ENVIRONMENTAL SUTDIES (DBES21)

(BA, BCOM, BSC, BBA)

ACHARYA NAGARJUNA UNIVERSITY

CENTRE FOR DISTANCE EDUCATION

NAGARJUNA NAGAR,

GUNTUR

ANDHRA PRADESH

LESSON : 1

DEFINITION, SCOPE AND IMPORTANCE OF ENVIRONMENTAL STUDIES

1.0 0bjective :

After studying this lesson, the student will be able to understand the definition, scope and importance of environmental studies

Structure

1.1 DEFINITION:

Environment is defined as the surrounds that influence the growth and development of mankind. The word environment is derived from the Greek word, 'environs' meaning 'surroundings'. The surroundings of whom? The surroundings of man. Environmental science is evolved exclusively for the welfare of the mankind. What constitutes our surroundings? Our surroundings are constituted by air, water, soil, plants, animals and the society. Hence, every human being is surrounded by human beings as man is a social animal. We can live only when all these components such as air, water, soil, plants, animals and society are in good equilibrium. Automatically the health, wealth and life style is totally depended on man's surroundings. Good wealth can let us lead good life style but without good health, one cannot enjoy good life style. Thus, the philosophy of environment is 'human health'. Medical science is a curative science whereas environmental science is a preventive science.

1.2 SCOPE:

Environmental Studies is a multidisciplinary subject. It embraces subjects like chemistry, physics, botany, zoology, physiology, geography, geology, geophysics, and meteorology to describe the physical, chemical and biological nature of our environment. **Environmental** Studies involves an understanding of philosophy, ethics, psychology, anthropology, demography, archaeology, economics and political science. Laid against an ecological format, the information glanced through the study of all these varied disciplines gives us a holistic view of the environment for sustaining life on earth infinitely.

The ruthless exploitation of nature (environment) by mankind for the sake of development

has threatened the survival of not only the living organisms but also the mankind itself. The number of species has been decreasing, a large number are threatened, and many are even extinct. Human beings too, are suffering from various health problems. Today India is one of the fastest growing industrialized countries in the world and the ever-increasing pollution levels in its environment are affecting all living organisms. People around the world are enjoying economic growth at the cost of quality of human life'. So the need of the hour is to save our environment. This insignifies the knowledge of our environment, its components and the different issues affecting the environment.

Environmental awareness is required not alone for environmental scientists but engineers, policy makers or NGOs or for that matter every citizen on this planet. Only environmental study can make us conscious and careful about the environment. Environmental education is aimed at developing environmental ethics in people. It teaches them the importance of conservation of life and biodiversity of the environment. Environmental study also teaches people to understand their role in the environment and learn to live with limited natural resources so as to avoid future disasters. The casual attitude of human beings towards the environment and its conservation is the root cause of all environmental problems.

Therefore, proper education and public awareness are necessary to tackle environmental problems. Towards this end, environmental studies will provide sufficient knowledge about the philosophy, genesis and consequences of local and global environmental problems and the necessary knowledge for their abatement and control. Thus, for a sustainable environment and for the survival of the present and future generations, environmental education is necessary.

1.3 THE NEED FOR PUBLIC AWARENESS

As soon as man acquired the ability to generate fire in the Paleolithic era, the environment began to get adversely affected. In the Iron Age, man discovered the use of tools whose application had diversified the utility of the matter for moulding and manufacturing new goods. With further growth of technologies, the services sector also increased.

The end of the Middle Ages saw a growth in population, concentrated within cities. This resulted in conspicuous increase of contamination of air, water etc. Air pollution began to be recognized as a health issue, while polluted water in densely populated areas served as medium for transmission of diseases. Thus, the cities have become hostels for communicable diseases.

In 1272, King Edward I of England promulgated a ‘law imposing a ban on burning of coal in London city. This was done after its smoke had become a problem. Every person who disobeyed the law was ‘executed’. However, during the industrial revolution, air pollution continued to be a problem there. London also recorded one of the earliest cases of water quality problems with the Great Stink on the Thames of 1858. This led to the construction of the London sewerage system. The incident of London Smog was a result of air pollution. The twentieth century is the worst in the annals of human history in terms of pollution inflicting health changes.

However, rapid industrialization and several developmental projects have disturbed the ecological balance in such a way that the survival of life on earth has been seriously threatened. People are now suffering from contamination in gases, liquids, and solids as well as phase transfer of contaminants.

The London Smog, Los Angeles Smog, Bhopal Gas Tragedy, Chernobyl disaster, DDT Episode, Mina Mata disease, Itai-Itai disease, oil pollution, and solid waste disposal are all examples of the far reaching effects of pollution. The repeated occurrence of such accidents has drawn the attention of the world towards environmental awareness. The union government of India has also enacted a comprehensive Environment (Protection) Act, 1986 to safeguard and protect our environment. This shows the increased awareness in both the government and the common people about the environment.

If you have a plan for one year – plant Rice

If you have a plan for ten years – plant a Tree

If you have a plan for hundred years – educate people

The above saying clearly shows the importance of creating awareness among the public. Social awareness can encourage people to use biogas and solar energy or non-conventional energy instead of fossil fuels. An informed citizen can raise his voice against using unfit air and water resources and force the responsible agencies (industry) to treat the particular resources before they are released into the natural environment. Global environmental issues like ozone depletion, climatic changes, acid rain and loss of biodiversity were the result of rapid industrialization, different developmental projects, and sprawling urbanization. In India, we also have problems of solid waste disposal, sanitation, and air and water pollution.

However, India has been facing the major problems like poverty and illiteracy. People, who cannot fulfill their daily needs, cannot think about the environment. This ignorance and illiteracy has generated a number of misconceptions and superstitions such as:

(i) Diseases are caused by the anger of Gods and demons.

(ii) Famines, floods, droughts are God's punishment for the sins of the society.

(iii) Showers of rain are by god’s grace

(iv) Only cities are polluted and not the villages

(v) Deforestation is the result of the industrial revolution.

To get rid of these superstitions and misconceptions about nature, environmental awareness is a must in India. This awareness ensures that everyone, including a farmer in the village and a policy planner in the government knows about the impacts of human activities on nature. Agricultural production can get a boost only if people know the patterns of land use, water resources and irrigation.

1.4 SELF ASSESSMENT QUESTIONS:

1. Define ‘environment’ and explain various aspects dealt in environment.

2. Explain the need for social awareness about environment

3. Environmental Studies is an interdisciplinary subject – discuss.

1.5 REFERENCES

1. A Text Book of Environmental Studies. D.K Asthana and Meera Asthana, S. Chand Publishers, New Delhi.

2. A Text Book of Environmental Studies – Erach Bharucha, Universities Press, New Delhi, 2005.

Prof. Z. Vishnuvardhan

LESSON : 2

ENVIRONMENT AND ITS COMPONENTS

2.0 Objective :

After studying this lesson, the student will be able to understand environment and its components

Structure

2.1 INTRODUCTION

The environment encompasses virtually everything that surrounds an organism in a holistic ecological approach.

Out of the nine planets, meteorites and satellites in our solar system, the earth is the only planet known to support life. Life on the earth exis spread among different types of

surroundings. These surroundings may be living or non-living. Each living organism constantly interacts with it's surroundings and adapts to it. These surroundings are our environment. The physical environment, which consists of soil, air, water and sunlight provide favourable conditions for the survival and growth of different life forms. Living beings constitute the biological environment.

Both the physical and the biological environments closely interact with each other to form a stable system. Everything that influences an organism and its living processes from outside is collectively known as 'environment.' The living things of the environment is known as the biotic component and the non-living things as the 'abiotic' component. Hence, the term 'environment' can be denned as the sum total of living and non-living components, their influences and events surrounding an organism.

No organism can live without interacting with the environment. Animals depend on green plants for food and oxygen, whereas plants depend on animals for pollination of flowers and dispersal of seed or fruit. Therefore, for the survival of human civilization, protection of environment is very essential. For this, some fundamental principles have to be followed:

(i) Maintenance of biodiversity.

(ii) Maintenance of all gaseous and material cycles and interdependence of living organisms among themselves and with abiotic environments.

(iii) Maintenance of ecological order and natural balance, which depend on the food chain relationship, sustainable productivity and biotic interaction.

These principles were known to early human beings, who lived in harmony with nature. However, in the course of evolution, man has developed a new type of environment, the man-made environment. The imbalance in nature is caused by this man-made environment. This man-made imbalance has forced us to rationalize the use of natural resources.

2.2 SEGMENTS OF THE ENVIRONMENT

Our environment can be broadly classified into natural and man-made environment.

Natural Environment

Each living organism has a specific surrounding with which it interacts and adapts. This surrounding is its natural environment. The natural environment can be broadly classified into two categories.

(i) The non-living or abiotic component, which includes:

(a) Climatic factors such as solar radiation, temperature, wind, water current, and rainfall.

(b) Physical factors such as light, air, pressure and gravitation.

(c) Clinical factors such as oxygen, carbon dioxide, acidity, salinity, availability of inorganic nutrients and so on.

(ii) Living or biotic factors such as plants, animals and microbes.

2.3 MAN-MADE ENVIRONMENT

With the development of science and technology, human beings have begun to alter the environment to suit their requirements. This has led to the evolution of a man-made environment. Hence, the environment— which earlier comprised of just air, land and water— now also includes crop fields, urban areas, industrial space, vehicles, power plants, telecommunications and much more.

The basic needs of human beings are food, shelter, potable water and sanitation. The resources for urban demands are transported from rural areas in cars, buses, trucks and trains, which consume a large amount of energy and pollute the atmosphere. The ever-increasing demand for comfort has resulted in the migration of people from villages to urban areas. Urban areas, on the other hand, are unable to meet the demand of basic civic amenities. As a result, they are becoming hovels of dirt, disease and crime. This has resulted in the paradox of concrete skyscrapers coexisting with slums and the atmosphere being polluted with exhaust from traffic, factories and domestic smoke.

Man-made Environment: An Urban Park

2.4 SOCIAL ENVIRONMENT

Human beings are social animals. This is why the socio-cultural environment plays an important role in their lives. The social environment is formed by the network of social institutions, which include political, religious and economic. Family is one of the basic institutions of the social environment. It is here that human beings perform various activities, including socialization of children and the transference of cultural heritage and morals from one generation to the next. Groups of families form communities which are classified according to their occupation, religious faith, and other parameters.

2.5 ENVIRONMENT OF THE EARTH

The environment of the earth has been studied with various modern and scientific

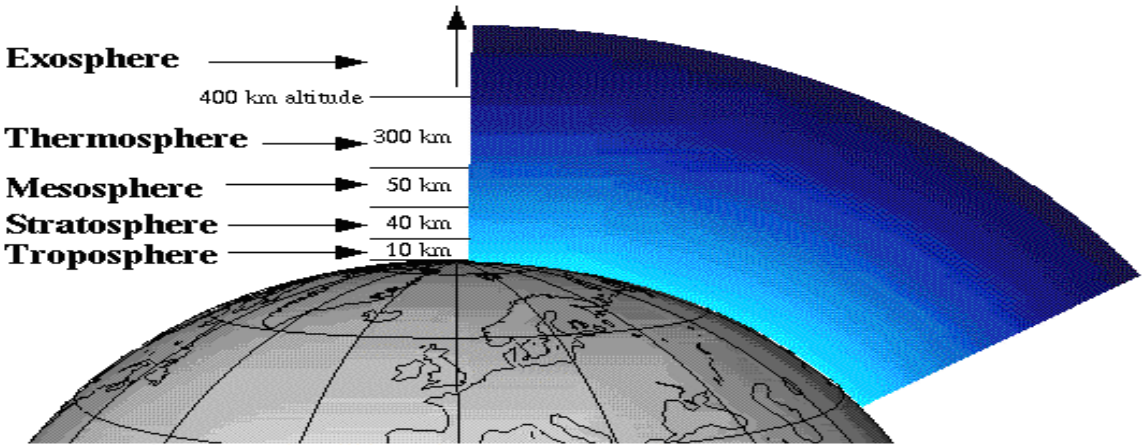
instruments, such as satellites, rockets, and balloons. The results indicate that the environment of our planet comprises of three segments. These are: (i) atmosphere, (ii) Water or hydrosphere (iii) Land or lithosphere.

2.5.1 ATMOSPHERE: The earth's atmosphere is an envelope of gases extending up to 2000 feet above the ground level. The gases include nitrogen, oxygen, argon, carbon dioxide, traces of carbon monoxide, oxides of nitrogen, sulphur and hydrocarbon, and very little amount of water vapour. The concentration of these gases decrease with the increase of altitude. Bulks of these gases are present within the atmospheric band that stretches up to 5 km above the earth.

The atmosphere protects the earth's biosphere by absorbing a major portion of the electromagnetic radiation and most of the cosmic rays. The atmosphere also absorbs infra-red radiation and thereby maintains the temperature of the earth at life sustaining levels. It also helps nature in maintaining its balance through different biochemical cycles, namely the oxygen cycle, nitrogen cycle, carbon cycle and hydrological cycle.

However, scientific advancements of the modern man are polluting this protective blanket by dumping waste materials like carbon emissions and smoke into the atmosphere.

2.5.1.1 LAYERS OF THE ATMOSPHERE: The earth's atmosphere is broadly divided into five regions:



2.5.1.1.1 ***TROPOSPHERE:*** The lower portion of the atmosphere is called troposphere. It contains 70 per cent of the atmosphere's mass. The density of the troposphere decreases with altitude. The air near ground level is heated by the radiation from the earth. As we move away from the surface of the earth, the temperature decreases with increasing altitude. Thus, the temperature has a negative relationship with altitude. For every 1000m increase of altitude (1 km) the temperature decreases by 6^{o} F. This decrease of temperature with altitude is known as lapse rate. The global energy flow, resulting from the difference in heating and cooling rates between the equator and the poles makes the troposphere a turbulent region.

2.5.1.1.2 ***STRATOSPHERE:*** Above the troposphere, the quiescent layer with a positive lapse rate is known as the stratosphere. Very little water vapour is found here. The ozone molecule, present in the layer, absorbs the Sun's ultraviolet radiation, and decomposes into oxygen molecules and an oxygen atom. When these particles combine, energy is released as heat radiation which causes a positive lapse rate.

$$O_3 \underset{\text{Heat released}}{\overset{\text{UV radiation 220–330 nm}}{\rightleftharpoons}} O_2 + O$$

The stratosphere not only shields life on earth from the injurious effects of the Sun's ultraviolet rays, but also supplies heat necessary ting the stratosphere from the turbulent troposphere. The stratopause separates the stratosphere from the mesosphere.

2.5.1.1.3 ***MESOSPHERE****:* In the mesosphere, the temperatures increase with the increase of altitude. This is because of low levels of ozone that absorbs ultraviolet radiation. The mesopause separates the mesosphere from the ionosphere.

2.5.1.1.4 ***THERMOSPHERE****:* In thermosphere, the positive lapse rate raises the temperature to a maximum of about 1200°C. Hence, atmospheric gases such as oxygen and nitric oxide split into atoms, which absorb solar radiation in the far ultraviolet region and then undergo ionization. That is why this layer is called ionosphere.

2.5.1.1.5 ***EXOSPHERE:*** The uppermost layer of the atmosphere is known as Exosphere. This extends up to a height of about 1600 km and gives way to interplanetary space. It is extremely rarefied. The upper layers of the atmosphere are continuously pressing down on the lower ones. Hence, the density of the lower layers is higher and it decreases as we move upwards.

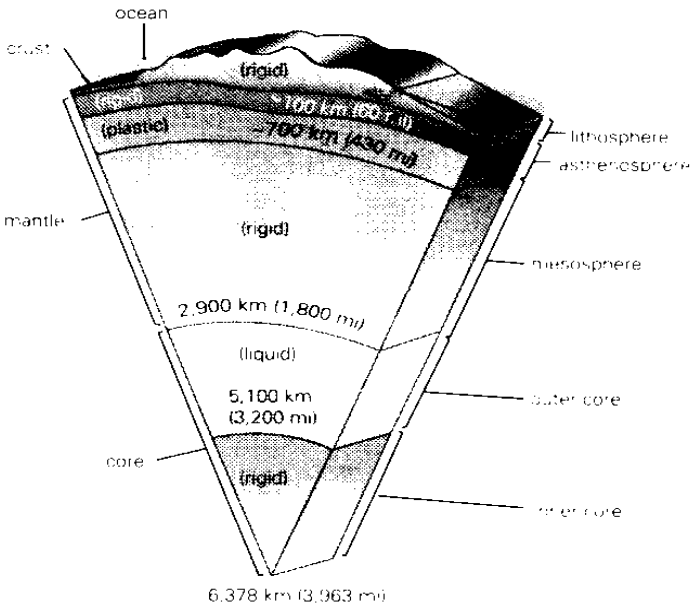
2.5.2 HYDROSPHERE: All types of water resources, namely the oceans, seas, rivers, lakes, ponds, streams, polar ice caps, glaciers, ground water, and water vapour are collectively known as the hydrosphere. Water being the elixir of life, all ancient civilizations were linked to major sources of water, be it the Egyptian Civilization along the River Nile, the Indus Valley Civilization along the River Indus, or the Mesopotamian Civilization between! the Tigris and Euphrates rivers.

The hydrosphere is an important part of the earths surface. About 70 per cent of the earth's surface is covered with water. The northern hemisphere is dominated by land surface, while the southern hemisphere is almost entirely occupied by water bodies (oceans).

Water is the most essential component of life for all living organisms. The hydrosphere is of immense importance to mankind. It maintains the availability of fresh water to the biosphere through the hydrological cycle. A major component of the hydrological cycle is the ocean. The oceans are great reservoirs of water and they also regulate carbon dioxide. The oceans can absorb more carbon dioxide than the atmosphere. Oceans are also the storehouses of vast resources, such as, water, salt, minerals, and food. The oceans are the largest sinks (pollutant receptor) of the planet. Thus, the role of the hydrosphere is critical to the sustenance of lite on the earth. This is underlined by the fact that life on the earth originated under marine conditions.

2.5.3 LITHOSPHERE: Lithosphere is the outermost mantle of rocks constituting the earth's crust. Rocks are subjected to continuous physical, chemical and biological weathering. Plants grow and decay on the soil covering the rocks. Soil is the major component of the lithosphere. The organic matter in soil is decomposed by micro-organisms. The major components of soil

are air, water, minerals, and inorganic matter. Organic matter of soil comprises plant biomass that is in various stages of decay. It also includes a high population of bacteria, fungi and animals such as nematodes, micro arthropods, termites and earthworms. Soil plays a vital role in supplying nutrients to the plant kingdom. The nutrient supply power of soil is a measure of its fertility, while the productivity of the soil is a function of crop and animal biomass per unit area. Thus, the yield ot crop depends solely on soil and crop management strategies. Therefore, this dynamic balance between the soil and the crop needs to be preserved to maintain the interrelationship between the two.



Different Layers of Lithosphere

The lithosphere has a thickness ranging from 64 to 96 km. The uppermost part of the lithosphere is rich in silica (Si) and aluminium (Al) and is therefore, known as the SiAl layer.

The zone next to the SiAl is rich in silica (Si) and magnesium (Mg). This layer is formed of basalt rocks and constitutes the ocean floors. The basalt rocks are heavier than the rocks formed by SiAl layer. Below the SiMg layer, the density of the layers increases with depth. Such differences in density cause the constituting layers to float, one over the other. The continents are basically large segments or 'plates' of the earth's crust floating on top of this heavier layer. These floating plates are responsible for the tectonic movement of the earth's surface during an earthquake.

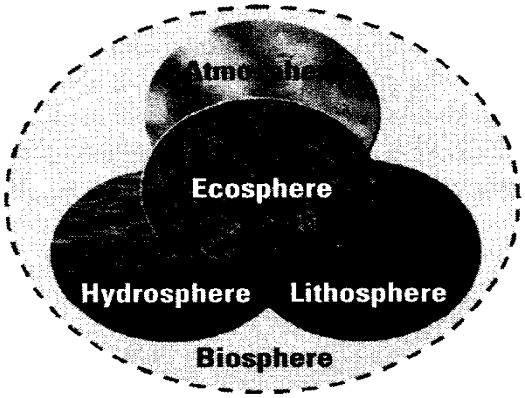
Below the lithosphere lies the mantle, which has a thickness of about 2400 km. The upper part of the mantle is known as the Asthenosphere, while the lower mantle is called the Mesosphere. The interior-most part of the earth is called the Core, which consists of minerals such as iron, nickel, cobalt mixed with sulphur, and silica. The thickness of the core extends to about 3500 km. The Core consists of the outer core and the inner core. The inner core appears to be solid, while the outer core is molten and metallic. The temperature of the core ranges between 5000 and 5500°C.

The direct interaction between the atmosphere, hydrosphere and lithosphere for millions of

years has made the earth suitable for life and has formed the biosphere.

2.6 BIOSPHERE: Life on earth occupies a 'thin skin' extending more than a few kilometres below and above its surface. This is commonly known as the biosphere. Both the biosphere and environment influence each other a lot. The oxygen and carbon dioxide levels of the atmosphere depend entirely on the plant kingdom. All the different biogeochemical cycles are essential for the continuous circulation of constituents necessary for supporting life. This is possible due to the interaction of the biosphere and the environment

It is in the biosphere that radiant energy is converted to chemical form (carbohydrates) through the process of photosynthesis. Only then does energy transfer take place from chemical to mechanical, and heat forms during cellular metabolism.



