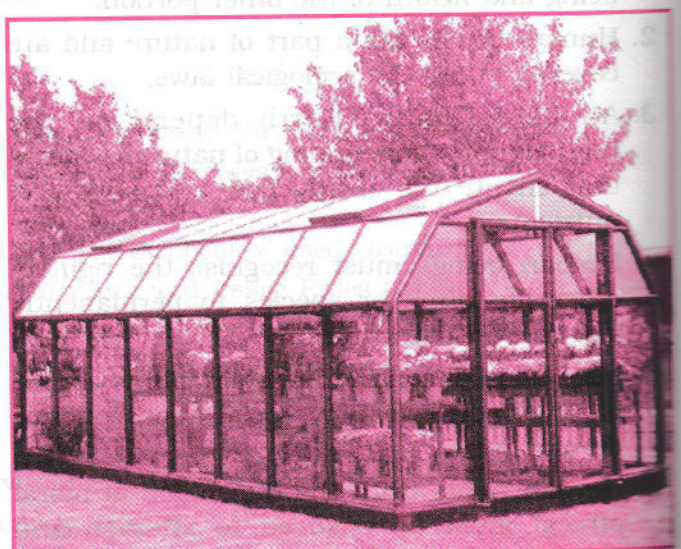
Emission of Greenhouse gases, deforestation, ejecting toxic chemicals into the natural surroundings, poaching of wildlife, creating threat to biodiversity, causing ecosystems degradation, etc., are all human and animal rights violations. Similarly, industrialism, commercialism and consumerism without sustainable approach are violations of human rights. Such violators give the excuse of abundance of natural resources that 'permits' such violations. It has been stated "The human right to a clean environment demands that the correct actions are undertaken. Not to do so is complicity with the wrong doing, even if engaged in by many."

Concept of Sustainable Development

Sustainable Development is a development strategy that manages all assets—natural resources and human resources as well as financial and physical assets for increasing long-term wealth and well-being. Sustainable development rejects policies that support current living standards by depleting the natural resources and that leave future generations with poorer prospects and greater risks than our own.

Basic Concepts

Sustenance and Development of a society with conservation of natural resources, including biodiversity for our future generations, are



among the basic concepts of sustainable development. Sustainability should have the following features:

1. Renewability: The rate of utilisation of renewable resources should be lower than or equal to the rate of production of the resources. Renewable resources that have already depleted should be given complete protection. They can again be utilised after attaining the sufficient quantity to sustain.

2. Adaptability: A society should adapt to the changing environment. It should be able to survive in a changed situation.

3. Interdependence: A sustainable society depends on its own resources. Interdependence among sustainable societies, is always evenly balanced.

4. Substitution: Sustainable development ensures substitution of the use of non-renewable natural resources by the use of renewable natural resources.

5. Institutional Commitment: It means that there should be political support, constitutional provisions, legal framework, coordination between institutions and, above all, the ability to understand deeply the need of sustainable development in a society.

FUNDAMENTAL DUTIES

Ten Fundamental Duties for every Indian citizen were added into the Constitution of India by the 42nd Amendment of 1976.

Part IV-A, added to the Constitution has the provisions regarding fundamental duties.

Article 51(A) of the Constitution of India reads: "It shall be the duty of every citizen of India:

(a) to abide by the Constitution and respect its ideals and institutions, the National Flag and National Anthem;

(b) to cherish and follow the noble ideals which inspired our national leaders' struggle for freedom;

(c) to uphold and protect the sovereignty, unity and integrity of India;

(d) to defend the country and render national service when called upon to do so;

(e) to promote harmony and spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversions, to renounce practices derogatory to the dignity of women;

(f) to value and preserve the rich heritage of our composite culture;

(g) to protect and improve the natural environment including forests, lakes, rivers and wildlife and have compassion for living creatures;

(h) to develop scientific temper, humanism and spirit of inquiry and reform;

(i) to safeguard public property and abjure violence; and

(j) to strive towards excellence in all spheres of individual and collective activity, so that the nation constantly rises to higher levels of endeavour and achievements.

Involvement of the State

Article 48 A was added in our Constitution to the Directive Principles of State Policy. It states: "The State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country". The Central and State Governments are to keep in mind the Directive Principles before making any law.

VALUE EDUCATION

It refers to a wide range of learning and activities ranging from training in physical health, mental hygiene and manners, proper social behaviour, civic rights and duties, aesthetic and religious training.

Value education is the powerful tool that can bring about some economic and cultural progress of a country. It has been projected as one of the national priorities in the National Educational Policy (NEP), 1986. The five dimensions that have been identified on value education are physical education, emotional education, mental development, aesthetic development and moral as well as spiritual education.