Spheres of the environment-

Thus, it is the biosphere which is responsible for large scale recycling of matter and energy. Even today, the existence of life on earth is closely dependent on the biosphere because it constitutes an essential life support system for all living beings.

2.7 SELF ASSESSMENT QUESTIONS:

1. What are the various components of Environment and their interactions.
2. Write an essay on the environment of the earth
3. Describe various layers of the atmosphere and their significance
4. Explain the role of lithosphere and hydrosphere in the environment.

2.8 REFERENCES

1. A Text Book of Environmental Studies. D.K Asthana and Meera Asthana, S. Chand Publishers, New Delhi.
2. A Text Book of Environmental Studies – Erach Bharucha, Universities Press, New Delhi, 2005.

Prof. Z. Vishnuvardhan

UNIT II : NATURAL RESOURCES

LESSON 3

CLASSIFICATION AND IMPACT OF HUMAN ACTIVITIES

3.0 Objective

After studying this lesson, the student will be able to understand about natural resources – forest, water, Mineral, Food resources

Structure

3.1 Natural Resources

A resource can be defined as any material that can be transformed into a more valuable and useful product or service. Ever since his appearance on earth, man has been dependent on the resources that nature provides. While air, water, soil, minerals, wind, solar energy and so on are non-living or abiotic resources of nature, plants, animals and other organisms are biotic or living forms of natural resources.

Everything that nature provides has some utility for mankind but its utilization is possible only with the help of appropriate technology. For example, coal and mineral oil have been present beneath the earth's surface for centuries but earlier we had no technology to help us make proper use of them. Thus, naturally found materials can be converted into a natural resource only after a suitable technology is discovered for its utilization and conversion to a more valuable product. Therefore, depending on the origin, natural resources are either biotic or abiotic. Similarly, based on availability and utility, natural resources may be classified into renewable resources and non-renewable resources.

(i) **Renewable Resources**: Resources which can be renewed even after use are known as renewable resources. For example, forest cover, solar energy and hydroelectricity are all renewable resources. Since these can be easily replaced they can be termed renewable or non-exhaustible resources.

(ii) **Non-Renewable Resources**: There are some resources in nature that have taken thousands of years in combination with highly favourable climatic conditions to form. If exploited recklessly they will be exhausted. Such resources that take too long to form and cannot be replaced easily are called exhaustible or non-renewable resources. Fossil fuels, minerals and so on come under this category.

Apart from these two types of resources, there are some natural resources that can be used continuously.

Water is one such natural resource. After using it for domestic, industrial and other purposes, water can be recycled and used repeatedly,

3.2 Natural Resources and Associated Problems

Due to the continuous increase in population, demand for natural resources has also increased. This is catalyzed by scientific progress followed by technological advancement for the utilization of natural resources. These two factors are responsible for the over-utilization of natural resources, particularly non-renewable resources.

Overexploitation of non-renewable resources will not only lead to economic imbalance between developed and developing countries, but also to environmental and ecological imbalance between nature and population growth. Today, developed countries are consuming up to 50 per cent more natural resources than developing countries and they are producing more than 75 per cent of global waste and Greenhouse gases. Over-utilization of underground water has resulted in the depletion of the groundwater table and the drying of streams and rivers and that is why conservation of natural resources is very important for the sustenance of life on earth. The health of the ecosystem is an indicator of the quality of human life. For the maintenance of a quality ecosystem, it is necessary to have:

(i) control over the use of natural resources;

(ii) protection of the environment from pollution;

(i) conservation of biodiversity and

(iv) controlled growth of human population.

3.3 FOREST RESOURCES

Forests are an important renewable natural resource. In fact, a major part of the earths lithosphere is covered with forests. Forests which can be considered the centers of biodiversity are complex and they constantly change their environment to house wildlife, trees, shrubs, fauna and flora, microscopic soil organisms and much more. They are not only valuable from the economic, historical, cultural, recreational, aesthetic and religious points of view, but their resources too, are extremely important for mankind. Wood is still a source of fuel for one-third of the human population. While tribals living in and around forests directly depend on forests for their lives and livelihood, the remaining human population also indirectly depends on forests.

Forest Fire in Indonesia

Houses, furniture, paper, clothes, dyes, gums, resins and lac are largely made from wood and other forest products. In fact, the photosynthesis of plants regulates the amount of the oxygen we inhale and the carbon dioxide we exhale into the atmosphere.

Harvesting, collecting and processing important forest products like timber generate employment. So does ecotourism including bird watching, outdoor adventures, nature study activities, hiking, camping and so on. Some of the uses of forest resources are listed blow.

Useful Functions of Forest Resources

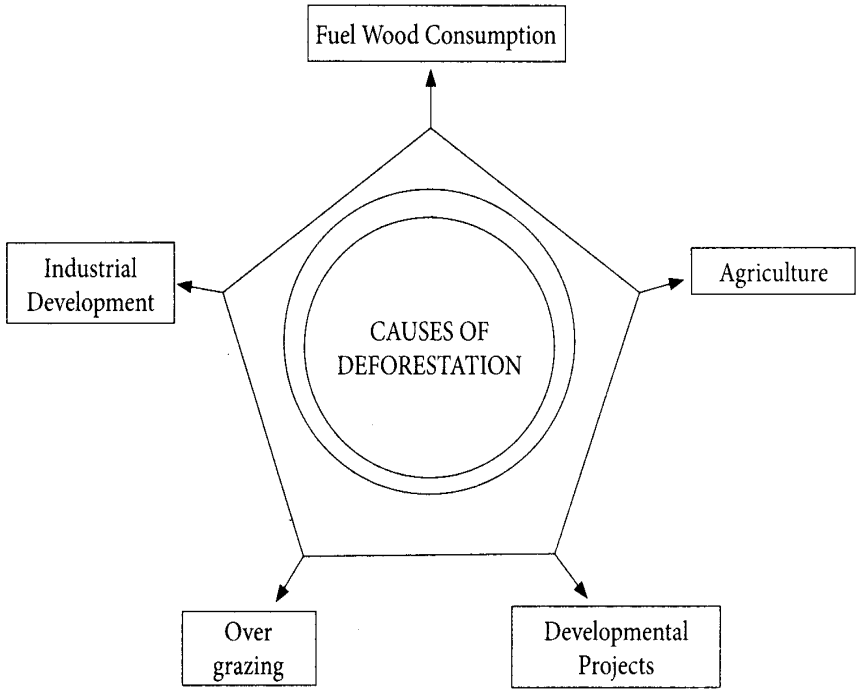
Function	Types of Benefits
Centre of biodiversity	• Forests provide home to unique plants, animals and wildlife.
Watershed protection	• Forests reduce the pace of surface run-off of water and thus encourage its percolation. • They stop soil erosion and prevent flash floods. • They help in preventing droughts through prolonged, gradual run-off.

Function	Types of Benefits
Clean water	• Trees cleanse the ground because their root system filters water and clears toxins and impurities. • Trees facilitate storing of clean water and maintain the availability of water during summer, when it is most needed.
Land erosion control	• Forests hold soil by preventing rain from directly washing away soil. • They reinforce soil to avoid landslides in mountainous areas. • They maintain soil nutrients and structures.
Clean air	• Trees absorb solar energy and cool and refresh the air we breathe. • Theymaintain local climatic conditions. • They absorb carbon dioxide and harmful pollutants and release oxygen into the atmosphere.
Economic benefits	• Timber production and other wood-based industries constitute an important part of the national economy. • Forests supply wood for fuel. • They supply fodder for cattle. • Trees provide fibres for weaving baskets, ropes, nets, strings and so on. • Sericulture for silk, apiculture for honey and pollinating crops, medicinal plants for medicines are economically beneficial. • Forests provide shelter for tribal people and building materials for others. • They provide foods, fruits, nuts, flowers, fish and meat. • Forests facilitate ecotourism.
Environment benefits	• Trees provide clean air. • They provide clean water. • They prevent global climate change through absorption of carbon dioxide, a leading Greenhouse gas, to produce wood and leaf matter, known as carbon sequestration. • They help in controlling soil erosion. • They absorb noise and reduce stress. • They provide an aesthetic place for mental peace and healing qualities. • They help in controlling climate and heat island effects resulting from city environments. • Forests also help in global recycling of water, carbon and nitrogen.

The over exploitation of forest resources has resulted in a serious threat to mankind. This was the cause of heated discussions at the Earth Summit in June 1972 at Rio de Janeiro on the topic of global transition to sustainable forest management. Forest cover all over the world is depleting fast, thus endangering rare varieties of plants, wildlife and other natural resources. India itself is losing about 15 lakh hectares of good forest land annually, which is estimated to be equivalent to the country's total consumption of oil, coal and electricity.

3.3.1 Deforestation

A demographic explosion has resulted in a steadily increasing demand for food and fodder for livestock, firewood and industrial raw materials. Croplands are being increasingly used for non-agricultural purposes due to rapid urbanization and industrialization; new croplands are being created by clearing forests. This wanton cutting of trees including lopping, felling, removal of forest litter, browsing, grazing and so on is known as deforestation.



Causes of Deforestation

The main causes of deforestation (as shown in Fig. 2.1) are:

(i) Fuel wood consumption;

(ii) Agriculture;

(iii) Industrial development;

(iv) Overgrazing and

(v) Developmental projects.

The causes of deforestation are fairly complex and range from a competitive global

economy, compelling international debt payment by developing countries, population growth and consequent increase in demands of agriculture to commercial logging, a shift to a cash crop economy and developmental projects like dams and mines.

Around the world, most of the forests are cleared for grazing cattle, planting crops and so on. Poor farmers cut down village common lands and forests, burn down trees to make the land fit for agriculture. Commercial logging of timber also enables the local tribals to enter the forests thus causing further deforestation.

Podu Cultivation (clearing of forests for agriculture)

Conversion of forest lands for agriculture

In developing countries, cash crops like rubber, tobacco, oil and palm need marginal lands which results in the clearing of rain forests or dense forests. Mining, industrialization, dams and hydroelectric projects also cause deforestation. The fact is that rich mineral resources are available mostly in forest areas. Similarly, steep embankments of river valleys suitable for dams, hydro and irrigation projects are usually fertile lands sustaining dense forests and biodiversity. Therefore, the construction of dams for hydroelectric projects or irrigation usually submerges forests, displacing tribals from their natural habitat.

The massive cutting of trees for firewood, developmental projects, raw materials for industry and/or other various reasons have resulted in the shrinking of forest cover thereby adversely affecting precious wildlife. A recent study shows that 600 different species of animals have become extinct on earth over the last 2,000 years.

3.3.2 Timber Extraction

Timber extraction results in deforestation and in the fragmentation of the last remaining forests. It harms valuable species of trees, birds and wild animals. In spite of this, it is sometimes necessary to extract timber, so as to meet the needs of a developing country. During the extraction of timber, cutting, felling and handling should be done selectively, carefully and in a planned manner, in order to save the remaining forests and biodiversity. The United Nations Food and Agriculture Organization (UNFAO) has framed certain guidelines for the same.

Timber extraction can be classified as follows:

(i) Clear felling;

(ii) Selective logging;

(iii) Mechanized logging;
(iv) Hand logging and
(ii) Reduced-impact logging.

Clear felling generally means the complete destruction of native forest, modifying it by harvesting commercial trees to create an even aged group and removing non-commercial trees, if required. Now, industrial timber logging is being done through clear felling all over the world.

In selective logging, only large individual trees of a few economically marketable species are harvested. The other trees are left untouched till the next harvesting. Although in selective logging only three to 10 of the tallest trees are targeted per hectare, the damage done may be as high as 50 per cent of the total forest areas because of the need to create access routes, dragging cut trees on the forest floor and lack of planning.

In mechanized logging, heavy machineries are used to pull, lift and transport the trees. This process can be used in clear felling or selective logging operations.

Local people use hand logging for non-commercial felling of timber or clearing of forests for agriculture. This labour-intensive, non-mechanized means involves the felling of trees by hand-held chain saws and then transporting the logs manually. This method is used in peat swamp forests which are regularly water logged and where heavy machinery movement is not possible.

Reduced-impact logging is now a common feature in industrialized nations where environmental damage can be minimized through the selection of site-sensitive techniques of harvesting and logging.

3.3.3 CASE STUDY

***Chipko* Movement:** The world famous *Chipko* trees, she sacrificed her life along with the lives of Movement, pioneered by *Dasohli Gram Swamjya* her husband, three daughters and 363 people. The *Mandal* in Gopeshwar brought about a general movement was given this name because the village awareness about conservation of forests. The first women embraced or

hugged the trees to stop *Chipko* Movement dates back to 1731, when a them from being cut. In 1972, in Uttar Pradesh, village woman named Amrita Bai led the *Bishnoi the Chipko* Movement was led by Bachnoi Devi women against the *Maharaja's men* to prevent of Advani who protected the hill forests from the them from catting trees. In this attempt to save the contractor's axe men.

3.3.4 Dams and their Effects on Forests and Tribal People

Post-Independence, a series of large dams were planned and built on some of the major rivers in India. In fact, India is one of the largest dam-building nations in the world, with as many as 4,291 dams either built or under construction. Though the estimates vary significantly the fact is that dams are the single largest cause of human displacement in India and account for 75 per cent to 80 per cent of displacement of about four to five crore people.

Nagarjuna Sagar Multipurpose Dam

Srisailam Multipurpose Project

The impact of large dams on forests and on the lifestyle and identity of tribal people is extremely high. Almost 40 per cent of those displaced by dams belong to scheduled tribes and

20 per cent to schedule castes. Only 25 per cent of the displaced people have been rehabilitated so far.

Of the 32 dams of a height of more than 50 m that were completed between 1951 and 1970, only nine (or less than 30 per cent) were in tribal areas. That figure doubled between 1971 and 1990, a period when another 85 dams of a height of more than 50 m were under construction. These were taller and more sophisticated than the earlier dams and about 60 per cent of these dams were in tribal areas. A recent government report based on a study of 110 projects stated that more than 50 per cent of the total 1.69 million people displaced by these projects were tribals. This means that the tribal communities which account for just 8 per cent of India's total population constitute about 40 per cent of the displaced persons. About 92 per cent of the tribal people in India live in rural areas which are dry, forested or hilly. Most of them depend on agriculture and minor forest produce for sustenance. These largely self-sufficient tribal communities live in close proximity to forests, rivers and mountains. Since these areas are rich in natural resources they are most likely to be developed for dams, mines, industries and so on.

Immediately after Independence, only a few dams were built in tribal areas. However, by the 1970s, when the resources in more accessible areas were exhausted, more dams were planned in tribal areas thereby displacing a large number of tribal people.

Tribals are socially, economically and politically the weakest and the most deprived community in India. They have been evicted from their ancestral homes and are either forced to migrate to urban slums in search of employment or become landless labourers in rural areas to pay the price of 'development'. Unfortunately, tribal people hardly get to share the benefits of development projects that cause their displacement. They are always forced to live without the basic amenities like roads, electricity, transport, communication, healthcare, drinking water or sanitation. On the contrary, a majority of them end up with less income than before, less work opportunities, inferior houses, less access to the resources of the common people such as fuel wood and fodder, poor nutrition and poor physical and mental health. Developmental projects have invariably led to the dispersal of communities, the breakdown of traditional support systems and the devaluation of their cultural identity. Therefore, the government should devise a strategy to minimize tribal displacement. It must ensure 100 per cent rehabilitation and make sure that the fruits of development are shared with the dispersed people as well. It must augment the rehabilitation of the displaced persons of previous projects, protect the customary rights of the tribal people over natural resources and take their opinions into consideration for future projects.

3.4 WATER RESOURCES

Water is the most important factor of life. History reveals that life began with water. Human civilization too, flourished wherever water was available in abundance. In fact, several cities and civilizations disappeared due to the shortage of water.

3.4.1 Hydrosphere—As a Source of Water on Earth :

The hydrosphere includes all sources of water such as oceans, lakes, rivers and underground water. Earth is known as the 'watery planet' because it is the only planet in the solar system with an abundant source of| water. About 97 per cent of the earth's total water supply lies in the oceans although it is unsuitable for human consumption due to its saline content. About 2 per

cent of the earth's water that is in the polar ice caps is frozen. The remaining 1 per cent of the earth's water is available as fresh water flowing in rivers, lakes, streams and groundwater which is suitable for human consumption

The composition of surface water differs widely from groundwater. Surface water contains a lot of organic matter and mineral nutrients, whereas groundwater contains dissolved minerals. When water seeps into the ground, a number of micro-organisms originally present in the surface water get depleted. Hence, groundwater is the most suitable domestic source of water.

Proportion of Different Types of Water

Form	Relative proportion (%)
Water in the oceans	97.390
Water in the rivers and lakes	00.020
Water in the atmosphere as vapour	00.001
Water in glaciers and polar ice caps	02.010
Underground water and soil moisture	00.580
Total hydrospheric fresh water	02.601

Water is also the most important component of protoplasm. In different metabolic processes, water is the only source of hydrogen and one among the several sources of oxygen. All living organisms draw water from the hydrosphere. Water consumed during different metabolic processes by organisms is partly given back into the environment in different ways. For instance, solar energy causes water to evaporate from different sources. These vapours cool down after gaining altitude and condense to form clouds which then precipitate as rain or snow and thereby return to the parent water system - the hydrosphere.

Water is an indispensable ecological factor for both plant and animal life. It is abundantly distributed in all segments of the environment, namely atmosphere, hydrosphere and lithosphere. In the atmosphere, water is present both as invisible and visible water vapour. Humidity is a form of water vapour present in the atmosphere which can be felt but not seen. However, clouds or fog are visible forms of atmospheric water vapour.

In soil water exists as gravitational water, capillary water, hygroscopic water, combined water and water vapour. When water moves downwards through moist soil under the force of gravity till it reaches a deep saturated zone of soil, it is called gravitational water. The upper surface of this is called the water table and it is available to the" plant kingdom only after frequent showers. However, this pool of water sometimes gushes out onto the earth’s surface through any weak point, when it is known as spring water. This water can also be made available artificially by digging wells and through lift irrigation. This water is generally free from impurities and may even contain dissolved minerals.

Wells are a major source of drinking water in villages and often well water has medicinal values too. After the draining of gravitational water, the water that is left over around the soil particles is known as capillary water. The sun dries this capillary water. The water that remains in the soil after the drying of capillary water is known as hygroscopic water. This water cannot be usually dried completely by the sun. Only if the soil is heated to about 105°C the hygroscopic water gets lost.

After the soil loses its hygroscopic water, the remaining water is present in the soil as oxides ot iron, silicon and aluminium and is therefore called combined water. Both hygroscopic and combined water are of no use to plants. On the contrary, it is water vapour or moisture present in the soil particles that helps in the germination of seeds and the growth of the root and so on.

3.4.2 Use and Over exploitation of Surface and Ground water:

As discussed earlier, the need for water, land, and energy has increased enormously with the increase in population. The demand for more land and energy has resulted in deforestation and the destruction of wetlands and flood plains. The demand for more water has forced human beings to use and overuse the natural water storage systems (aquifers). This has resulted in the destruction of nature's ecosystem. The water table has also receded because of overuse. Further, the loss of vegetative cover is not only a deterrent in the rilling of these natural reservoirs but also causes floods and droughts.

The abundant availability of water has led to the overuse and abuse of water in every area of our lives. Water is overused in household chores during brushing, bathing, washing and cleaning. Water is overused in agricultural fields too. One can get the same or even more yield with less amount of water by using the drip irrigation method. Water is overused by industries too. The situation worsens when untreated water is released by these industries into nearby water bodies, leading to water pollution.

Dams and irrigation canals have been constructed on rivers for the production of hydroelectricity and year-round supply of water. Since these dams and irrigation canals alter the flow of the river, they are the cause of overexploitation of water. The large landholders get the maximum share of water from canals, while, unfortunately the conditions of the poor, weak cultivators remain the same.

Water is wasted in urban India too. For instance, water can often be seen flowing incessantly from municipal taps that are left open on the roadside or from pipes that leak. Although water is overused, the cost of water has remained constant.

3.4.3 Floods

A river overflowing its banks has always been a great threat to human civilization. Ancient civilizations have flourished along the banks of all of the world's greatest rivers. As population density has increased, the need for more land has risen. To create more space, the catchment areas are deforested and wetlands filled up. The advancement of science and technology has strangled the rivers with bunds, dams and so on. As a result, the wetlands of the flood plains which were natural flood controllers have been lost. No longer can they act as sponges to hold the excess water from the rivers. Deforestation of hills and mountains, which are the sources of rivers, has added to the problem. Water does percolate underground but due to deforestation it runs downward, carrying with it a great load of top soil. This not only washes away the fertile top soil but temporarily blocks the rivers only to suddenly allow an enormous amount of water to move downstream towards the plains either through the same path or a changed path. In both the cases, the river swells and due to the lack of floodplains and wetlands the water overflows, submerging cities, towns, villages, agricultural lands and much more.

Flood situation in Bangladesh

3.4.4 Droughts

Drought which is mainly the consequence of climatic conditions that lead to a serious scarcity of water is one of the major problems in India. It occurs due to the failure of more than one successive monsoon in the area. Usually arid and semi-arid regions are drought-prone and they have very little or no vegetative cover which explains the condition of groundwater in the area. During a drought, water scarcity becomes so acute that there is no water for farms, industries, households or even drinking. Moreover, the intensity of the drought depends on how long the drought lasts in that area. A prolonged drought may result in famine.

Discorded dead Caracasses of cattle during drought

Severe Drought in Rajasthan : Women walking miles for drinking water

Thus, droughts occur mainly due to the failure of the monsoon, supplemented by the non-availability of groundwater due to a receding water table. Although the failure of the monsoon cannot be prevented the intensity of a drought can be reduced with the help of proper watershed management.

One of the main causes of water scarcity during a drought is deforestation. Due to the wanton cutting of trees in forests and hill slopes, rain water cannot percolate the subsoil and recharge the natural aquifers. However, afforestation can recharge the natural aquifers.

We also need to control the overuse of water. During a drought, this stored water can be used by the animal and plant kingdom to reduce the effects of drought. In a water-scarce region, the financially stronger section of society draws groundwater with the aid of pumps. As a result, members of the poorer and weaker sections are deprived of their supply of adequate water. Moreover, the release of industrial waste water into nearby water bodies makes the water unfit for human consumption besides turning it into a death trap for all aquatic life. Hence, strict measures have to be taken to compel industries to release liquid waste into water bodies only after adequate treatment to prevent pollution.

3.4.5 Conflicts over Water

Nearly three-fourths of the earth's surface is covered with water. There is abundant sea water on earth but it is not fit for human consumption, agriculture or manufacturing industries. Fresh water is essential to sustain life, development and the environment. It has been estimated that 1 billion people do not have access to clean water and 1.7 billion do not have access to sanitation.

As water becomes increasingly scarce, national conflicts over water have risen. Industry, agriculture and citizens compete with each other for the water they require for sustenance and development. National tension over the distribution of water can quickly escalate into discord

between groups dependant on a shared resource. Over 200 water bodies are shared by two or more countries or areas. There are water disputes in the Middle East, eastern Europe and South East Asia. In the Indian subcontinent, the Indus Water Dispute between India and Pakistan, the Ganga river controversy between India and Bangladesh and the inter-state water disputes, namely the Cauvery Water Dispute, Yamuna Water Dispute, Krishna-Godavari Water Dispute, Ravi-Beas Water Dispute and Bansadhara Water Dispute are some major ones.

Indus Water Dispute between India and Pakistan:

The dispute started with the Partition in 1947 when the Indus water basin was divided between India and Pakistan. Pakistan disputed India's share of irrigation water from the Indus river. The dispute ended in 1960 when the Indus Water Agreement was signed by the two countries after 12 years of World Bank-led negotiations.

Ganga Water Dispute between India and Bangladesh:

This dispute too, started with the Partition in 1947 between India and East Pakistan (present Bangladesh). In 1962, India built and operated the Farakka Barrage 40 km away from the Indo-Bangladesh border for navigability of the Calcutta Port. This resulted in the escalation of the dispute regarding allocation of the flow of the Ganga River and its tributaries between India and Bangladesh and in the development of a rational plan for an integrated watershed development, including supplementation of the flow of the Ganga. During the long conflict, short term agreements were reached in 1977, 1982, and 1985 that temporarily settled the dispute between 1977 and 1982, and 1982 to 1984 and 1985 to 1988. In December 1996, a 30-year treaty was signed between the two riparian based on the 1985 accord to help reduce the regional tensions.

Cauvery Water Dispute:

The Cauvery river is one of the most contentious sources of water in Southern India. Its watershed is divided between Karnataka (former princely state of Mysore) and Tamil Nadu (former Madras Presidency). Although Tamil Nadu does not control any of the Cauvery head waters, it is in possession of two of its tributaries, Bhavana and Moyar. Similar to the other divided watersheds (Mekong in Southeast Asia and Colorado in Western United States) there is peace in times of good rains.

The Cauvery Water Dispute has been a serious issue since 1974 when a 50-year-old agreement, signed in 1924 between Madras Presidency and Mysore State expired, compounding a century-old dispute over the vital interests of farmers in Tamil Nadu and Karnataka. According to Karnataka, the 1924 agreement entailed a discontinuation of the water supply to Tamil Nadu after 50 years. In 1991, the Supreme Court reassigned a tribunal to settle the dispute. The tribunal gave the decision that Karnataka must release 205 TMC of water from the Cauvery reservoirs to Tamil Nadu on a monthly basis. Karnataka declined to implement the order, arguing that if more than 100 TMC of water is released to Tamil Nadu, it would cause distress to its people.

Krishna-Godavari Water Dispute:

This dispute was mainly about the inter-state utilization of untapped surplus water between the states of Maharastra, Karnataka, Andhra Pradesh, Madhya Pradesh and Orissa. After tailed negotiations, the dispute was resolved by a tribunal judge who ordered equitable apportioning

of water. The Krishna Tribunal reached its decision in 1973 and the verdict was published in 1976, while the Godavari Tribunal commenced hearing in 1974 and gave its final verdict in 1979. Meanwhile, the states continued negotiations among themselves and reached agreements on all disputed issues and the tribunal only endorsed the same.

With more than 4,200 dams, India is one of the largest dam-building nations of the world. India has invested enormous capital, effort and resources in building large dams and irrigation projects amounting to more than Rs 80,000 crore, which is the total irrigation budget in the 50 years since Independence.

Large dams are meant to solve problems of hunger and starvation by providing irrigation, boosting food production, controlling floods and providing much-needed electricity for industrial development. Dams are therefore one of the major causes of development in India, as they result in enormous benefits to society in the areas of economy, agriculture, food production, irrigation and water supply, electricity generation, industrial development and so on.

It is these benefits that prompted Pandit Jawaharlal Nehru, the country's first Prime Minister, to term dams as 'secular temples of modern India.' Along with the stupendous benefits, dams also pose great problems to society. The problems that include environmental degradation, development-induced displacement and consequent aggravation of an already skewed social structure are massive. The utilitarian logic of 'few people having to sacrifice for the greater national good' for dam building has often grossly underestimated the environmental and social costs of dam building.

The impact of dams on forests and tribal communities has also been discussed in the section titled Forest Resources in this Unit. Dams are the single largest cause of 'displacement for development'. In fact, approximately 80 per cent of about five crore people, who have been estimated to be displaced in India since Independence for all development projects, are due to dams. Displacement caused by large dams has actually resulted in the transfer of resources from the weaker sections of the society to the more privileged ones. Large dams do little to change the existing social inequalities. On the contrary, they further aggravate the already skewed social structure. The largely self-sufficient, nature-dependant tribal societies generally live near forests, rivers, and mountains. These are resource-rich areas likely to be mined or turned into a dam. The impact of displacement of people affected by large dams has been overwhelmingly negative in India. The majority of displaced persons in most of the resettlement operations have ended up with lower incomes, less land than before, less work opportunities, inferior housing and less access to common resources such as fuel wood and fodder. They also suffer from lack of nutrition and poor physical and mental health.

Moreover, even a relatively liberal compensation and rehabilitation package cannot compensate for the loss of forests, rivers and ancestral land which is intricately woven into the social, cultural, religious and economic practices of a community.

After Independence, large dams were built as symbols of India's national development. All human and ecological costs were justified in its name. On this premise, people's movements such as the *Narmada Bachao Andolan* (NBA) have raised several fundamental questions such as: Who constitutes the nation? Who benefits from dams? Who pays the cost? Who decides and who obeys? Why? Can development that impoverishes the poor and the marginalized communities and destroys the ecological balance for the sake of the privileged classes be called development? Our society needs just and sustainable development, which in turn needs

dams to be built selectively without inflicting massive human and social exploitation by the state.

Narmada Bachao Andolan *(NBA)*

The Narmada Valley Development Project is the single largest river development scheme in India. The Government of India plans to build some 3,200 dams on the Narmada River, 90 per cent of which flows through Madhya Pradesh, skirts the northern border of Maharastra and flows through Gujarat prior to its confluence in the Arabian Sea. It is one of the largest hydroelectric projects in the world and has displaced approximately 1.5 million people from their homes in these three states.

Building a dam over the Narmada River will not only erode fertile agricultural soil due to continuous irrigation and salination, it will also make the soil toxic. Sardar Sarovar, the largest dam under construction, will flood more than 37,000 hectares of forest and agricultural land on completion and will displace about half a million people from their homes, land and livelihood. But the government's Resettlement and Rehabilitation (R&R) Programme will benefit only a certain percentage of the displaced persons. According to the World Commission on Dams, the impact assessment includes all people in the reservoir, upstream, downstream and in catchment areas whose properties, livelihood and non-material resources are affected and also those affected by the construction of dam-related infrastructure like canals and transmission lines. But the people affected by the canal system are not considered as Project Affected People (PAP).

Baba Amte addressing the Narmada affected people

In response to the continuous protests by the NBA, the Government formed a five-member team to review the project. But this team too, endorsed the World Bank view. Following a writ petition by the NBA in 1994 which called for a comprehensive review of the project, the Supreme Court of India stopped the construction of the Sardar Sarovar Dam in 1995. After this, the NBA shifted its attention to the other two big dams in Madhya Pradesh, the Narmada Sagar and Maheshwar. Although the height of these dams was less than their project-approved height, their impact on the environment was already apparent. However, in 1999, the Supreme Court ordered the height of those dams to be raised from 80 m to 88 m, followed by a judgment in October 2000 for immediate construction of the Sardar Sarovar Dam to a height of 90 m with

permission to increase its height to the originally planned 138 m. These court decrees have come despite major unresolved issues on resettlement, the environment's biodiversity and the cost and benefit of the project. According to the government, the project will provide water to 20 to 40 million people, irrigate 1.8 to 1.9 million hectares of land and produce 1,450 MW of power. But the social, environmental and human costs of the projects were obviously not evaluated properly by the planners.

3.5 MINERAL RESOURCES

A mineral is a natural substance that forms in the earth's crust over a period of millions of years. It has a definite chemical composition and identifiable physical properties. On extraction from the earth's interior, with or without technological and economic benefits, minerals can be used as raw materials for industries or for domestic purposes. They are of the following categories:

(i) metals and metallic compounds like iron, aluminum, zinc, copper, manganese, limestone, gypsum and dolomite;

(ii) rare earth metals such as uranium and niobium;

(iii) non-metals such as silica;

(iv) building materials such as granite, marble and mica;

(v) gems such as diamonds, rubies and emeralds;

(vi) noble metals such as gold, silver and platinum and

(vii) fossil fuels such as oil, gas and coal.

Some of these minerals are ores. An ore is a mineral or combination of minerals from which a useful substance such as a metal can be extracted and used to manufacture a useful product. For example, hematite and magnetite are ores used for steel manufacture; bauxite is an ore used for aluminum extraction.

3.5.1 Mining

The process of extraction of these underground minerals is known as mining. Mining operations follow four phases:

(i) Prospecting: Searching for the mineral.

(ii) Exploration: Assessing the size, shape, locations, qualities and economic value of the deposits.

(iii) Development: Preparing for the extraction of the mineral

(iv) Exploitation: Extracting the mineral from the mines.

Two types of procedures are followed for mining: Opencast or open-pit mining and deep or shaft mining. Of the two, an appropriate method is selected to get maximum yield at minimum cost and one that provides least danger to the mining personnel.

3.5.2 Mine Safety:

Open-pit (surface) mining is always less hazardous than underground or shaft mining and metal mining is safer than coal mining. Since these processes are used when mining is done on an industrial scale, it is undoubtedly a hazardous task. During the process, mining personnel are posed with dangers such as roof felling, insufficient ventilation, release of poisonous gases such as methane (specially in coal mines), flooding and radiation and also long term effects like lung diseases (black lung disease or pneumoconiosis) and bronchitis.

3.5.3 Environmental Problems:

Mining also causes irreparable environmental damage. During the prospecting and exploration phases, modern sophisticated and heavy machineries are used by geologists, mining engineers, geochemists, geophysicists and others. Such activities increase access to remote forest areas and disturb the local habitat. The most significant degradation of the natural environment occurs during the next two phases of mining, that is, development, exploitation and also long after exploitation. Some of the adverse effects of mining on forests and the environment are:

Photograph of Open Cast Mining

(i) Minerals are non-renewable natural resources. Their unplanned extraction and exploitation poses a threat to raw material resources for future generations.

(ii) Disposal of the waste which is generated during the process of mining is a problem as it causes land, soil and water pollution.

(iii) Land erosion which is the transportation of fine soil particles carried away by water and deposited in the tailing dam causes a problem as it leads to sedimentation.

(iv) Mining causes damage to forest cover as well as felling of trees.

(v) Dust generated during mining causes air pollution, which in turn causes

respiratory problems and asphyxia of plants and trees.

(vi) A large quantity of timber is used in underground mining.

(vii) A lot of water is used in hydro-metallurgical the beneficiation of minerals and the discharge of the same, contaminates water.

(viii) Movement of heavy machinery used during mining and the process of blasting causes heavy noise pollution.

(ix) Mining causes large disturbances to the environment adversely affecting terrestrial habitats.

(x) Some of the adverse social impacts of mining include:

(a) Loss of land of local people.

(b) Impact on health.

(c) Destruction of forms of community subsistence and life.

(d) Alteration of social relationships and social disintegration.

3.5.4 MINERAL RESOURCES OF INDIA

India has a large number of economically useful minerals. About 25 per cent of the world's known mineral reserves are found in India. The availability of various ores and minerals in India is given in Table…….

Mineral Resources of India

Minerals	Main sources	Other available sources	Remarks
Iron ore	Orissa, Jharkhand	Madhya Pradesh, Maharashtra, Chhattisgarh, Karnataka, Goa, Tamil Nadu, Himachal Pradesh	2nd largest reserve after Brazil.
Coal	Orissa, Jharkhand, West Bengal,	Chhattisgarh, Maharashtra, Tamil Nadu	
Manganese	Madhya Pradesh, Maharashtra	Orissa, Jharkhand	2nd largest reserve after Russia.
Chromites	Orissa, Jharkhand,	Andhra Pradesh, Karnataka,	
Bauxite	Orissa, Jharkhand, Maharashtra	Tamil Nadu, Karnataka	India produces 75 per cent of the world's total production.
Mica	Bihar, Andhra Pradesh, Rajasthan		
Gypsum	Tamil Nadu, Rajasthan		
Nickel	Orissa		
Ilmenite	Kerala		

Minerals	Main sources	Other available sources	Remarks
Silmanite	Madhya Pradesh,Meghalaya		
Copper	Andhra Pradesh, Jharkhand, Rajasthan, Sikkim, Karnataka		
Gold	Andhra Pradesh, Karnataka		
Diamond	Madhya Pradesh,		
Uranium, rare earths	Jharkhand		
Petroleum	Assam, Gujarat, Maharashtra	Tripura, West Bengal, Punjab, Himachal Pradesh Andaman & Nicobar Islands	

3.5.5 CASE STUDY

1. Two-thirds of India's iron ore reserves lie in Orissa and Jharkhand. Due to the growth of the steel industry worldwide, many international steel players have been attracted to the iron ore reserves in these two states and have been coming to Orissa and Jharkhand to mine iron ore reserves and, if possible, to export the ore. They also sign memoranda of understanding, promising to set up steel plants in the states. For example, POSCO signed an agreement with the Orissa Government to set up a Rs 53,000 crore steel plant with a capacity of 12 million tonnes per annum. They want to export iron ore to Brazil also. Similarly Arcelor Mittal, the number one steel maker in the world and Tata also signed agreements with the Jharkhand Government to set up steel plants with a capacity of 10 million tonnes each per annum at an estimated investment of Rs 42,000 crore and Rs 39,000 crore, respectively.

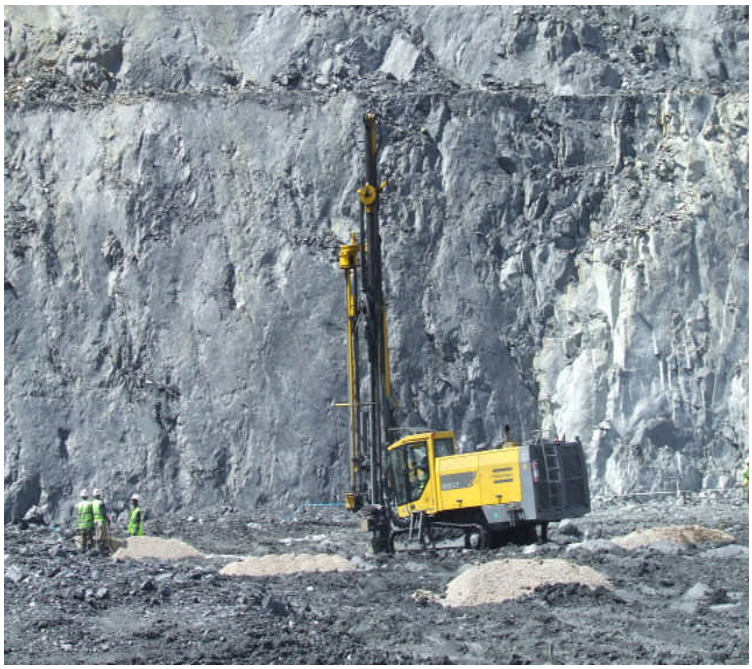
Arcelor Mittal had to withdraw their proposal of right to export iron ore before signing the agreement. If all these recent developments materialize, the states of Orissa and Jharkhand will be leaders in the industrial and economic map of India.

2. A classic example of the local population's right to mineral resources leading to the birth of a new state is Bougainville Island which is a part of Papua New Guinea. On May 17,1990

Bougainville Island spread across an area of 10,000 sq km with a population of about 1,50,000 people, declared itself an independent nation. The island was a part of Solomon Islands under British Rule till 1899. Then, it was a part of New Guinea under German rule till 1914. In 1947, Australian Papua merged with Guinea and came under Australian administration under the United Nations (UN) trusteeship. Papua New Guinea (PNG) became independent on September 6, 1975. Bougainville's CRA (Conzine Rio-Tinto Australia) copper mine started its operations in 1972 and accounted for 40 per cent of PNG's export and 20 per cent of government revenue.

Bougainville Island leaders wanted independence from PNG since the 1960s and submitted their demand to the UN's Decolonization Committee. Displacement, environmental pollution and inadequate compensation made Bougainville Islanders fight against the PNG administration which ultimately culminated in the closure of the PANGUA mine in May 1989. After almost a decade of ethno-nationalist conflicts, which started with the Bougainville

Revolutionary Army's demand for independence and PNG's resistance and oppression; Bougainville Island headed towards peace in 1997-1998 due to international intervention.



3.5 FOOD RESOURCES

Food is essential for the survival of all living beings on earth. Equilibrium of the food chain is therefore necessary for the sustenance of the environment. More so because it is estimated that starvation and malnutrition take the lives of 18 million people per annum. Most of the victims are children and women and those who survive suffer from hunger and dietary deficiencies.

Some vegetable food items

Wheat crop

Green peas

Sunflower oil seed crop

An assurance of a constant food supply or the ability of all people to earn their meals at all times is therefore absolutely essential for the maintenance of peace and harmony in the society. This depends on the following factors:

(i) Availability of enough food for all (sufficient food production for the total population).

(ii) Accessibility of food for all persons (buying power and freedom for every person to purchase food).

(iii) Adequacy of food for all (food utilized by everybody should meet the nutritional requirement.

3.5.1 World Food Problems

As the world population continues to rise, great pressure is being placed on arable land, water, energy and biological resources to provide an adequate supply of food while maintaining the integrity of our ecosystem. According to the World Bank and the United Nations, between one to two billion human beings on earth are malnourished, indicating a combination of insufficient food, low incomes and inadequate distribution of food. This is the largest number of hungry humans ever recorded in history. Based on current statistics, the world population is projected to double from roughly six billion to more than 12 billion in less than 50 years. Reports from the Food and Agricultural Organization (FAO) of the United Nations numerous other international organizations and scientific research also confirm the existence of a serious food problem owing to the phenomenal growth in population. For example, the per capita availability of food grains which make up 80 per cent of the worlds food has been declining for the past 15 years. With a quarter million people being added to the world population each day, the need for grains and all other foods will certainly reach unprecedented levels.

More than 99 per cent of the world's food supply comes from land while less than 1 per cent comes from oceans and other aquatic habitats. The continued production of an adequate food supply is directly dependant on ample fertile land, fresh water, energy, along with the maintenance of biodiversity. As the human population grows, the requirement for these resources is also growing. Even if these resources do not get depleted on a per capita basis, they will decline significantly because they must be divided among more people.

At present, fertile cropland is getting lost at an alarming rate. For instance, nearly one-thirds of the world's cropland (1.5 billion hectares) has been abandoned during the past 40 years because erosion has made it unproductive (Pimentel et al., 1995). Solving the problem of erosion is difficult because it takes 500 years to form 25 mm of soil under agricultural conditions.

Eroded agricultural land is now being replaced by marginal lands and forestland. The pressing need for agricultural land accounts for 60 per cent to 80 per cent of the world's deforestation. Despite such land replacement strategies, per capita world cropland has been declining and is now only 0.27 hectare per capita; in China only 0.08 hectare is available at present. This is only 15 per cent of the 0.5 hectare per capita cropland considered minimal for a diet as diverse as that in the United States and Europe. The shortage of productive cropland combined with decreasing land productivity is partially the cause of the current food shortages and associated human malnutrition. Other factors such as political unrest, economic insecurity and unequal food distribution patterns also contribute to food shortages.

Competition for water resources among individuals, regions and countries and associated human activities are already occurring because of the current world population. About 40 per cent of the people live in regions that directly compete for shared water resources. Worldwide water shortages are reflected in the per capita decline in irrigation over the past 20 years. A major threat in maintaining future water supplies is the. continuing over-draft of surface and

groundwater resources.