Value education provides a proper direction to the youth, inculcating a positive attitude in them. It teaches them to distinguish between right and wrong. It also teaches them to inculcate values like compassion, helpful attitude, love for peace, generosity and tolerance, thus enabling them to move towards a harmonious peaceful, enjoyable and sustainable future. Value education enables one to arrive at the value-based judgements in life based on

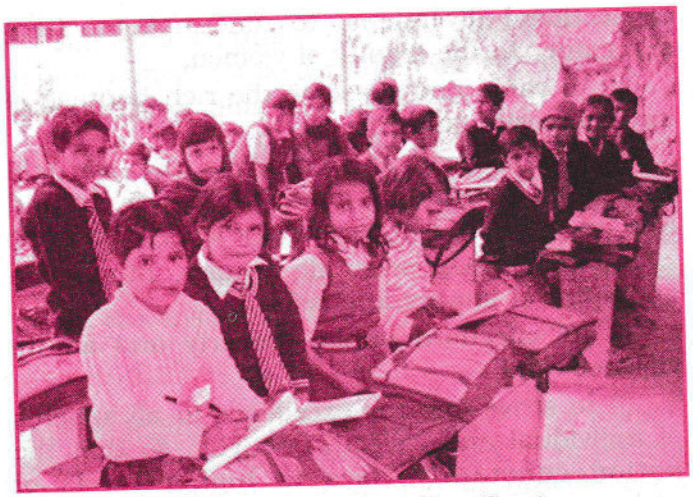


Fig. 19.3. A Village Class in Session

practical understanding of various natural principles rather than becoming prejudiced. Value education encompasses different phases like value selection, value commitment and value action. The time has come to make even environmental education a value that should develop in people a sense of earth citizenship. It would also arouse in them a sense of duty to care for the planet and its resources, and manage them in a sustainable way. This would help the future generations also to inherit a safe and clean planet to live on.

The Supreme Court of India has issued a directive making Environment Education a compulsory subject right from the school stage to the college level. The prime aim is to make everyone environment literate. The environment belongs to each one of us and our actions affect the environment. If the environment gets affected, it affects our health adversely thereby tampering with our well-being and our future. The following ways can help in making the environmental education value-based:

1. Textbooks should be prepared on environmental education. They should emphasise the basic human values in nature rather than the concept 'nature for man'.
2. Values like love, compassion, tolerance and justice should be woven into the fabric of environmental education. It is primarily through nurturing of these values that all forms of life and biodiversity on this planet can be protected.
3. Cultural and religious values must be infused by teaching everyone not to exploit nature without nurturing her.
4. Ethical values must be encompassed where everyone thinks of the welfare of the earth rather than considering themselves as supreme.
5. Global values must be stressed which tell us that all the phenomena occurring on the earth are inter-connected and interlinked with bonds of harmony. Disturbing this harmony would eventually lead to disaster.
6. Spiritual values focussing on self-discipline, contentment, reduction of wants, freedom from greed, etc, would help to promote the idea of conservation and transform the consumeristic approach of the people.

These values will definitely go a long way in attaining the goals of sustainable development and environment conservation. They can help in bringing about a rapid transformation in our mind set attitudes and lifestyles.

Citizens Resoponsibility Towards Environment

Every human being has a responsbility towards the environment. Our environment is basically the world around us that affects us, directly or indirectly. We all know about the environmental problems like pollution, global warming, dumping of waste, depletion of resources, deforestation, ozone layer depletion, greenhouse effect, etc.

But caring about the environment does not end with knowing about it. We must take measures to curb this, both at an individual level and as a community. Small acts performed daily can go a long way in protecting the environment.

Some of the measures every responsible individual should take are the following:

(i) Say no to plastic carry bags, instead use bags made of cloth.

(ii) Use organic manure instead of chemical fertilizers.

(iii) Keep the surroundings clean by not dumping the wastes in the open. Arranging separate dustbins for biodegradable and non-biodegradable wastes.

(iv) Travel by public transport or in a car pool instead of using own vehicles

(v) Plant more trees, especially in the areas where the felling of trees has taken place. Plant three times the number of trees uprooted in the adjoining areas.

(vi) Do not over-irrigate the fields without proper drainage to prevent water logging and consequently increased salinity of the soil.

(vii) Do not undertake construction in the areas marked as 'green belts'.

(viii) Do not keep the taps running while washing utensils and clothes, brushing, your teeth, taking a bath, shaving, etc.

(ix) Water the plants using a bucket rather your teeth, than a pipe.

(x) Make provision for rain water harvesting system in your house and locality.

(xi) Install water saving toilets.

(xii) Encourage eco-tourism.

(xiii) Use alternative sources of energy rather than using conventional fossil fuels.

So, we have to take the responsibility for each of our actions towards the environment. And if each citizen acts and feels it is 'my' responsibility to save the environment, a lot can be easily achieved. So, apart from our own home, efforts have to be made to keep the surroundings clean. We need to respect the rights of every individual on the environment. This will evoke respect for our colony, city and country.

EXERCISES

A. Short Answer Type Questions

1. What do you mean by ethics?
2. What are the human rights?
3. Where was the concept of human rights related to environment first taken up?
4. Name the basic features of sustainability.
5. State the Fundamental Duty of a citizen which enunciates concern for environment.

B. Long Answer Type Questions

1. Name the ethical principles listed by IUCN for preserving biodiversity.
2. Explain the link between human rights and ecological balance.
3. What do you mean by 'Sustainable Development'?
4. Explain the basic concepts and ethics of sustainable development.
5. What is said in our Constitution about protecting the environment?
6. What does the Directive Principles of State Policy say about the environment?
7. Give three measures that can help in making the environmental education value-based.
8. What are the responsibilities of a citizen towards the environment?

C. Project/Activities

1. Visit a village or a slum area and write a report on the role played by women in home management. In what way do they deal with social conflict?
2. Compare the roles played by women from urban and rural areas. How are they an asset to the society in which they live?
3. Talk to a group of children and mention the need for educating all children in India. How is the poor financial background of families prove to be an obstacle in the education of children?