Diseases associated with water, rob people of health, nutrients and livelihood. The problem is serious to developing countries. For example, about 90 per cent of the diseases occurring in developing countries result from the lack of clean water. Worldwide, about four billion people are contracting water-borne diseases and approximately six million deaths are being caused by the same each year. When a person is ill with diarrhoea, malaria or some other serious disease, anywhere from 5 to 20 per cent of an individual's food intake offsets the stress of the disease,

Disease and malnutrition problems in the Third World are as serious in rural areas as they are in urban areas, especially among the poor. This will intensify in the future. Furthermore, the number of people living in urban areas is doubling every 10 to 20 years, creating major environmental problems including water and air pollution, increase in the number of diseases, and food shortage.

Fossil energy is another prime resource used for food production. The intensive farming technologies of developed countries use massive amounts of fossil energy for fertilizers, pesticides, irrigation and for machines as a substitute for human labour.

In developing countries fossil energy has been used primarily for fertilizers and irrigation to help maintain yields. Economic analyses often overlook the biological and physical constraints that exist in all food production systems. The assumption is that market mechanisms and international trade are effective insurances against future food shortages. A rich economy is expected to guarantee a food supply adequate enough to meet a country's demand despite the existing local ecological constraints. In fact, it is the opposite. When global biological and physical limits to domestic food production are reached, food import will no longer be a viable option for any country. At that point, import of food for the rich can only be sustained by starvation of the powerless poor.

Improved technology will certainly assist in more effective management and use of resources but it cannot produce an unlimited flow of those vital natural resources that are the raw material for sustained agricultural production. For instance, fertilizers enhance the fertility of eroded soils but humans cannot make topsoil. However, fertilizers made from finite fossil fuels are presently being used to compensate for eroded topsoil.

Per capita fish catch has not increased even though the size and speed of fishing vessels have improved, Consider also the supplies of fresh water that are available not only for agriculture but also for industry and public use. No available technologies can double the flow of rivers, although effective water conservation would help. Similarly, the shrinking groundwater resources stored in vast aquifers cannot be refilled by human technology. Rainfall is the only source of supply.

Strategies for the future must be based first and foremost on the conservation and careful management of land, water, energy and biological resources needed for food production. Our usage of world resources must change and the basic needs of people must be balanced with those resources that sustain human life. The conservation of these resources will require coordinated efforts and incentives from individuals and countries. Once these finite resources are exhausted they cannot be replaced by human technology. Further, more efficient and environmentally sound agricultural technologies must be developed and put into practice to support the continued productivity of agriculture.

Yet none of these measures will be sufficient to ensure adequate food supplies for future generations unless the growth in human population is simultaneously curtailed.

3.5.2 Changes Caused by Agriculture and Overgrazing

Productive lands for sustainable agriculture have been systematically damaged by overexploitation, mainly through agriculture and overgrazing. The Human Development Report, 1998 states that nearly one-sixths of the world's productive land, amounting to two billion hectares has been degraded since 1945. The loss has been spectacular in developing countries where two-thirds of the worlds poorest people live. Modern agriculture is mainly responsible for the pollution of land through unskilled irrigation, non-judicious use of chemical fertilizers and pesticides and the practice of shifting cultivation and so on. Unskilled irrigation causes serious problems of salination and water-logging. This converts healthy land into a wet desert. These days, inorganic fertilizers are being used on a large scale to increase crop yield. This increases contamination in run-off water and groundwater. Tribal people all over the world use the shifting-cultivation technique which involves slashing and burning forests to create cropland.

The increase in livestock population with a simultaneous decrease in grazing land has resulted in overexploitation of natural resources. The removal of vegetative cover on the soil and the gradual depletion of soil organisms turn productive land into wasteland.

3.5.3 Effects of Modern Agriculture

The effects of modern agriculture, as discussed in world food problems and elsewhere, are not very good. The adverse impacts are:

(i) Soil pollution
(ii) Contamination of water
(iii) Water scarcity
(iv) Global climate change
(v) Water-logging
(vi) Soil salinity and
(vii) Loss of genetic diversity.

Soil pollution can be traced to wind or water erosion of exposed top soil, compacting of soil, depletion of organic matter in the soil, loss of water retention capacity, reduction in biological activity, salination of soil, accumulation of irrigation water in irrigated farming area due to poor absorption or poor drainage and desertification due to overgrazing.

The use of pesticides and chemical fertilizers results in water contamination. Water is becoming increasingly scarce due to its overuse for irrigation and increase in domestic and industrial requirements.

Deforestation and loss of vegetation cover are the consequences of modern agriculture. This may cause climatic change in the area. Over-irrigation and agriculture cause water-logging and salinity. Water logging is caused by the excessive use of water in a land, mostly clayish land, due to over-irrigation. The surplus water in the over-irrigated land evaporates, resulting in an increase in the salt content in the soil which leads to a loss of crop productivity. Modern agricultural practices have also resulted in a serious loss of genetic variety of crops.

3.5.4 Fertilizer Pesticide Problems

The problems that arise from the usage of fertilizers and pesticides are commonly known.

3.5.5 Water-logging and Soil Salinity

Water-logging and soil salinity, as mentioned earlier, are caused by over irrigation. When there is water-logging due to excessive rainwater, irrigation, flood in clay-type soil or in soil containing an impermeable layer of clay, plants decay because their roots cannot get enough oxygen to breathe and grow. Soil salinity is also due to over irrigation. When crops are over irrigated surplus water evaporates and the dissolved salts are left behind in the soil thereby increasing the salinity of both the soil and the remaining water. Increased soil salinity affects water intake by plants and thus their productivity. The effects are most evident in fruits, followed by vegetables and then crops.

3.5.6 CASE STUDY

1. In India, some traditional communities in urban and semi-urban areas cultivate vegetables in their backyards with waste water from their own homes.

2. The Kolkata Municipal Corporation releases its waste water into surrounding lagoons in the eastern side (Dhaka). Fish farming is done in these waters and this water is used to grow vegetables.

3. Israel is short of water. So, it started the drip irrigation system to increase crop production. Over a period of 20 years, irrigation efficiency improved by 95 per cent and food production has doubled in that country.

4. Desertification and salination of the Aral Sea basin, covering about 36,000 sq m, in some of the independent states of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan of the former Soviet Union resulted in the poisoning of food and drinking water due to accumulated salts and contamination by harmful pesticides and fertilizers. These spread by wind to other areas. This resulted in a food crisis and diseases affecting the lives'! of about five million people. Former Soviet planners are responsible for this disaster. The water of the Aral Sea receded because the water of the Amu Darya and Syr Darya rivers was diverted into deserts to grow cotton. Cotton' production shot up by the 1980s. However, the Aral Sea basin which once covered an area of the size of Lithuania became a desert exemplifying the harm caused by modern agriculture.

3.6 SELF ASSESSMENT QUESTIONS:

1. What is a natural resource? Give an account of different natural resources.
2. What is the impact of the present trend of population growth on the availability of natural resources?
3. What are the main benefits of forest resources?
4. What is deforestation? How does deforestation affect us? State a few possible steps to check deforestation.
5. Explain the causes of timber extraction/logging in dense forests and also its impact on tribal people.
6. Explain briefly the necessity and the problems of building dams over rivers.

7. What are the water resources on earth?
8. What is the future threat to the availability of fresh water?
9. Write a note on the conflicts over water around us.
10. Write briefly about the mineral resources of India.
11. Give a clear picture of the present-day world food problem.
12. Write a few lines on global food security in the near future.
13. Describe the impact of modern agricultural practice on the environment.

3.7 REFERENCES:

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Dr. A.V.V.S. Swamy

LESSON 4

ENERGY RESOURCES

4.0 Objective :

After Studying this lesson, the student will be able to understand about energy resources and role of an individual in the conservation of Natural Resources

Structure

4.1 ENERGY RESOURCES

Energy is the capacity to do work. It can neither be created nor destroyed but can be converted from one form to another. The advancement of science and technology has increased the energy consumption of the human civilization. The rate of energy consumption by a country has now become a measure of the pace of its development. The higher the rate of energy consumption, the faster is the pace of development. To meet this increasing energy demand, efforts are being made to improve existing technologies and to develop new energy resources as well.

Energy can be obtained from various sources. The sun is an inexpensive and unlimited, therefore ideal source' of energy. Besides energy from the sun (solar energy) can also be obtained from different resources such as fossil fuels, biomass, biogas, nuclear power, hydroelectricity, wind energy, tidal energy and geothermal energy.

Depending on the source, energy can be broadly classified into renewable and non-renewable energy.

Renewable or non-exhaustible sources of energy are those that are present in nature and are continuously produced, irrespective of human activity. Solar, wind, tidal, geothermal and biogas energy are examples of renewable resources of energy.

Non-renewable resources are also present in nature as deposits. Once they are used, these deposits get exhausted (depleted) and cannot be replaced. Fossil fuels like coal, petroleum, natural gas and timber, different ores and electricity are all non-renewable sources of energy.

Due to constant use, not only is the stock of non-renewable resources reducing but their increased use is also creating a number of socio-economic and environmental problems like forest cover depletion, global warming and pollution.

4.2 Growing Energy Needs

The economic growth and development of a nation constantly needs more energy to be generated and| consumed, irrespective of the increase in energy efficiency due to technological development. The demand and consumption of energy is therefore an index of a nations development. For example, according to the World Resources Institute, in 1998, the per capita energy consumption in USA was 24 times the per capita energy consumption in India thus establishing the superiority of economic development of the United States of America. Demand and consumption of energy increases with the passage of time and as human civilization grows in stature. For example, the world's energy consumption increased four-fold in the 40 years from 1950 to 1990. The form of energy consumed also changes with the passage of time, geographic location and technological development. Electrical energy is the most widely used. Coal was the primary energy source in the world till the 19th century. Oil was the most widely consumed energy source in the world at the end of 20th century, accounting for 39 per cent, with coal, natural gas, nuclear energy and hydro/renewable energy accounting for 24 per cent, 24 per cent, 7 per cent and 6 per cent, respectively. In India, as estimated in 2001, the predominant commercial energy source was coal accounting for 55 per cent, followed by oil (31 per cent), natural gas (8 per cent), hydro-energy (5 per cent) and nuclear energy (1 per cent). However, rural India uses biomass, fuel wood, cow dung and so on which account for 40 per cent of the primary energy supply of India.

Coal, oil, natural gas, forests and others are non-renewable and exhaustible energy resources which account for 87 per cent and 94 per cent of the energy sources of the world and India, respectively. They need to be preserved for our future generations keeping in mind the increasing population load, economic development and consumption demand. We have to harness other forms of energy such as solar, nuclear and renewable energy, enhance our energy efficiency with technological development and restrict the overuse of energy. However, our energy demands are bound to grow as long as the earth exists and we have to sustain energy sources innovatively and find alternative sources of energy.

4.3 Non-renewable Sources

Non-renewable sources of energy include fossil fuels and ores such as uranium and so on. These sources of energy get exhausted with use and cannot be replaced.

About 90 per cent of present-day energy consumption is based on non-renewable sources. Since they deplete fast, the demand for renewable sources of energy has become more important in recent times.

Fossil Fuels: Fossil fuels include coal, petroleum and natural gas. About 90 per cent of the world's energy requirements are met by burning fossil fuels. Burning these not only produces energy but also many harmful gases such as carbon dioxide, carbon monoxide, sulphur dioxide and oxides of nitrogen. About 60 per cent of air pollution occurs due to the burning of petrol and diesel in automobiles.

The presence of carbon dioxide within a certain limit is not harmful since it is used by plants during photosynthesis but excess deposit of carbon dioxide in the earths atmosphere causes global warming due to the Greenhouse Effect. Carbon monoxide, if combined with haemoglobin of blood can cause death in humans within seconds. Oxides of sulphur cause irritation of the respiratory system and prevent the growth of plants. Sulphur dioxide combines with atmospheric moisture to cause acid rain. Oxides of nitrogen affect the respiratory system, pulmonary function and cause irritation in the eyes and nose. Photochemical smog is a result of the increase in oxides of nitrogen in the atmosphere. Therefore, in order to check air pollution the rampant burning of fossil fuels has to be banned.

Coal: Due to its high abundance and easy availability, coal is the most widely used fossil fuel. It is a solid fossil fuel formed by partial decomposition of plants deposited in layers at varying depths.

Coal was formed about 300 million years ago. At that time the earth's atmosphere was hot, damp and rich in nitrogen and carbon dioxide. This favoured the growth of huge non-flowering plants which in due course of time died and fell into swampy water. Layers of lush growth formed a layer several feet thick of decaying vegetation. Volcanic eruptions and earthquakes facilitated the burning process. Gradually, the high pressure of mud and sand squeezed out water and oxygen from the layers and converted them to a pasty mass which s\owly hardened to form coal. The conversion of wood to coal usually takes thousands of years.

Depending upon the depth, pressure and quality of plant materials, the quality of coal varies. Depending on the carbon content coal has different grades.

Lignite Coal: It is the lowest grade of coal and is also known as brown coal. It contains about 70 per cent carbon and 27 per cent volatile materials.

Bituminous Coal*:* It is the widely used solid fuel all over the world. When lignite coal is buried deep, the pressure drives out more volatile matters present in it and its carbon content increases. Bituminous coal contains 75 to 85 per cent of carbon. It is also known as soft coal.

Anthracite Coal*:* This is the best quality of coal with 95 per cent carbon content and 5 per cent volatile matter. So, on burning it gives off very little smoke. It is hard and jet black in colour. It is found deep inside the earth's crust. Anthracite coal produces 6,000 to 7,000 kcal of heat per

kilogram. The high cost and less availability has restricted the use of this good quality coal.

Coal is used mainly for cooking and heating purposes. It is used as a fuel for steam power plants and for running locomotive engines and industries. It is also used for the generation of electricity in thermal power plants. Coal can be transformed to gas, liquid or low-sulphur, low-ash solid fuels and used as a substitute for petroleum.

Many chemical products are also made from it. On destructive distillation, bituminous coal produces gas, coke, tar, and ammonia and sulphur compounds. After purification, this gas is also used as a substitute for petroleum. From tar, many synthetic products like dyes, drugs and plastics are manufactured. Ammonia is used as a refrigerating substance, while sulphur compounds are used in fertilizers, explosives and dyes. 7he residual coke is used for the manufacture of iron and steel.

Natural Gas: It is formed by the decomposition of organic matter buried in the interiors of the earth and is recovered by a process of compression and cooling. Natural gas is a mixture of helium and a number of hydrocarbons like methane, propane and butane. It burns with a hot, blue, non-luminous flame. For its easy transportation and cleanliness it is used as a cooking gas in almost all households.

Petroleum: Petroleum is a mineral oil found between the rocks under the earths surface. It is mostly covered with compressed natural gas. The availability of petroleum and natural gas governs the energy growth and status of a country. Although the Industrial Revolution was initially fuelled by coal subsequently the emphasis shifted to cleaner fuels like oil and gas.

According to scientists, petroleum is formed in the same way as other fossil fuels such as coal and natural gas, from the remains of plants and animals, which were buried under sand and mud due to earthquakes. The high pressure and temperature of the earths crust change these remains to petroleum. Depending upon the depth, pressure and quality of buried material, the nature and texture of fossil fuel vary from gas to coal and finally to petroleum (solid, gas or liquid).

These underground mineral oils are explored through seismic methods by exploding dynamite in shallow holes drilled in the earth's crust. The shock waves produced by the explosion travel down to various layers of rock. The vibrations reflected through various layers are recorded on seismographs. The time gap between the detonation and reception of the reflected signal gives information regarding the depth of the layer. The strength of the vibration provides information about the nature of the layers of rocks. More sophisticated tests are performed on soft rocks to get information about the presence of oil.

Underground crude oil is always associated with natural gas. When the oil is drilled, the compressed natural gas forces the crude oil up the well. However, pumping becomes necessary when gas pressure is less than sufficient.

Petroleum is obtained by refining crude oil. It is a mixture of hydrocarbons of different chain-lengths. Small molecules with one to four carbon atoms such as methane, ethane, propane and butane form gases, while larger molecules with up to 10 carbon atoms form gasoline. Light fuels contain hydrocarbon chains with at least 50 carbon atoms while giant molecules up to several hundred carbon atoms constitute heavy fuels and waxes. Different components of the crude oil are separated by fractional distillation. Gasoline is used as a fuel in automobiles and airplanes while diesel is also used as a fuel in automobiles and in locomotives. About 70 per

cent of these oils are used in power stations in producing steam, lubricating oils, gear oil and greases, which are used as lubricators to reduce friction.

4.4 RENEWABLE SOURCES

The non-exhaustible sources of energy like solar energy, hydroelectricity, wave and tidal energy, wind energy and bioenergy from biomass or biogas are known as renewable sources of energy.

Biomass: All types of biological substances like plant products (wood, crop, algae and aquatic plants), their residues (straw, husk, sawdust, cow dung, animal droppings) and also waste materials like garbage and night soil are collectively known as biomass.

Biomass is used as a source of energy in many parts of the world. Burning of the biomass produces heat energy known as bioenergy. It is obtained through the oxidation of biomass. The residue left after burning of the biomass is used as manure in agriculture fields. Burning one kilo of wood produces about 4,000 to 5,000 kcal of heat. Wood is inexpensive and lights up easily, but the burning of wood causes depletion of forest cover, which in turn leads to the accumulation of carbon dioxide in the atmosphere, the Greenhouse Effect and soil erosion.

These problems are being tackled now-a-days by a wide range of social forestry or energy plantation schemes. Plants like eucalyptus, acacia and cassia are planted widely to be used as fuel wood.

Biogas: India is rich in cattle, sheep, goat, horses and camels and they produce approximately 1,000 tonnes of dung every year. Besides dung, water hyacinth, hydrilla, duck weed, salvinia and so on are also used to produce biogas. First, the dung and other materials are allowed to ferment in the absence of air in a slurry form. The produced gas, known as *gobar gas* or biogas, contains 55 per cent methane and 45 per cent carbon dioxide by volume. The residue left in *a gobar gas* plant after gasification makes for good manure and is used in fields. A *gobar gas* plant can be operated with a maximum output of two cubic metres per day, which requires collection from just four heads of cattle per day. This amount of gas is enough for cooking and lighting the house of a family of six. In fact, one cubic metre of gas produces 4,713 kcal of heat. *Gobar gas* (biogas) is used for cooking, lighting and running pump sets, engines and machines in factories and turbines to generate electricity.

The construction of a *gobar gas* plant is very simple. The main unit is a well called a digestive well. The floors and walls of the digestive well are made up of brick and cement and it is covered with a metal dome that prevents the entry of external air into the well, thereby helping in aerobic fermentation of the dung by microbes. The *gobar gas* plant also has an inlet and an outlet pipe. A mixture of dung and water in the ratio of 1: 5, is fed into the well through the inlet pipe. As the gas forms inside the well by fermentation, the metal dome gradually pushes up due to the pressure. The gas is then released through the outlet pipe provided at the top of the dome. The residue left (slurry) is then taken out and dried in the sun. Drying in the sun increases the nitrogen content of the slurry from 0.25 to 1.5 per cent, thus, making it a better fertilizer than cow dung. Presently, there are more than 6.5 lakh biogas plants in India. This number will increase rapidly in the near future as the potential for the production of biogas and slurry in India is very high.

Solar Energy: The sun is a storehouse of enormous energy formed by nuclear fusion reactions

in the interior of the sun. In fusion reactions, light nuclei fuse together to yield heavier nuclei, where the mass of the end-product is less than the total masses of the reacting species. The difference of masses between the reacting and product species is usually converted to energy. When heavy elements like radium and plutonium undergo nuclear fusion reaction, they produce huge amounts of energy.

Alternative energy (wind and solar energy)

Solar lighting for gardens

Scientists have predicted the central temperature of the Sun to be nearly 20 million degree Celsius. They have also predicted that the sun contains mainly hydrogen. About 56.4 million tonnes of hydrogen nuclei fuse together per minute to produce 56 million tonnes of helium. So the sun is losing about 400,000 tonnes.

This energy reaches the earth as electromagnetic radiation, commonly known as solar energy. The solar energy consists of mainly ultraviolet, visible and infrared radiation. Of these, the harmful ultraviolet radiation is mostly absorbed by the ozonosphere. The visible and infrared radiation reaches the earth as heat radiation.

The sun is 150 million kilometers away from the earth and its rays travel this path and lose most of their energy while travelling. Only 4 per cent of the total solar energy reaches the earth, which is approximately 1 kW per sq m of flat land on the earth's surface.

Approximately 35 per cent of the total solar energy is reflected back, 18 per cent is absorbed by the atmosphere and the solar energy reaching the earth depends upon

atmospheric conditions.

Since it is non-polluting, solar energy helps in maintaining the changes in the atmosphere and the climate cycle. It is a life sustaining source of energy. Solar energy is used by plants for photosynthesis to produce food energy. Human beings use solar energy for evaporation. But for its effective use, solar energy has to be gathered and concentrated. For this, solar mirrors are used. Solar energy is mainly used for heating purposes. The availability of solar energy depends on seasons, length of days, and the latitude of the place and so on. For commercial use, this energy is collected and stored, so that it can be used on days when the sunlight is not adequate.

Electrical energy can be generated from solar energy through solar power plants. The largest solar power plant is in the deserts of California in USA and it consists of a power tower 90 metres high, encircled by 1,800 giant movable mirrors known as Heliostats. These Heliostats reflect the sunlight in the tower to boil water which turns to steam. The steam, in turn, rotates the turbines and produces electricity. In western countries, solar power is gathered during the day to light streetlamps at night. Now-a-days photo-electric cells are used for calculators and in small machines. Solar cells are also used to provide power to satellites, water pumping, communication and radio and television receivers in remote areas. The Oil and Natural Gas Commission (ONGC) is using photocells for drilling in Kerala. Solar energy is also used for cooking in solar cookers. A solar cooker is a simple hot box-type device provided with a reflector. It saves about 40 to 50 per cent of fuel. However, it suffers from some disadvantages:

(i) More time is required for cooking.

(ii) It becomes inactive in the absence of adequate sunlight.

Solar energy is also used in refrigerators for cooling purposes by liquefying ammonia which vaporizes to run the refrigerator.

Nuclear Power: All matter, whether an element or a compound, consists of an elementary particle called an atom. An atom has a tiny nucleus and electrons revolve around the nucleus.

Inside the nucleus, protons and neutrons are held together by a strong nuclear force of attraction. Hence, when an atomic nucleus splits, a tremendous amount of energy is released. This energy is known as nuclear energy or atomic energy. The atom bombs, which were dropped on **Hiroshima** and Nagasaki in August 1945, are examples of the tremendous power of atomic energy. The splitting of the atomic nucleus is caused either by nuclear fusion (as it occurs in the sun) or nuclear fission. Due to technological problems, scientists have not been able to harness energy from a nuclear fusion reaction.

Nuclear Fission: The principle of nuclear fission reaction is the opposite of nuclear fusion reaction. In this method, a heavy nucleus with a large mass is bombarded with fast moving neutrons. As a result, an atom with a heavy nucleus splits into smaller, lighter atoms. The mass lost in the process, is converted to huge amounts of energy.

Atoms with a large mass and heavy nucleus used for the purpose are uranium, thorium, plutonium, radium and so on. Of these, uranium is the ideal atom for fission reaction. Uranium is always found as a mixture of its three isotopes, namely U^{238}, U^{235} and U^{234}. Of these, U^{235} is more fissionable and is separated from the mixture by a process called 'enrichment.' All nuclear

power (fission) reactors are based on fission ofU^{235}.

The released energy is used to heat water in a reactor to produce steam to drive a steam turbine. The released 2.5 neutrons, on an average, per fission are utilized to bring about further nuclear fission reactions leading to a chain reaction. This reaction can become uncontrollable if proper care is not taken.

Nuclear Reactors: A nuclear reactor is a nuclear reaction chamber in which nuclear fission reaction is allowed to occur at a controlled rate by controlling the speed and number of neutrons. It consists of (a) a fuel rod ofU^{235}, (b) control rod for absorbing excess neutrons made of Boron (B) and Aluminium (Al), (c) moderator like heavy water or granite to slow-down the speed of the neutron, (d) coolants like heavy water to carry the heat and (e) shield to prevent heat loss. The large amount of energy which is released in the form of heat due to the controlled reaction rate is used to produce steam which can run turbines and produce electricity.

Hydropower: The energy we get from flowing water is known as hydropower. India is rich in rivers like the Ganges, Narmada, Godavari, Krishna, Mahanadi, Brahmani and others. As dams are constructed over big rivers in addition to generation of hydropower, they also help in (i) irrigation, (ii) flood control, (iii) generation of electricity, (iv) employment generation, (v) transportation, (vi) inland fisheries and (vii) recreation. At present, India has 1,550 major hydel power projects and many thousand minor projects. An estimate shows that the cost of one unit of hydel energy is about 17 to 30 paise against 9 paise in the case of wood or 7 paise for getting the same amount of energy from coal. This high cost of hydropower is due to the high rate of transmission and losses in distribution.

Hydroelectric power generation

Dams also control floods and provide water for irrigation. These projects also help in local transportation, recreation and development of fisheries. However, recently it has been found

that the large hydel projects are ecologically disruptive as (i) construction of big dams changes the lifestyle of the *Adivasi* community which traditionally depends on forests, (ii) construction of dams lead to destruction of forest, which includes felling of trees and destruction of wild animals, (iii) big dams destroy the riverine system, thereby affecting a large number of people who depend on rivers, (iv) big dams cause soil pollution leading to infertile land due to extensive water-logging and salination and (v) big dams increase the risk of earthquakes because the huge amount of standing water puts enormous pressure on land. Hence, it is both economically and ecologically profitable to construct medium-level hydel projects.

Wind Energy: Wind energy is another alternative source of renewable energy. It can be converted into mechanical and electrical energies and made to run turbines to generate electricity. Mechanical and electrical energies, are particularly useful for lighting, pumping and devising the change of barriers in remote and windy areas and where the aerodynamics of the area provide suitable conditions. Wind powered mills of approximately 2 MW capacity have been installed in a number of places in India where the wind density is as high as 10 KWM/m'^/day in winter and 4 KWM/rr^/day in other 5-7 months of the year in peninsular and central areas of the country. According to the Department of Non-Conventional Energy Source (DNES) in India, 20,000 MW of electricity can be generated from wind. Wind farms have already been set up in Mondovi, Okha, Deogarh, Tuticorin and Puri.

Wind Mill for generation of electricity

Ocean (Tidal) Energy: In some countries, tidal energy is also used to rotate turbines and generate electricity. The energy derived from the rise and fall of the sea tide is converted into electricity in small, tide-driven turbines at sea shores. France was the first country to construct a major tidal electricity generation plant.

In India, places like the Gulf of Kutch, Cambay and Sundarbans are exploited for the most prospective tidal energy harnessing sites. Sea shores near Lakshadweep and the Andaman and Nicobar Islands are also found to be most suitable for the generation of electricity from the ocean. At both these places, cold water is available at a depth of 1,000 mm near the shore. In fact, a one MW plant for Lakshadweep Island has already been designed.

Tidal power potential of 9,000 MW has been identified in India. In Ocean Thermal Energy Conversion (OTEC) and wave energy, the temperature difference between warm, surface sea water (28-30°C) and cold, deep sea water (5-7°C) at 800 to 1,000 m depth in tropical waters is utilized to drive turbines to generate electricity. A floating OTEC plant can generate electricity even in the middle of the sea for offshore mining operations and so on.

Geothermal Energy: This is the heat of the interior of the earth present at volcanic regions, geysers or hot springs. This is utilized to generate electricity. Exploration, for the identification of prospective sites of geothermal energy is to be undertaken. Presently, nearly 350 geothermal springs have been identified in India.

Tapping Geothermal Energy

Dendro-thermal Energy: Wastelands can be used for the plantation of fast growing, high calorific shrubs and trees, which can be used for both fuel and fodder. This method is widely practiced in Philippines. In 1987, the energy plant produced 1.5 MW power through gasification of over 8,000 hectares. In India, this method is yet to become popular. The wastelands of Rajasthan and Madhya Pradesh can be exploited for the same.

Energy from Urban Waste: In Delhi, a pilot plant has already been set up where municipal sewage and solid waste is used for energy generation. Bagasse and other farm waste can also be used to generate electricity, which will not only make the industry energy-sufficient, but the surplus power that is generated can also be used for improvement in neighbouring areas. Energy generation from solid waste has been discussed in detail in Unit-V, under the heading Solid Waste Management.

4.5 LAND RESOURCES

Land is a critical natural resource but it constitutes only about 29 per cent of the total earth's surface. Yet, all life (both animals and plants) flourish on land. Be it the prehistoric 'hunter gatherer' society or today's 'technocrat', human beings depend on land for their food (hunting and agriculture), occupation (roads, mining, industry, communication and so on), storage of surface and ground water and living (housing).

With the advancement of civilization and technology, man has been harming the land by clearing forests and depleting many resources.

The soil profile of land determines its ability to serve socio-economic needs. Statistics depict that more than 5,000 million tonnes of top soil is eroded annually along with 5 million tonnes of nutrients. About

One-third of it is lost to the sea, while the rest turns into silt on river beds leading to floods. In India, 38 per cent of the land area suffers from water-based erosion which needs immediate watershed development. In addition to this, 4 per cent of arid area also suffers from soil erosion. Thus, 42 per cent of the total land resources require immediate conservation management.

CASE STUDIES:

I. 18 watt modern compact fluorescent lamp can replace a 40 watt tube light or a 100 watt incandescent lamp. It is an energy saver in the house.

II. Today, refrigerators are made with new and energy-efficient technologies. A refrigerator with a 200 litre capacity consumes 90 kWh now, instead of the 350 kWh consumed previously.

III. Instead of steel, light materials such as aluminium and fibre are used for making car bodies to reduce weight by up to 15 per cent, thereby increasing fuel economy by up to 6 to 8 per cent Further, using bicycles is an excellent energy saving transportation method.

IV. Industries need to be developed using advanced energy efficient technologies, an area in which India lacks. For example, the steel industry in India consumes 9.5 million kilo calories per tonne of steel against 4.3 and 4.1 million kilo calories in Italy and Japan, respectively. Similarly, the cement industry in India consumes 2 million kilo calories to produce one tonne of cement compared to 0.82 and 0.92 million kilo calories in Germany and USA, respectively.

V. Fuel wood and chulhas are used by 50 per cent of the world population. This is one of the reasons for the depletion of forest cover.

VI. The first hydroelectric power dam in the world was built in Appleton, Wisconsin in 1982. In India, Jamshedji Tata built the first hydroelectric power damin the Western Ghats of Maharastra in the early 1900s to supply clean power to Bombay's Cotton and Textile Mills. He took the British Government's permission to build dams, namely the Andhra, Sirowata, Valvan and Mulshi hydel dams in the Western Ghats to generate electricity using high rainfalls in the hills as storage areas.

4.5.1 Land Degradation

Land degradation or the decline in land quality or land pollution is the result of both natural processes and anthropogenic activities. Human activities like deforestation, mining, overgrazing, intensive cultivation, dam and other developmental activities and solid waste disposal result in the exposure of soil and thus accelerate the process of land pollution. Land degradation in turn results in consequent surface run-off, floods, desertification, loss of soil productivity and also reduction of productive land for sustainable agriculture.

As per the Human Development Report 1998, about one sixth of the world's productive land, that is two million hectares has been degraded in the 53 years since 1945. Every year about 30 million acres of productive land gets eroded in India. This results in loss of food, cultivable land and thus food security. Land degradation is more severe in developing countries like India. Nearly half of the world's degraded land is in Asia and one-fourths of the world's moderate to strongly degraded land is in Africa. Two-thirds of the world's population lives in these degraded lands of Asia and Africa. The food shortage due to less cultivable land caused by land degradation is, therefore, a great concern to the world and necessitates urgent attention.

4.5.2 Landslides

A sudden, uncontrolled descent of a mass of earth and rock down a slope (mountain slope) under the force of gravity is called a landslide. As already mentioned, the mountainous regions of northern and north-eastern parts of India are vulnerable to landslides.

Landslide Prone Areas of India

Regions	Intensity
Himalayas	High to very high
North-eastern hills	High
Western Ghats	Moderate to high
Eastern Ghats	Low
Vindhyachals	Low

Although landslides are a natural process, anthropogenic causes like deforestation, industrialization, construction of dams, hill roads, railway tracks and making place for human habitation accelerate the process, Thus, for the implementation of developmental projects proper precautionary measures should be taken.

Landslides not only destroy human life but also destroy plantation and wildlife. They also block roads causing immense casualties to human life and economic loss to the country. In remote areas, landslides disrupt emergency services such as water, power and communication. Further details are available in Unit-V of this book.

4.5.3 Soil Erosion

Soil erosion is one of the outcomes of land degradation caused both by natural processes as well as human activities. The continuous eroding away of the earth's crust by the forces of weather is known as soil erosion. Normal geological erosion is very slow and it tends to bring

the earth's surface to a uniform level. When this soil erosion is accelerated due to different human activities it is called artificial or accelerated erosion, Deforestation and overgrazing are the most prominent causes of soil erosion. Depending upon the factors causing it, erosion is classified as wind erosion, gully erosion, water erosion, coastal erosion and so on.

Soil Erosion (eg. Gully erosion)

Soil erosion is the washing or wearing away of the topmost layer of soil. By this process not only is the productivity of the eroded land destroyed but when the top soil run-off lands on top of other productive soil, it destroys the productive soil as well.

However, soil erosion can be prevented by using remedial measures. Wind erosion can be prevented by;

Planting trees to break the wind force. Trees can also check soil erosion by holding together the soil particles. Water erosion can be checked by terracing, contour cultivation or through strip cropping.

4.5.4 Overgrazing

The increase in livestock population with simultaneous decrease in grazing land has resulted in the overexploitation of natural resources. India supports about 85 per cent of the world's total livestock such as buffaloes, cattle, goats and sheep, with only 1/40th of the total land area of the world at its disposal. The result is overgrazing on fallow, uncultivated forestlands. This uncontrolled grazing removes the ground vegetation, causing soil erosion and gradual depletion of soil organisms which turn the land to wasteland.

Soil conservation through a planned growth of fodder and grasslands on the outskirts of dense forests and wastelands can check soil erosion and simultaneously solve the problem of overgrazing.

4.5.5 Mining Activities

With the advancement of science and technology, our underground resources are now excavated through mining activities. For this usually, the two principles of opencast mining and underground mining are followed. In opencast mining, the underground resources are excavated directly by removing the topsoil and other strata. As a result, the total area gets destroyed and loses its productivity. In underground mining, the minerals are mined through tunnels. When the mine is abandoned after mining, the whole area collapses into a big

depression and becomes a wasteland.

However, in both types of mining the mined materials are dumped near the mine. This not only causes unwanted occupation of land but the rainwater washes away the mining waste (rich in sulphuric acid) to the nearby agricultural fields and pastures. The debris blocks the drainage system leading to water-logging as well. This type of land pollution can be stopped only by large-scale planned land filling followed by plantation.

4.5.6 Desertification

There are two main causes because of which a fertile piece of land or a forestland gets converted into a desert.

(i) Continuous climate change and
(ii) Abuse and overuse (exploitation) of land

The continuous pressure of the rise in population is squeezing the earth's forests to create more land for agriculture pastures and for the implementation of the results of technological developments. This is resulting in the denudation and degradation of the forest areas. This removal of vegetation cover of the land changes the microclimate of the area. The changes in rainfall, temperature, wind velocity and so on disturb the local ecological equilibrium. This in turn leads to soil erosion, loss of the nutrient cycle and finally to the onset of desert-like conditions. Thus, it is the improper land use practices and removal of vegetative cover of the land that is responsible for the climate change of the area.

The onset of desertification is marked first by the destruction of productive land in patches. Loss of forest cover decreases humidity or increases the temperature of the area. Thus, productive land gets slowly converted into a barren, sandy desert. At the time of Independence, India had 22 per cent land area under forest cover which has diminished to only 10 per cent within 50 years.

According to a report of the Government of Australia, in 1985, about two-thirds of the vegetative cover of Australia had been destroyed. Almost half the agricultural land had serious soil pollution and needed treatment to stop soil degradation. The situation is worse in Third World countries, where desertification remains unchecked. For example, it is reported that a new desert at a rate of 170 hectares per hour is being created around the area of the Sahara desert in Africa.

4.6 Role of an Individual in the Conservation of Natural Resources

The role of the individual can be best understood by the following words of Mahatma Gandhi, 'The earth provides enough to satisfy every person's need but not every person's greed.' The global ecosystem has a limited capacity for replenishing natural resources. The increasing overuse and misuse of natural resources will destabilize the natural balance. Non-renewable natural resources if not checked will get exhausted soon. Even renewable resources, namely those from oceans, forests, grasslands, wetlands and so on are also going to get exhausted or degraded in the future. Population growth and increasing consumerism of the affluent members of society put pressure on natural resources.

As an individual, we must decide what we want to leave for our children and at what cost do we get our resources. Our small actions can help a lot in conserving natural resources. The following are some illustrations:

1. Switch off lights, fans, air conditioners and other electrical gadgets when they are not required.

2. Close the tap; mend the leakages to avoid wastages and to save water.

3. Do not use plastic products; instead use recyclable paper products.

4. Use energy-efficient lights and electrical gadgets to save electric energy.

5. Use a pressure cooker. Keep the vessels covered with a lid. Keep cooled foodstuff out of the refrigerator to bring it to room temperature before cooking.

Let us play a positive role in conserving natural resources instead of waiting for the society and the government to do everything.

4.7 Equitable Use of Resources for Sustainable Lifestyles

The world is sharply divided between developed and underdeveloped, the haves and the have-nots. Ideally, the fast depleting natural resources should be evenly distributed among countries as well as among the communities within the countries. This will bring down disparities and will reduce overexploitation of natural resources. It will also lead to a sustainable lifestyle which primarily depends on the earth. Instead of overexploiting natural resources we may be able to lead a better lifestyle through the equitable use of natural resources such as sharing of community halls, ponds, grounds, forest products, staying in flats instead of houses and using public transport or car pools instead of using one vehicle each. Such a lifestyle will help sustain natures wealth. A dense forest, green grassland, the clean water of a lake, the ocean sheltering all types of aquatic plants, animals and resources all these can be sustained in our lifestyle if we avoid wastefulness and over utilization of the fast-depleting natural resources and by equitable use and sharing.

4.8 SELF ASSESSMENT QUESTIONS

1. Write a few lines on the growing energy needs of the present day urban people.
2. What are the main causes of soil erosion and how can it can be prevented?
3. How does land degradation occur? Explain.
4. What is conservation of natural resources? Explain the role of an individual for the same.
5. Write a note on equitable use of resources required for a sustainable lifestyle.
6. Write a paragraph on the interaction between women and the forest.
7. Write short notes on the following:
   (i) Tidal energy; (ii) Geothermal energy. (iii) Dendrothermal energy. (iv) Wind energy. (v) Biomass energy.
8. Write short notes on:
   (i) Agro Forestry. (ii) Desertification.

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Dr. A.V.V.S. Swamy

UNIT III: BIODIVERSITY AND ITS CONSERVATION

LESSON: 5

BIODIVERSITY AND ITS VALUES

5.0 Objective :

After studying this lesson, the student will be able to understand Genetic Diversity, Species Diversity, Ecosystem Diversity and Values of Diversity

STRUCTURE

5.1 Introduction

Biodiversity is the variety and the number of living organisms (both plants and animals) present in the ecosystem. At the 1992 Convention on Biodiversity held in Rio de Janeiro, it was defined as 'the variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. This includes diversity within species, between species and of the ecosystem.'

Diversity is a rule of nature and the policy of the natural habitat. So, there is variability

(difference) of genes within and between the species and also diversity of ecosystems. It is impossible to have a species with zero diversity. 'Food chains that form a food web, link the species to one another. This keeps the energy flowing continuously inside the ecosystem. Any loss of species (biodiversity) means the breaking of a link in the food chain which in turn affects all those who benefit the chain. Human beings, who are at the bottom of the chain are the ultimate sufferers. Hence, every effort is to be made to conserve biodiversity.

Biodiversity represents the quality and characteristic features of life in an ecosystem. This diversity can be divided into:

(i) Genetic diversity.
(ii) Species diversity.
(iii) Ecosystem diversity.

5.2 Genetic Diversity

When there is a variation of genes within the same species (single population) and also among geographically separated populations it is called genetic variation. It is responsible not only for the difference in characteristics but also for the adaptation of organisms to a particular habitat or environment. Within the same species, while some individuals are taller than others, some have brown or blue eyes.

A change in external as well as internal factors is responsible for genetic variations. The species that is spread out over a large area interbreeds thereby spreading its genes but the species that is confined to a small area, has a low, very localized gene flow.

According to an estimate, there are 10,000,000,000 different genes distributed all over the biosphere though all of them do not make similar contributions towards genetic diversity.

5.3 Species Diversity

This diversity provides a quantitative idea of the number of species and the variety of species present in a particular ecosystem. The following table gives us the number of various life forms (species) described so far on earth.

Species Diversity in the Biosphere

Sl. No.	Life Forms (Species)	No. Described
1	Virus	1,000
2	Bacteria	3,060
3	Cyanobacteria	1,700
4	Fungi	28,983
5	Algae	26,900
6	Lichens	18,000
7	Bryophytes	16,000
8	Pteridophytes	11,299
9	Gymnosperms	929
10	Dicotyledons	1,70, 000
11	Monocotyledons	50,000
12	Invertebrates	9,89,761
13	Mammals	4,000
14	Other vertebrates	48,853
15	Other forms	27,400
	Grand Total	13,92,485

So far there are approximately 13.92 million species on earth and the expected number is about 25-30 million, with tropical and sub-tropical parts contributing around 70 per cent of the global biodiversity. Presently, about 3,000 scientists are engaged in exploring and identifying these life forms.

Species diversity is the most basic way to keep an account of biodiversity as it includes all forms of life from micro-organisms such as viruses and bacteria to multi-cellular kingdoms of plants, animals, and fungi.

5.4 Ecosystem Diversity

A broader scale of biodiversity depicts the differences between different habitats, ecological processes, and the ecosystem in which the species exist. Based on the physical structure and species composition, the ecosystem can be divided into:

(i) Terrestrial Ecosystems such as forests, grasslands, deserts and so on.
(ii) Aquatic Ecosystems: These are of two types:
(a) Freshwater, consisting of lotic and lentic.
(b) Marine, consisting of oceans and estuaries.
(iii) Artificial or Man-made Ecosystem consisting of lakes, croplands and so on.

With about 8 per cent of biodiversity concentrated in about 2 per cent of the earth's space, India is one of the 12 megadiversity countries in the world. To ensure proper planning and conservation of the environment at the national, state, and local levels, India needs to be further classified into different biogeographic zones and then into biotic provinces or land regions or ultimately into biomes. The total area of 32, 87, 263 sq km in India has been classified into 10 biogeographical zones listed in Table.

Bio-geographic Zones of India

S.No	Biogeographic Zones	No. of biotic provinces in the zone	Area of India (In per cent)	Speciality
1	Trans-Himalaya	2	5.6	Contains 60 percent of the biodiversity of India. One of the hotspots of diversity in India
2	Himalaya	4	6.4	
3	Desert	2	6.6	
4	Semi-arid	2	16.6	
5	Western Ghats	2	4.0	
6	Deccan Peninsula	5	42.0	
7	Gangetic Plain	2	10.8	
8	Coasts	2	2.5	
9	North East	2	5.2	
10	Islands	2	3.0	

5.5 Values of Diversity

Nature gives us sustenance and biological resources form the basis of all life on earth. The fundamental, social, ethical, cultural and economic value of these resources has been recognized in religion, art and literature from the earliest days of recorded history. Thus, conservation of these resources is very essential and has now become a global issue. For

conservation of biological resources an economic evaluation of biodiversity is essential. Depending on the economic evaluation different funding agencies such as banks, governments, and so on provide monetary assistance for the conservation of biodiversity. But the hidden cost of loss of biodiversity is very difficult to determine. However, economists and biologists have categorized the values of biodiversity by assessing how people benefit from them. These values are of:

(i) market-place resources, (ii) unharvested resources and (iii) future resources. The economic values of biodiversity can be categorized as:

(i) **Direct** Use **Values:** These are values directly used by people. (ii) **Indirect** Use **Values:** They provide benefits even if not used by people.

(iii) **Social Values:** These provide some usable or non-usable benefits in the future.

(iv) **Existence (Ethical) Values:** These provide benefits in the present and may not benefit our future generations.

5.5.1 Direct Use Values

These are values directly consumed by the people and include food, products for developing pharmaceuticals, for developing and maintaining the genetic basis for agriculture, supporting industry through timber extraction, fisheries, poultry, dairy farming, and so on. Direct values may be of both consumptive and productive use.

5.5.2 Consumptive Use Values: These include food products and fossil fuel (wood) which does not figure in the national or international market but are consumed locally. About 3,000 plant species, 200 of which have been domesticated are used as a food source. Presently, 20 per cent of these plants provide more than 80 per cent of our food. To meet the huge demand breeders opt for the hybrid variety. This variety has better resistance to drought and disease and has wide genetic diversity. Compared to plants, a smaller variety of animals are used by humans for food. However, trees provide 3.8 million cubic meters of food annually by way of fuel, timber or pulp.

Productive Use Values: These are values of products that are harvested from the wild and sold in national and international consumer markets. For instance, many of the raw materials used for drug manufacturing are either plant-based or animal-based. Globally, 3.5 billion people consume herbal medicines. Raw materials for industries such as fibres, resins, dyes, waxes, lubricants, perfumes, pesticides, timber and so on are either plant or animal-based and have a high monetary value in the market. In fact, the cost of the productive use value of biodiversity is constantly rising.

5.5.3 Indirect Use Values

These are as important for the well-being of human beings as are direct values. Indirect Values are obtained without using up the resources and include soil formation and protection, watershed protection, waste disposal, pollination, nutrient cycle, oxygen production, carbon sequestration, control of floods, climate regulations, recreation and eco-tourism, educational and scientific value and environmental monitoring.

5.5.4 Social Values

Aesthetic, recreational, cultural and spiritual, social values are ideals and beliefs which people preach and uphold in order to structure the traditions, institutions and laws of the society they live in. The relationship between human beings and nature and the one between society and nature is very important. These values evolve and undergo changes with changes in circumstances and relationships. There can be a marked difference in landscape and biodiversity preferences according to age, socio-economic factors and cultural and religious influences. The following six values provide a definition of social values:

(i) Human conquest of nature carries a moral responsibility for the perpetuation of other life forms. (Hornday, 1914)

(ii) Wanton consumption and merciless slaughter of wildlife is uncivilized. (Hornday, 1914)

(iii) Aesthetic and intellectual contemplation of nature is integral to the biological and cultural inheritance of many people. Monuments of nature, great works of art and architecture, should be guarded from ruin. (Conwentz, 1909) (iv) Healthy ecosystems are necessary to safeguard economic growth, quality livelihoods and social stability. (Ehrlich & Eherlich, 1992; Daily, 1997; Carson, 1999) (v) It is prudent to maintain the earth's genetic library from which society has derived the basis of its agriculture and medicine. (Myers, 1979)

(vi) Society has a moral duty to permit traditional people inhabiting natural landscapes to choose their own destiny in time frames appropriate to their history and culture. (WCED, 1987)

Social movements along with the efforts of non-governmental organizations at the national and international levels, play an important role in the conservation of nature. Today, there is a marked shift towards development. In that context if nature is divided into discrete units and assigned a monetary value it can be treated as a commodity and conservation can be treated as a free market delivery of economic goods and services. The social values in conserving nature can then become more effective.

5.5.5 Aesthetic Values: The use of biodiversity for recreation, scientific investigation, and eco-tourism is also growing rapidly. The fast growing 'leisure industry' has now begun to value nature for its aesthetics, and treats it as part of the cultural heritage. People too prefer to visit a reserve forest and enjoy nature-based activities such as hiking, trekking, bird and wildlife watching, fishing and photography. The aesthetic value of our ecosystem contributes to the emotional and spiritual well-being of a highly urbanized population. Partly due to the government's contribution, eco-tourism contributes financially to conservation. Thus, nature provides opportunities for outdoor recreation to millions of nature lovers if it is conserved. In fact, the travel and tourism economy in India accounts for 5.6 per cent of the total Gross Domestic Product.

5.5.6 Option Values: The potential of a species to provide economic benefits to human beings in the future is called option value. The biotechnologists working towards generating new species to fight and cure deadly diseases such as cancer and AIDS are a fine example of option value.

5.5.7 Existence (Ethical) Values

Unlike the other values, ethical values are an intrinsic part of nature. It is very difficult to quantify their economic value. But, these play a major role in the protection and conservation of biodiversity along with all the other values. All religions, cultures and philosophies, stress on being ethical. The ethical obligations for protecting biodiversity are:

(i) Protect other species from extinction.
(ii) Do not waste resources.
(iii) Remember that all species are interdependent and have a right to exist.
(iv) People must take responsibility for their actions.
(v) People must feel responsible towards their future generations.
(vi) Remember that nature has spiritual and aesthetic values that can be transformed into economic values.
(vii) Keep in mind that nature matters to us and so our actions must not harm it.

The ethical values of biodiversity teach us:

(i) How to improve quality of life. (ii) How to conserve natural resources. (iii) How to enrich environmental quality, cuture, religion and aesthetics of society.

5.6 SELF ASSESSMENT QUESTIONS

1. Define biodiversity. How is it related to the availability of genes, species and ecosystem of a region?

2. Justify the status of India as a megadiversity nation.

3. What are the values of biodiversity? Differentiate between direct use values and indirect values.

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Dr. A.V.V.S. Swamy

LESSON :6

BIODIVERSITY HOT SPOTS AND BIODIVERSITY CONSERVATION

6.0 Objective :

After studying this lesson, the student will be able to understand the Hotspots in Diversity, Threats, Measures and Conservation of Biodiversity

Structure

6.1 Hotspots in Diversity

According to British ecologist Norman Myers, certain ecosystems despite their small size account for a high percentage of global biodiversity. Many of these areas also suffer from logging, overexploitation of land due to excessive agriculture, hunting and climatic changes. Myers was the first to devise the concept of biodiversity **hotspots** so as to identify these areas and preserve the endemic species there.

Biodiversity hotspots are environmental emergency rooms (store houses) of the earth. They are biologically rich areas with a large percentage of endemic species. For example, a terrestrial biodiversity hotspot is based on plant diversity that has:

(i) At least 0.5 per cent or 1,500 of the world's 3,00,000 species of green plants

(ii) Has lost 70 per cent of its primary vegetation.

Coral reefs and multiple taxa (species of coral, snails, lobster and fishes) signify marine hotspots. Most hotspots are found tropical and sub-tropical areas because warm, moist tropical environments are conducive to the growth and reproduction of the species present there. Species and ecosystem diversity varies with altitude and depth. For instance, the mountainous

environment (or biome) is vertically divided into montane and alpine ecosystems and diversity in the aquatic ecosystem (both marine and freshwater) species decreases as we go deeper. Biodiversity also tends to increase from the Poles to the Equator.

Keeping in mind Myers' definition of hotspots, biologists have identified areas of high endemism with species richness and labelled them as hotspots. Hotspots are defined as the localized concentration of biodiversity, and are in need of sincere conservation action. Conservation International has identified 25 terrestrial biodiversity hotspots around the world for conservation.

The identified hotspots around the world are:

(i) Tropical Andes,

(ii) Meso-American forests,

(iii) Caribbean,

(iv) Brazil's Atlantic forests,

(i) Choco Darien/Western Ecuador,

(vi) Brazil's Cerrado,

(vii) Central Chile,

(viii) California Floristic Province,

(ix) Madagascar,

(x) Eastern Arc and coastal forests Tanzania/Kenya,

(xi) Western African forest,

(xii) Cape Floristic Province (South Africa),

(xiii) Succulent Karoo,

(xiv) Mediterranean Basin,

(xv) Caucasus,

(xvi) Sunderland,

(xvii) Wallace (Eastern Indonesia),

(xviii) Philippines,

(xix) Indo-Burma (Eastern Himalayas),

(xx) South-Central China,

(xxi) Western Ghats of India and the Island of Sri Lanka,

(xxii) South-West Australia,

(xxiii) New Caledonia, (xxiv) New Zealand and

(xxv) Polynesia and Micronesia Island complex including Hawaii.

A recent global study conducted over four years, by nearly 400 scientists and other experts has identified nine new hotspots; bringing the total to 34. These new hotspots are home to 75 per cent of the world's most threatened mammals, birds and amphibians. Originally, these

hotspots covered 16 per cent of the earth's surface which has now reduced to 2.3 per cent due to human encroachment and habitat destruction.

The nine new hotspots are:

(i) East Melanesian Island,
(ii) Madrean Pine-Oak Woodland on the US-Mexico border,
(iii) Japan,
(iv) Horn of Africa,
(v) Irano-Anatolian region of Iran and Turkey,
(vi) Mountains of Central Asia,
(vii) Maputaland-Pondoland-Albany in southern Africa (parts of Mozambique, South Africa and Swaziland),
(viii) Himalayan region and (ix) Eastern Afro-Montana along the eastern edge of Africa from Saudi Arabia to Zimbabwe.

However, World Wildlife Fund (WWF) replaced the biodiversity concept that Myers had devised in 1977 with the 'Global 200' Strategy in 1998. Global 200 expands the conservation priorities to 233 eco-regions, comprising 19 terrestrial, freshwater and marine major habitats thereby covering major biodiversities of the planet.

6.2 India—A Megadiversity Nation

India has a rich heritage of forests, wetlands and marine areas, which range from the temperate forest to coastal land and tropical rain forest to the alpine region. This richness makes it one of the 12 megadiversity nations of the world.

As per the statistics of the Ministry of Environment and Forest, India accounts for 7.31 per cent of the total fauna, and 10.88 per cent of the total flora of the world. It has different biogeographic zones and 25 biotic provinces and also hosts mega fauna such as rhinoceros, tigers, elephants and so on.

Comparison between the number of species in India and the World and Percentage and Ranking of India

GROUP	Number of species in		percentage of species of India with respect to the global total	India's ranking in the world
	INDIA	WORLD		
Mammals	350	4,629	7.6	8th
Birds	1,224	9,702	12.6	8th
Reptiles	408	6,550	6.2	5th
Amphibians	197	4,522	4.4	15th
Angiosperm	15,000	25,000	6.0	15th
Total Plant Species	45,000			
Butterflies and Moths	13,000			
Total Insects	50,000			
Fishes	2,546	21,730	11.7	

Of the 75.23 million hectares of forest in India, 40.61 million hectares are classified as reserved and 21.51 million hectares as protected area. This includes over 40 wildlife sanctuaries and 70 national parks spread across 1, 40,000 sq km. The remaining 13.11 million hectare forest area is maintained as unclassified. Marine protected area covers 2, 76,042 hectares, supporting economically valuable ecosystems such as mangroves, estuaries, lagoons and coral reefs.

Over 70 million years ago, India was formed when a giant continent split up, resulting in the formation of Gondwanaland and the southern land mass. India was attached to Africa, Australia and Antarctica. Subsequently, due to tectonic movements, India shifted northward to converge with the northern Eurasian continent across the Equator. When the intervening Tethys Sea started drying up, plants and animals that evolved in Europe and the Far East began migrating to India.

Subsequently, the Himalayas grew to form a natural barrier in the north, along with the three seas -Arabian Sea, Bay of Bengal and the Indian Ocean - in the south. Some of the other prominent features of India as a megadiversity nation are its three important biomes: tropical humid forests, tropical dry deciduous forests and the arid or semi-arid deserts.

India has 25 hotspots mainly in the Western Ghats and the Eastern Himalayas. It ranks seventh in its contribution to world agriculture. India has more than 34,000 cereals and 22,000 pulses in its gene bank.

6.3 Endangered and Endemic Species of India

Natural and anthropogenic causes have always remained a great threat to biodiversity. Developmental works are only accelerating habitat loss and pushing wildlife (both fauna and flora) towards extinction (1,000 to 10,000 per year). Based on this, the International Union for Conservation of Nature and Natural Resources (IUCN) has categorized wild flora and fauna into eight categories. The list containing these categories is known as the Red List. These categories are: extinct, extinct in wild, critically endangered, endangered, vulnerable, lower-risk, data-deficient and not evaluated. This data, recorded in the Red Data Book is updated every four years. According to the Red Data Book, a threatened species is one whose natural habitat is disturbed. As a result, the species population decreases rapidly and there is a fear that the species may become extinct. As per Schedule I, of the Wildlife (Protection) Act, 1972 of India, a species is considered endangered when its number reduces to a critical level. The species is then provided with legal protection. So far, 38 species of birds, 18 of amphibians and reptiles and 81 species of mammals have been labelled endangered in India.

Endangered Species of India

Andaman Shrew *(Crocidura andamanensis)* (endemic to India)

Andaman Spiny Shrew *{Crocidura hispida)* (endemic to India)

Asian Elephant *(Elephas maximus)*

Banteng *(Bos javanicus)*

Blue Whale *(Balaenoptera musculus)*

Capped Leaf Monkey *(Trachypithecus pileatus)*

Chiru (Tibetan Antelope) *(Pantholops hodgsonii)*

Fin Whale *(Balaenoptera physalus)*

Ganges River Dolphin *(Platanista gangetica gangetica)*

Golden Leaf Monkey (*Trachypithecus geei)*

Hispid Hare *(Caprolagus hispidus)*

Hoolock Gibbon. *(Bunopithecus hoolock, previously Hylobates hoolock)*

Indian Rhinoceros *(Rhinoceros unicornis)*

Indus River Dolphin *(Platanista minor)*

Kondana Soft furred Rat *(Millardia Kondana)* (endemic to India)

Lion-tailed Macaque *(Macaco silenus)* (endemic to India)

Markhor *(Capra falconeri)*

Marsh Mongoose *(Herpestes palustris)* (endemic to India, it was previously considered to be a sub-species of *Herpestes favanicus)*

Nicobar Shrew *(crocidura nicobarica)* (endemic to dia)

Nicobar Tree Shrew *(Tupaia nicobarica)* (endemic to India)

Nilgiri Tahr *(Hemitragus hylocrius)* (endemic to India)

Parti-colored Flying Squirrel *(Hylopetes alboniger)*

Peters Tube-nosed Bat *(Murina grisea)* (endemic to India)

Red Panda (Lesser Panda) *(Ailurus fulgens)*

Sei Whale *(Balaenoptera borealis)*

Servant Mouse *(Mus famulus)* (endemic to India)

Snow Leopard *(Uncia undo)*

Tiger *(Panthera Tigris)*

Wild Water Buffalo *(Bubalus bubalis* previously *Bubalus arnee)*

Woolly Flying Squirrel *(Enpetaurus cinereus)*

Endemic Species

Species that have very restricted distribution and are found over relatively small ranges are called endemic species. Since their ecological requirements are met over a small area these species remain restricted to a particular area as rare or endemic species.

About 33 per cent plants of the world are endemic to India. North-east India, the Western Ghats, northwestern and eastern Himalayas, a small pocket of the Eastern Ghats and of course Andaman & Nicobar Islands are rich in endemic species. In fact, as per the 1983 Botanical Survey of India, the Andaman & Nicobar Islands boast of at least 220 species of endemic flora in India. Agastyamalai Hills, Silent Valley, New Amarambalam Reserve, Periyar National Park, all the mountains of Western Ghats and eastern and western Himalayas are known for their conservation.

There are 44 endemic species of mammals, confined to a small range within the Indian Territory. The Western Ghats have been identified as the abode of four of these endemic species:

(i) Lion Tailed Macaque (Macaca Silenus)

(ii) Nilgiri Leaf Monkey *(Trachypithecus johnii* called Nilgiri *Langur* by the locals)

(iii) Brown Palm Civet *(Paradoxurus Jerdoni)*

(iv) Nilgiri Tahr *(Hemitragus Hylocrius)*

Endemic bird species are not a very common sight in India. About 55 of the endemic bird species can be spotted along the mountain ranges in eastern India. The other places where they can be found are south-west India (the Western Ghats) and the Andaman and Nicobar Islands.

As for the other animals, the number of endemic reptiles and amphibians in India is high. There are 187 reptiles and 110 amphibians endemic to India. In fact, India is the only country which is abode to eight amphibian genera. The most notable among them is the monotypic *Melanobatrachus,* which has only one species known only from a few specimens collected in the Annamalai Hills, in 1870.






6.4 Hotspots of India

The high endemism of Indian biodiversity is under constant threat. Among the 34 hotspots of the world, two are located in India and they extend to the neighbouring countries. The two hotspots are located in the eastern Himalayas, covering the Indo-Myanmar region and the Western Ghats, extending to Sri Lanka. About 30 per cent of the total flora recorded in the world are endemic to India and are concentrated in these two regions. About 62 per cent of the known amphibian species, reptiles, swallow-tailed butterflies and some mammals are endemic to the Western Ghats.




Eastern Himalayas :

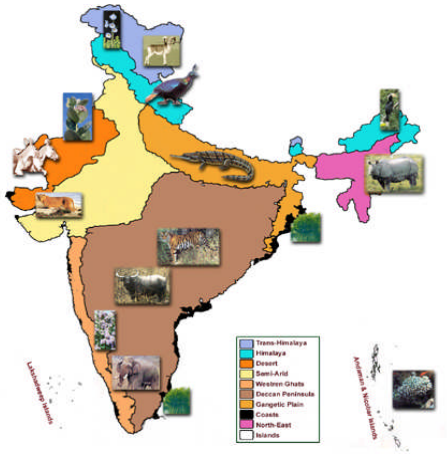
The eastern Himalayas include Bhutan, north-eastern India, southern, central and eastern Nepal and Yunan province in South West China. The species geographic distribution shows a distinct growth in the flora and fauna of these areas. The eastern Himalayas have a greater variety of oaks and rhododendrons than the Western Himalayas because of the higher rainfall and warmer conditions in the eastern Himalayas. Many deep, semi-isolated valleys are exceptionally rich in endemic flora. For example, of the 4,250 plant species in Sikkim in an area of 7,298 sq km, 2,550 or 60 per cent are endemic. India has 2,000 or 36 per cent of the endemic plant species out of 5,800, while Nepal has 7,000 of which many overlap with those of India, Bhutan and Yunan. Yunan has 500 endemic plants, nearly 8 per cent while Bhutan has 5,000, which is 15 per cent of the total plant species that are endemic to the eastern Himalayas.

The discovery of a new large mammal *Muntiacus gongshanensis* and four new genera of flowering plants in South East China have confirmed the findings of a study that said north-east India along with Yunan is an active centre of organic evolution. This hotspot is also home to 163 globally-threatened species, including three of Asia's largest herbivores - the Asian Elephant *(Elephas Maximus),* the great One-Horned Rhinoceros *(Rhinocero Unicorn),* Wild Water Buffalo *(Bubalus Bubalis),* its largest carnivore, the tiger *(Panthera Tigris)* and several large birds like vultures, adjutant storks and hornbills.

Earlier, clubbed with the Indo-Burma biodiversity hotspot, the eastern Himalayan region now stretches across the Indo-Burma hotspot and the Himalayan hotspot. The Himalayan hotspot was identified as a new hotspot in 2005.

Diversity and Endemism of Eastern Himalayas Hotspot

Taxonomic Group	Species	Endemic Species	Present Endemism
Plants	10,000	3,160	31.6
Mammals	300	12	4.0
Birds	977	15	1.5
Reptiles	176	48	27.3
Amphibians	105	42	40.0
Freshwater Fishes	269	33	12.3



Western Ghats (Southern India) and Sri Lanka

The tropical rain forests of Maharastra, Karnataka, Tamil Nadu and Kerala in the west and south of India are very rich in biodiversity. In fact, the Western Ghats feature in the 34 hotspots of the world. The two main centres of diversity are Agasthyamalai Hills and the Silent Valley/New Ambalam Reserve Basin. The Agasthyamalai Hills in the south harbour, houses the highest level of plant diversity. This hotspot is home to 11,000 animal species. Of the 140 mammal species present, 20 are endemic, the most prominent being the lion-tailed macaque and Asian elephants. Similarly, of the 450 bird species, as many as 35 are endemic. The hotspot also contains 6,000 vascular plant species, of which more than 3,000 (52 per cent) are endemic to the area. Table 4.5 gives a clear picture of the diversity and endemism of the Western Ghats.

Biodiversity and Endemism of the Western Ghats Hotspot

Taxonomic Group	Species	Endemic Species	Present Endemism
Plants	5,916	3,049	51.5
Mammals	140	18	12.9
Birds	458	35	7.6
Reptiles	267	174	65.2
Amphibians	178	130	73.0
Freshwater Fishes	191	139	72.8

6.5 THREATS TO BIODIVERSITY

The human drive for 'development', has led him to exploit more natural resources than are actually needed to improve the living conditions. This is responsible for endangering other species of the biosphere. These human actions are beginning to threaten biodiversity. The human urge to transform habitats and exterminate rivals and competitors has led to a lot of harm being caused to all ecosystems and species. Some of the major threats to biodiversity are:

(i) loss/degradation of habitat,
(ii) overexploitation of resources,
(iii) pollution,
(iv) extinction of species due to aggressive non-native species and
(v) global environmental changes.

Degradation of Habitat

A habitat is where every living being finds food, water and shelter to survive and a safe place to reproduce and bring up their offspring. So, loss of habitat is actually the greatest threat to the world. As per a global study by IUCN in 2000, 89 per cent of all threatened birds, 83 per cent of all threatened mammals and 91 per cent of all threatened plants have already been affected by loss or degradation of habitat. This can be caused by natural disasters like flood, fire, hurricanes and erosion. The human need for wood, minerals and water (dams) could also be responsible for this loss. Air and water pollution along with global climate changes also affects sensitive species.

Deforestation for agriculture *(jhum* cultivation), clearing of land for developmental work, overgrazing and so on, are also responsible for fragmenting habitats into small, isolated, scattered populations that are vulnerable to inbreeding, depression, high infant-mortality and susceptible to environmental stochasticity and possible extinction.

Changes in forest composition, quality and habitat-type, lead to a decline in primary food species for wildlife and eventually to loss of habitat. However, statistics show agricultural practices as one of the major causes of loss of habitat.

Cropland in million hectare

Region	1900	1980	Percentage Change
Sub Saharan Africa	73	222	+204
Latin America	33	142	+330
North America	133	203	+53
South Asia	89	134	+51
South-East Asia	15	55	+267
China	89	134	+51
Europe	145	137	- 5
Ex-USSR	147	233	+58

According to a recent estimate, at least 120 out of the 620 living primate species (apes, monkeys, lemurs and others) will become extinct in the wild, in the next 10 to 20 years. Large animals like tigers, mountain gorillas, pandas, Indian lions, tropical orchids and spotted owls often suffer more because they need larger areas for survival. The only species that benefit from human activity are rats, cockroaches, house flinches and so on.

Overexploitation of Resources

Unlimited extraction (through mining, fishing, logging, harvesting and poaching) and development work (human settlement, industry and associated infrastructure) are the major factors that contribute to the Overexploitation of resources. As a result of this Overexploitation, tigers, giant pandas, black rhinoceros, musk deer, cod and several whale species are on the verge of extinction.

Pollution

Loss of biodiversity due to pollution is very common these days. When we pollute nature with the waste generated by us, only the biodegradable waste gets broken down slowly and gets recycled. But the non-biodegradable or less biodegradable waste remains in the environment and enters our food chain. This waste travels through the food webs, gets biomagnified and reaches the tissues of all living species. These wastes are very toxic and sometimes their toxicity increases with time. A very common example of this is the organic pesticide DDT which affects all types of birds (peacocks, hawks, kites, and so on). Therefore, pollution in various forms is responsible for global climatic changes and for the extinction of most of the species till date.

Extinction of Species due to Aggressive Non-native Species

Despite its importance, this aspect is often overlooked particularly in island areas. When two or more species are inter-dependent or a particular species has strong links with another, the Domino Effect takes place causing extinction of the weaker species. It is the reported cause of extinction of almost 50 per cent species on islands all over the world since 1600 AD.

Global Environmental Change

Scientists feel that 35 per cent of the world's existing terrestrial habitat may face extinction due to global warming. Global warming is a result of the accumulation of Greenhouse gases. It causes the global environment to change and leads to the extinction of many species which fail to adapt and acclimatize to the changing environmental conditions.

However, poverty, macro-economic policies, international trade factors, policy failures, poor environmental laws or weak enforcement of the same, unsustainable developmental projects and a lack of local control over resources as well as population pressure are some of the underlying causes of biodiversity loss. Increase in the collection of fuel wood, fodder and grazing of animals belonging to local communities also take a toll on the forest and its biodiversity.

Threats to Indian Biodiversity

With 7.31 per cent species of fauna and 10.78 per cent floral species in the world, India is very rich in biodiversity. It has 89,451 animal species and several floral species, one-third of which are endemic to the country. These species are concentrated in the North East, Western Ghats, North West Himalayas, Lakshadweep and the Andaman and Nicobar Islands. But today, this rich biodiversity is under severe threat because of:

(i) loss/degradation of habitat due to agriculture, extraction,

(ii) fragmentation and overexploitation of resources,

(iii) poaching and international trade of wild species and products,

(iv) economic and social causes such as poverty, government policies, environmental laws and enforcement, population pressure and unsustainable development projects and

(v) deforestation due to the collection of fuel wood, fodder, overgrazing and agriculture.

Hunting and poaching alone are responsible for bringing to the verge of extinction as much as 37 per cent of the birds, 34 per cent of the mammals and 8 per cent of the plants, in addition to many reptiles and fishes. In fact, some animals such as tigers are more in demand than others which leads them to be poached more often.

Islands are particularly susceptible to invasion by alien species. This poses a serious threat to 30 per cent of the birds and 15 per cent of the plant species.

Combating the Problem

The fact that the world has become conscious of the value of, and a threat to, biodiversity was proven when at the International Convention on Biological Diversity at Rio de Janeiro in

1992, the focus was on the sustainable use of the components of biodiversity. It was decided that the strategies for sustainable conservation of biodiversity should be:

(i) Worldwide reduction of industrial and domestic pollution.

(ii) Controlling overexploitation of natural resources. Bodies such as the International Whaling Commission and Convention on International Trade on Endangered Species (CITES) are already active in this field.

(iii) Agricultural activities with conservation measures should be encouraged. Organic farming, which promotes habitat diversity, should be promoted.

(iv) The government should set up parks and reserves to protect and rehabilitate wildlife and natural vegetation.

(v) The government should formulate and strictly implement conservation legislations.

(vi) Progress in combating the alarming loss of biodiversity depends not just on the commitment and sacrifices of individuals but also on the actions of the government.

Poaching of Wildlife

Simply put, poaching is an illicit wildlife trade. It is the illegal killing of wildlife for sale in the international trade market. The animals are killed not only for their meat but also for their hides, and different parts of their body that are used as clothing, for food, to make folk medicine, or Jewellery or as trophies. Some people poach just for the thrill of it, while others poach for trade. Poachers operate in groups throughout the year and are interested in any marketable animal that is available. Antlers are sold as trophies and are also used in folk medicine. The gall bladder of a bear can bring $18,000 in Asia. Its paws, claws and teeth are used in taxidermy and folk art trade. The horns and skin of a rhinoceros for traditional medicine, tusks of elephants for ivory, eggs from the paddle fish for caviar, musk of the musk deer for perfume, meat of pangolin, the skin, hide and bones of tigers, leopards, deer and bear are all much in demand.

It is the duty of every citizen to stop poaching and conserve wildlife by:

(i) Trying to identify poaching offences in your area.

(ii) Reporting poaching incidents to the local wildlife enforcement officer, local poaching hotline or to the state level officers.

(iii) Discussing the value of wildlife and threats posed by poaching with your near and dear ones.

(iv) Encouraging effective wildlife legislation.

(v) Encouraging the publication of articles against poaching, in local newspapers, journals, television and different mass media, distribution of pamphlets or arranging for lectures meant for a variety of audience.

(vi) Refusing to purchase products that you suspect have been illegally obtained from wild animals.

(vii) Improving wildlife law enforcement, including sufficient patrol officers with proper funding, effective penalties and supporting the judicial system.

Elephant Poaching and Ivory Trade

Despite the fact that CITES has banned international trade in ivory (elephant tusks) in 1990 and provided massive funds for the protection of elephants, poaching has continued albeit at a lower rate. As per statistics, between January 1, 2000 and May 21, 2002, more than 5.9 tonnes of ivory, 2,542 tusks and 14,648 pieces of ivory were seized worldwide; all these facts mean that more than 2,000 elephants have been killed.

Over the last 16 years, more than 289 adult elephants have been poached for ivory in Orissa in India. Illegal ivory trade is extremely lucrative. Ivory sells at Rs 12,000 to 15,000 per kg. If the trend continues, Orissa will soon lose its exalted status of being famous for its magnificent elephants since the time ofAshoka, the Great.

CASE STUDY

Tiger Poaching

In 1900, the population of Royal Bengal Tigers in India was 40,000. It came down to 1,800 in 1972 which prompted the Indian government to launch Project Tiger for the conservation of these big cats. As a result, the tiger population increased to 4,200 by the early 1990s. This came down again to 3,500 due to increased habitat loss and poaching besides other reasons. The population of the South Chinese or Indo-Chinese or Sumatran tiger has also reduced and they are close to extinction. The demand for tiger bones and other body parts for use in oriental medicine is also responsible for bringing the tiger to near extinction.

In 1994, trade in tiger parts was banned in China, Taiwan, Hong Kong, South Korea and most of South East Asia but it is still legal in Japan and North Korea. Medicines containing tiger parts are still used in Canada and the United States. In fact, as per statistics, one tiger per day is poached in India. If the trend persists, this large cat will become extinct in India in the next five to 10 years. In India, the well-organized poachers face little or no opposition at all from ill-equipped, unarmed wardens and rangers. Although a number of legislations have been enacted in India and a good number of tiger reserves have been created; the enactment of the law with such few wardens is very difficult. In India, tiger poaching is rampant in Madhya Pradesh, Uttar Pradesh, Orissa, West Bengal, Assam and Arunachal Pradesh. A tiger cell has been created in Madhya Pradesh with a view to protect the tigers and seize body parts. The largest seizure took place in 1993, in Delhi, when 400 kg of tiger bones, eight skulls, 58 leopard skins and the skin of a number of other animals was seized and taken into custody.

Man-Wildlife Conflict

When wild animals leave the protected areas (forests) to raid human settlements in search of food and water it gives rise to a conflict between man and wildlife.

The main reason for this conflict is the growing anthropogenic pressure on wildlife habitat which results in:

(i) Fragmentation and honeycombing of animal habitat.

(ii) Loss of corridors and migratory routes for long-range animals such as elephants, big cats (tigers, leopards, bears) besides others.

(iii) Loss of food and water in their habitat due to the shrinking of forest cover and loss of biodiversity.

When wild animals destroy crops causing economic and food losses to farmers, affect water supplies, kill or injure humans and cause havoc in the lives of human beings, they retaliate by killing the wild animal.

The conflict is fast becoming a critical threat to the survival of many globally endangered species such as the Sumatran tiger *(Panthera Tigra Sumatrae),* Asian Lion *(Panthera Leo Persica),* Snow Leopard *(Uncia Uncia),* Red Colobus Monkey *(Procolocus kirkii.)* and many more. It has also been observed that the more volatile species are more prone to extinction because of injury and death caused by humans, traffic (road, railway track) or other accidents (for example, falling into traps, wells, poisoning, electric fences and so on).

Considering that this conflict will always remain, strategies are being evolved by government wildlife managers, scientists and local communities, not just for the protection of humans but also for the conservation of biodiversity (wildlife).

This multi-faceted problem can be minimized with good management practices and approaches involving low-cost strategies such as electric fencing, community-based natural resource management schemes, incentives, and insurance programmes along with regulated harvesting and wildlife or human translocation.

Man-Tiger Conflict in Sumatra

A study by Nyphus and Tilson reveals that the man-tiger conflict is more common in intermediate disturbance zones than in high or low disturbance zones. Intermediate disturbance zones are isolated human settlements surrounded by extensive tiger habitats. There are less chances of conflict in logged, degraded and heavily used areas or in and around protected areas where human entry is prohibited by natural barriers or due to the presence of guards. But in Sumatra, tiger attacks have been recorded around different national parks due to the lack of spatial separation. Hence, for their conservation priority should be given to the security of large animals around reserve borders and in buffer zones.

Man-Wildlife Conflict in India

In India, people living in and around the protected areas mainly depend on forest products, agriculture and agro-pasture. As a result, very often man-wildlife conflicts result in crop loss, injury or loss of human life and sometimes the death of wild animals.

About 1,07,770 people live in 117 villages in and around the Sariska Tiger Reserve Project in Rajasthan. Agriculture and rearing livestock are the main sources of livelihood for them. Many species of wild herbivores such as the *Nilgai* and wild boars are to be blamed for 50 per cent of the damage to their crops while *sambar, chital,* the common *langur,* rhesus monkeys and parakeets are blamed for the rest. Wild carnivores such as tigers and leopards are responsible for livestock loss. Tigers prey on big domestic animals like cattle and buffalos while leopards prey on goats, sheep and calves.

Once upon a time the forests of Orissa were home to thousands of elephants. But the establishment of Brutanga Irrigation Project in Nayagarh district, the coming up of a large number of steel and iron projects in Jaipur, Keonjhar and Sundergarh districts, the proposed Vedanta Alumina's refinery in Kalahandi district, the Hirakud Dam, the Rengali Irrigation Project and thermal power plants at Talcher in Orissa have caused a severe dent to the wildlife population. Owing to severe pressure on their habitat and food loss, elephants are in their

worst-ever confrontation with people. Between 1995-1996 and 2003-2004, a total of 259 persons were killed by wild elephants in Orissa.

But in this case, the good news is that people have understood the problem and are cooperating in regenerating forests, especially in the Dhenkanal district of Orissa. Elephants have also begun to move towards the newly generated forests.

MEASURES TAKEN

To prevent man-wildlife conflicts, elephant-proof trenches are dug and rubble walls and energy fences are erected. Awareness is spread among people through newspapers, electronic media and by the distribution of pamphlets. Anti-depredation committees are formed to keep track of problem animals or groups and inform villagers and forest departments in the case of any approaching emergencies. High intensity focus lights, fire torches, drums and crackers are used to ward-off problem-causing animals from the site to the interiors of the forests. Apart from this, compassionate payments are also made to victims sustaining severe losses.

6.6 CONSERVATION OF BIODIVERSITY

Conservation of biodiversity is aimed at the protection, preservation, management or restoration of natural resources such as the forests and their flora, fauna, and water. Thus, biodiversity conservation includes:

(i) Protection of all critically endangered, endangered, vulnerable, rare and other species of life present in the ecosystem.
(ii) Preservation of all varieties of old and new flora, fauna and microbes.
(iii) Protection and preservation of critical habitats, unique ecosystems.
(iv) Regulation of international trade in wildlife.
(v) Reduction of pollution.
(vi) Increase in public awareness.

Conserving biodiversity becomes a problem when there is lack of resources and a need to use the land for human activities. The term hotspot is used to define regions of high conservation priority with their biodiversity richness and high endemism and a high threat.

Conservation efforts are often focused on a single species. This is called 'keystone species' because the idea of conserving one species over others is more appealing. For example, conservation of tigers over say Zayante band-winged grasshoppers is not only more appealing and convincing, but it also attracts more resources, which can be used for the conservation of an endangered habitat.

However, the process of conservation can be broadly divided into two types:

(i) **In-situ Conservation:** In this type of conservation, the natural process and its interaction with the habitat as well as with all the elements of biodiversity are conserved. The establishment of protected areas such as national parks, sanctuaries and biosphere reserves is an example of in-situ conservation.

(ii) **Ex-situ Conservation:** In case of complete degradation of a habitat, in-situ conservation

is not possible, as the endangered species need special care. In such cases, the endangered species is removed from the area and kept under total human supervision in places such as zoos, botanical gardens and seed banks. This is called ex-situ conservation.

In-situ Conservation

The basic principle of in-situ conservation is the protection and management of components of biological diversity through a network of protected areas in their natural habitat. In this method, the total ecosystem is protected by eliminating the factors that are harmful to the existence of the species concerned. Not only, do the endangered species benefit from this, but all the constituent species present in that ecosystem benefit as well. In-situ conservation is a cheap, convenient and natural way of conservation. The species are allowed to grow in their own natural habitat with the conservationists playing a supportive role. As the species grow in their natural habitat, they face natural calamities such as rain, floods, droughts and snow, and thereby evolve into better-adapted forms. For this reason, the wild species are more resistant to the prevailing environmental conditions than the domesticated or hybrid varieties.

However, the main disadvantage of in-situ conservation is that it requires a large area for the complete protection of biodiversity. This implies a restriction of human activity and a greater overlap or interaction of wildlife with local residents near a reserve forest. People living on the outskirts of a natural reserve depend on the forest for their livelihood. At present there are 7,000 protected areas, parks, sanctuaries and natural reserves in the world, covering more than 650 million hectares of the earth's surface, which is about 5 per cent of the total global land area.

National Parks and Sanctuaries

These are small reserves for the protection and conservation of a few species in their habitat. A national park has a well-defined boundary. Sanctuaries do not have a well-defined boundary and tourists are allowed inside a sanctuary.

Natural Reserve or Biosphere Reserve

These are large, protected areas where the entire biotic spectrum of the climatic zone is preserved. These have boundaries properly identified by legislation. Exploitive human activity or tourists are allowed only up to the outskirts of these reserves areas, which are also scientifically managed.

Project Tiger

The tiger is the finest symbol of earth's natural heritage but tiger sightings these days are very rare in India because of poaching. Tiger poaching is a recurrent problem in countries such as, India, Bangladesh, Bhutan, Cambodia, China, North Korea, Indonesia, Laos, Malaysia, Nepal, Myanmar and Thailand. Almost all the body parts of a tiger are traded for huge amounts of money. Many believe that tigers have healing powers. They believe that tiger bones cure rheumatism, muscular weakness, back pain and enhance longevity. Tiger skins can fetch $1,50,000, the soup made from its penis is said to increase one's sexual prowess, the whiskers are potent poisons, tiger brain is used to treat acne, tiger tail mixed with soaps cures skin diseases and pills made from its eyes purportedly calms convulsions. Thus a tiger is considered equivalent to a big bag full of money.

Some species of this big cat are already extinct while others are endangered or close to extinction. According to the WWF, tigers are hunted primarily for the use of their body parts in Chinese medicine; these patented Chinese medicines have a huge demand in Asia. Tigers are also poached for souvenirs such as, their skin and mounted heads.

Efforts are being made to preserve this magnificent predator from extinction. Former Indian Prime Minister, the Late Indira Gandhi, launched Project Tiger in 1972, for the conservation and upliftment of the tiger population in India. At present, India has 27 tiger reserves, which extend from the high Himalayan region to the mangrove swamps of the Sundarbans and the thorny scrubs of Rajasthan. Of these 27 tiger reserves, Manas National Park of Assam has been declared a World Heritage Site by UNESCO. Table 4.7 gives a detailed list of the tiger reserves in India. However, more wildlife conservation laws and greater awareness among people are still required for the success of Project Tiger.

Tiger Reserves of India

Sl. No.	Year of creation	Name of tiger reserve	State	Total area in sq. km.
1	1973-74	Bandipur	Karnataka	866
	1999-2000		Nagarhole (Extension)	642
2	1973-74	Corbett	Uttaranchal	1316
3	1973-74	Kanha	Madhya Pradesh	1945
4	1973-74	Manas	Assam	2840
5	1973-74	Melghat	Maharashtra	1677
6	1973-74	Palaman	Jharkhand	1026
7	1973-74	Ranthambore	Rajasthan	1334
8	1973-74	Simlipal	Orissa	2750
9	1973-74	Sundarbans	West Bengal	2585
10	1978-79	Periyar	Kerala	777
11	1978-79	Sariska	Rajasthan	866
12	1982-83	Buxa	West Bengal	759
13	1982-83	Indravati	Chattisgarh	2799
14	1982-83	Nagarjunasagar	Andhra Pradesh	3568
15	1982-83	Namdapha	Arunachal Pradesh	1985
16	1987-88	Dudhwa	Uttar Pradesh	811
	1999-2000		Katerniaghat (Extension)	511
17	1988-89	Kalakad-Mundanthurai	Tamilnadu	800
18	1989-90	Valmiki	Bihar	840
19	1992-93	Pench	Madhya Pradesh	758
20	1993-94	Tadoba-Andheri	Maharashtra	620
21	1993-94	Bandhavgarh	Madhya Pradesh	1162
22	1994-95	Panna	Madhya Pradesh	542
23	1994-95	Dampha	Mizoram	500
24	1998-99	Bhadra	Karnataka	492
25	1998-99	Pench	Maharashtra	257
26	1999-2000	Pakhui-Nameri	Arunachal Pradesh	1206
27	1999-2000	Bori, Satpura	Assam	1486

Ex-situ Conservation

Due to the degradation and fragmentation of habitat, a large number of species are on the verge of becoming extinct. Ex-situ conservation aims at protecting and preserving such endangered species in zoos, nurseries and laboratories. Breeding plants and animals under human care is the strategy employed by ex-situ conservation. Although, earlier it was not practiced for wildlife conservation today with the advancement of science and technology the practice has emerged as a well-defined technology for the purpose. The following are the two

main steps for ex-situ conservation:

(i) Identification of the species to be conserved.

(ii) The selection of method to be followed for its ex-situ conservation.

(i) **Identification of the Species to be conserved:** Those species that are at the maximum risk of extinction are chosen for preservation. The life cycle of the species, its degree of specialization, rich location, dispersal ability, adult survival and atrophic status are studied for the final selection.

(ii) **Methods for Ex-situ Conservation:** From the study on the selected species, the method for its growth, reproduction and survival under ex-situ conservation is decided. The various methods adopted for ex-situ conservation of the critically endangered species are as follows:

(a) *Long-Term Captive Breeding:* If the species is being pushed into extinction due to habitat loss or by some adverse external conditions then they are removed from their natural habitat for long-term captive breeding. Captive breeding can increase their population and help the species to survive. Thereafter, as most of these species cannot survive in their wild habitat they are kept in zoos and botanical gardens under proper care.

(b) *Short-Term Propagation and Release:* If the population of a particular species decreases suddenly due to some temporary setback then it is removed from its natural habitat, maintained with ex-situ conservation methods, bred and later released into their natural habitat. Ex-situ crocodile conservation is an example of this method.

(c) *Animal Translocation:* If the population of a particular species decreases suddenly then some animals of the same species are brought from a similar habitat and released in the less populated area. For example, if the number of male tigers decreases in habitat number one, then male tigers of the same species are brought from some other area and released in this habitat so as to increase the tiger population here. However, the capture, transfer and release of wildlife from one area to another require maintenance of the species in captivity for a short period.

(d) *Animal Reintroduction:* When an animal becomes extinct from its natural habitat, attempts are made to reintroduce the species there. For this, newborn animals bred in captivity or animals caught in infancy and kept in captivity for some time then they are selected and released into the habitat from where the original population has disappeared. It is important to rehabilitate the reintroduced species or they too may suffer the same fate as the original species. For this purpose, proper maintenance of the natural habitat and constant observation of the reintroduced species is very important. These days radio collars are used for observation. The capture, transfer and release of animals from one locality to another is difficult, so special drugs are administered to the target animal from a distance to immobilize the animal. Special emphasis is laid on the nutrition and health care of the animals by administering preventive medicines and systematic vaccinations to them.

Artificial insemination, embryo transfer and cryo-preservation of gametes and embryos are the techniques used to maintain the genetic diversity of nature.

Biosphere Reserves of India

Biosphere reserves are protected areas of representative ecosystems of terrestrial as well

as coastal areas. They are internationally recognized under the Man and the Biosphere (MAB) Programme initiated by UNESCO in 1971. A biosphere reserve is aimed at:

(i) In-situ conservation of biodiversity of natural and semi-natural ecosystems and landscapes.

(ii) Contribution to sustainable economic development of the human population living within and around the biosphere reserve.

(iii) Providing facilities for long-term ecological studies, environmental education, training, and research and monitoring.

Thus, these reserves could serve as a referral system for monitoring and evaluating changes in the natural ecosystem. A biosphere reserve is classified into three zones:

Core Zone: This zone is meant for the conservation of biological diversity and is securely protected. Nondestructive research work and low-impact activities like education and ecotourism can be conducted here.

Buffer zone: This zone surrounds the core zone and is used for cooperative activities such as environmental education, recreation, basic and applied research and so on.

Transition area: It surrounds the buffer zone and may be used for agricultural activities, settlement of local I communities, NGOs', cultural groups and by other stakeholders for economic interests and sustainable | development of the area's resources.

Globally, 425 biosphere reserves have already been established in 95 different countries since 1979. The Government of India constituted a panel of experts in 1979, to identify potential areas of biosphere reserves under the MAB Programme of UNESCO. The experts identified 14 sites to be declared as biosphere reserves. Of them, 13 sites were declared biosphere reserves in 2005 and later Achanakmar-Amarkantak was declared the 14th biosphere reserve of India. Table 4.8 lists the biosphere reserves of India that have been declared till date.

List of Biosphere Reserves of India

Sl. No.	Name	Date of establishment	Area (km²)	Location
1	Achankamar-Amarkantak	2005	3,835.55 (core 551.55, buffer 3283.96)	Covers part of Anupur and Dindori district of Madhya Pradesh and Bilaspur of Chhatisgarh state
2	Agasthyamalai	12 Nov. 2001	1,701	Neyyer, Peppara and Shendurney wildlife sanctuaries and their adjoining areas in Kerala
3	Dehang-Debang	2 Sept. 1998	5,111.50 (core 4,094.80, buffer 1, 016.70)	Part of Siang and Dibang valley in Arunachal Pradesh
4	Dibru-Saikhowa	28 July 1997	765 (core 340, buffer 425)	Parts of Dibrugarh and Tinsukhia district of Assam
5	Great Nicobar	6 Jan. 1989	885 (core 705, buffer 180)	Southernmost island of Andaman and Nicobar
6	Gulf of Mannar	18 Feb. 1989	10,500 (Total gulf area)	Indian part of Gulf of Mannar between India and Sri Lanka
7	Khangchenzonga	7 Feb. 2000	2,619.92 (core 1,819.34, buffer 800.58)	Part of Khangchenzonga hills and Sikkim
8	Manas	14 March 1989	2,837 (core 391, buffer 2446)	Parts of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamrup and Darang districts of Assam
9	Nanda Devi	18 Jan. 1988	5,860.69 (core 712.12, buffer 5148.57, transition 546.34)	Part of Chamoli, Pithoragarh and Bageshwar districts (Uttaranchal)
10	Nilgiri	1 Sept. 1986	5,520 (core 1240, buffer 4,280)	Part of Wayanad, Nagarhole, Bandipur and Madhumalai, Nilambari, Silent Valley and Siruvani hills (Tamilnadu, Kerala and Karnataka)

Sl. No.	Name	Date of establishment	Area (km²)	Location
11	Nokrek	1 Sept. 1988	82 (core 47.48, buffer 34.52)	Part of Garo hills (Meghalaya)
12	Pachmarhi	3 March 1999	4,926	Parts of Betul, Hoshangabad, Chindwara district of Madhya Pradesh
13	Simlipal	21 June 1994	4,374 (core 845, buffer 2,129, transition 1,400)	Part of Mayurbhanj district of Orissa
14	Sunderbans	29 March 1989	9,630 (core 1,700, buffer 7,930)	Part of delta of Ganges and Brahmaputra river system (West Bengal)

World Heritage Sites

The World Heritage Site list was established in November 1972 at the 17th General Conference of UNESCO, under the terms of the convention concerning the protection of world culture and natural heritage. The main responsibility of the World heritage committee was to provide technical cooperation under the World Heritage Fund to safeguard these sites. Table 4.9 lists the world heritage sites of India.

The World Heritage Sites of India (Natural)

Sl. No.	Name of the site	Location
1	Kaziranga National Park	Assam
2	Manas Wildlife Sanctuary	Assam
3	Keoladeo National Park	Rajasthan
4	Sundarbans National Park	West Bengal
5	Nanda Devi National Park	Uttar Pradesh

Ramsar Sites in India

A close observation of the current list of Ramsar sites in India (Table 4.10) represents only a fraction of the diversity of wetland habitats existing in the country.

List of Ramsar Sites in India

Sl. No.	Name
1	Ashtamudi Lake
2	Bhitarkanika Mangroves
3	Bhoj Wetlands
4	Chilika Lakes
5	Deepor Beel
6	East Kolkata Wetlands
7	Harike Wetlands
8	Keoladeo National Park
9	Kolleru Lake
10	Loktak Lake
11	Point Climere Wildlife and Bird Sanctuary
12	Pong Dam Lake

Sl. No.	Name
13	Sambar Lake
14	Sasthamkota Lake
15	Tsomoriri
16	Vembanad-kol Wetland
17	Wular Lake
18	Kanjli Lake

6.7 SELF ASSESSMENT QUESTIONS

1. Define a hot spots and write about the hot spots in India.
2. What are endemic species? Discuss the status of India as the abode of endemic flora and fauna.
3. What are the major threats to biodiversity? Discuss.
4. Write a note on the cause, effect and combating of the problem of man-wildlife conflict.
5. Write a note on efforts taken for biodiversity conservation.
6. Differentiate between in-situ and ex-situ conservation principles.

6.8 REFERENCES:

1. Environmental Studies from Crisis to Cure, Rajagopalan, Oxford University Press, New Delhi
2. Essentials of Ecology and Environmental Sciences, SVS Rana, PHI Learning Pvt. Ltd., New Delhi.
3. People and Environment, G. Tyler Miller, Cengage Learning , New Delhi.

Dr. A.V.V.S. Swamy

LESSON - 7

ECOSYSTEMS AND THEIR FUNCTIONS

7.0 : Objective

After studying this lesson, the student will be able to understand Concept, Structure, Functions, Types of Ecosystems, Ecological Pyramids, Different types of ecosystems.

Structure

7.1 Concept of Ecosystem

Life is found in the biosphere on this planet and the species interact with their biotic and non-biotic components. The study of the relationship between organisms and between the organism and the environment is known as ecology. The structural and functional unit of ecology is known as the ecosystem. The lifecycle of a tree or a fish in a pond indicates the interdependence of the organisms among themselves as well as with the environment. The part of the earth where these ecosystems operate is called the biosphere. In some natural ecological groupings, plants and animals of a regional climate and soil-type interact to produce a characteristic land community known as biome. In biomes, the emphasis is on biotic community whereas in the ecosystem it is on the interaction between plants, animals, and microbes.

7.2 Structure and Functions of an Ecosystem

The functional unit of the ecosystem consists of two distinct structural components namely biotic and abiotic components. The ecosystem may be as small as a drop of pond water or as large as an ocean. Depending on how they are generated, ecosystems may be natural or man-made and may either be permanent or temporary.

7.2.1 BIOTIC COMPONENTS

The biotic component of an ecosystem consists of all living components of the environment, such as plants, animals, human beings and microbes. A detailed study of the biotic components reveals that all living organisms of our environment can be further categorized depending on their self-food producing capability, They can be categorized as autotrophic component or producers and heterotrophic component or consumers, Biotic components.

7.2.1.1 Autotrophs or Producers

These include all green plants, bacteria and algae which contain chlorophyll and are capable of converting preparing their own food through photosynthesis. They produce carbohydrates by converting solar energy into chemical energy and storing foodstuff in the presence of carbon dioxide and water.

7.2.1.2 Heterotrophs or Consumers

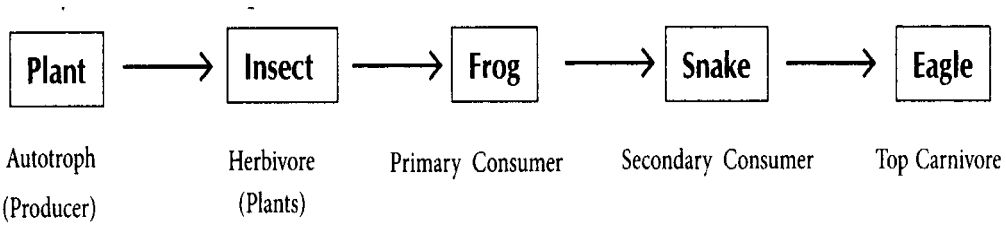
All other organisms, which cannot prepare food and depend on autotrophs to obtain their energy for survival, are called consumers or heterotrophs. Heterotrophs utilize, rearrange and decompose the food produced by autotrophs.

Depending upon their feeding habits, the heterotrophs are classified as follows:

(a) **Primary Consumers:** Organisms or animals, which feed on green plants for survival, are called primary consumers or herbivores. Cows, goats, horses, rabbits, insects and grasshoppers are examples of herbivores.

(b) **Secondary Consumers:** Animals which feed on are known as secondary consumers. Secondary consumers eat the flesh of primary consumers (that eat autotrophs) and are hence known as carnivores. For example, frogs and lizards are secondary consumers as they eat grasshoppers and other insects.

(c) **Tertiary Consumers:** Tertiary consumers are those that eat the flesh of secondary consumers, as is the case with a tiger or a lion, which eats a fox which in turn feeds on herbivores. Tertiary consumers are animals, such as lions, tigers and vultures. Since they are not killed and eaten by other animals, they are known as top carnivores.



Trophic Level in a Grassland Ecosystem

7.2.1.3 Saprophytes or Decomposers

The dead bodies of the producers and consumers (organic matter) are eaten and broken down into simple inorganic substances by certain microbes (bacteria and fungi). These simple substances are utilized again by the producers (plants) to prepare food. Hence, the decomposers play the vital role of releasing essential materials from the dead organic matter or the plant, thereby maintaining a continuous cycle of materials. Certain decomposers are also called scavengers. Water, carbon dioxide, phosphates, nitrogen, sulphates and a number of organic compounds are by-products of activity of organisms on dead organic matter.

7.2.2 ABIOTIC COMPONENTS

All the non-living components of the environment such as light, temperature, humidity, moisture, solar radiation and salinity of soil as well as inorganic and organic compounds constitute the abiotic components of the ecosystem. All biotic organisms (such as plants, animals and microbes) interact only with the abiotic components of the environment.

7.3 TYPES OF ECOSYSTEMS

The biosphere includes four major types of habitats namely marine, freshwater, terrestrial and man-made (agriculture) ecosystems.

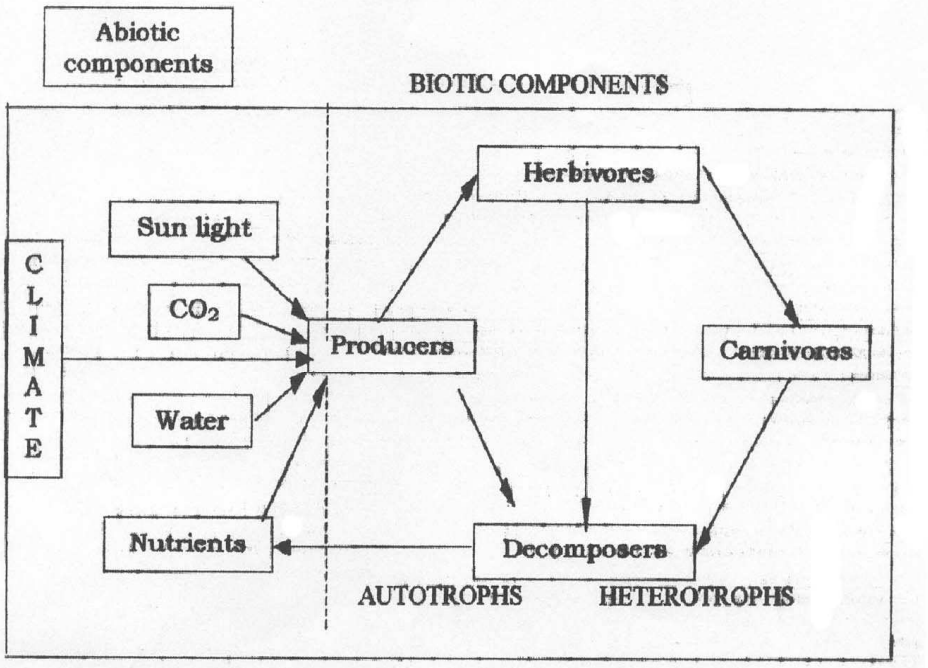
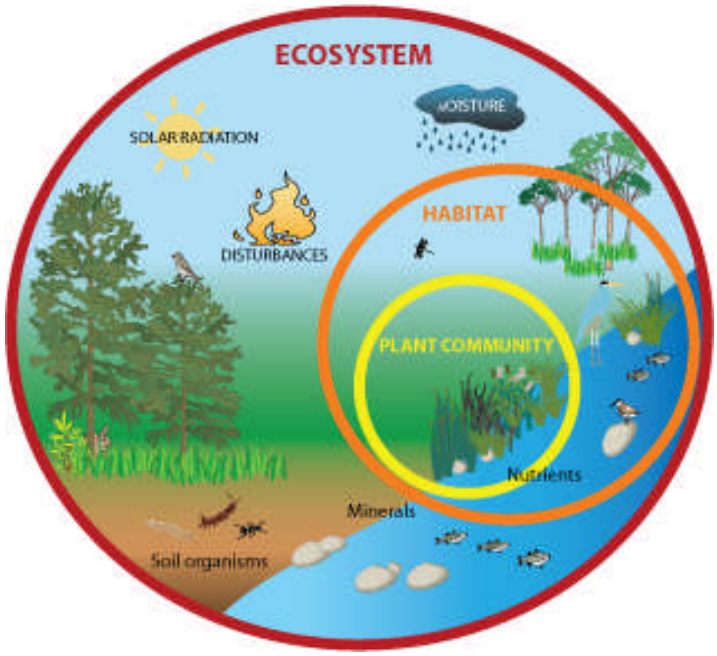


Fig. Simplified ecosystem model.



Marine ecosystem: All the saline water reservoirs on earth such as the seas, oceans and estuaries with their characteristic biome form the marine ecosystem.

Freshwater ecosystem: Ponds, streams, rivers and lakes along with their flora and fauna form the freshwater ecosystem.

Terrestrial ecosystem: It includes desert ecosystem, grassland ecosystem, tree ecosystem, crop fields, forest ecosystem and so on.

Man-engineered ecosystem: Agriculture and aquaculture systems are man-engineered ecosystems. These ecosystems have all the essential components such as producers, consumers (both herbivores and carnivores), decomposers and abiotic materials. The main purpose of these ecosystems is to produce more yields in terms of grains, milk, fish or meat. This can be done by increasing the supply of energy in the form of labour, extra nutrients fossil fuels, fertilizers, and pesticides. This is a monoculture system as a single crop is grown whereas natural ecosystems are polyculture systems. Hence, natural ecosystems are more stable compared to man-made ecosystems which are fragile and highly productive and generate lots of pollutants.

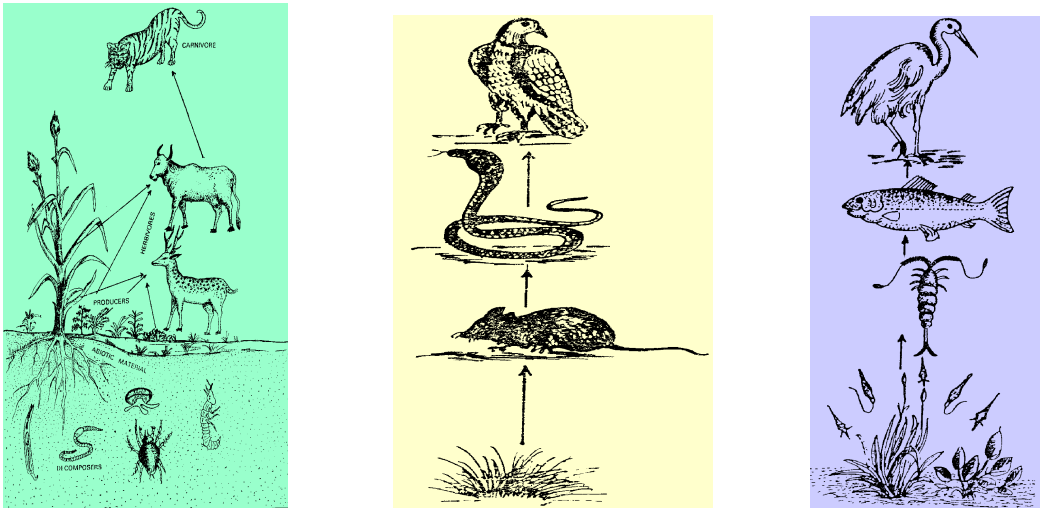
Functional Components of an Ecosystem

The functional components of an ecosystem are:

(i) Biodiversity;
(ii) Productivity (primary and secondary);
(iii) Food chains and food webs;
(iv) Material cycling and energy flow;
(i) Balance of nature and
(ii) Succession and evolution of ecosystems.

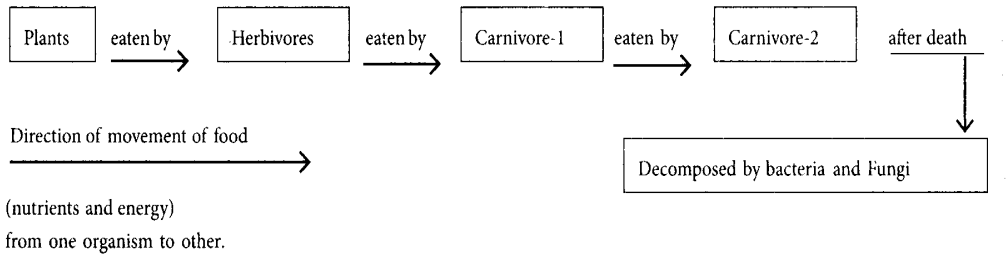
7.4 Food Chains and Food Webs

As already discussed, in the ecosystem only green plants contain chlorophyll with the help of which they can convert solar energy to food which is being taken by different heterotrophs. Heterotrophs cannot produce food for themselves. Herbivores, carnivores, and decomposers are collectively known as heterotrophs. The food which is produced by an autotroph is eaten by herbivores (cows, goats, horses, rabbits and so on) which are eaten by small carnivores which in turn become food for bigger carnivores and the process continues.



Food chains in terrestrial grassland and pond ecosystems

Ultimately after the life cycle, the dead organism is decomposed by different decomposers (bacteria, fungi, microbes etc.) as shown in Figure



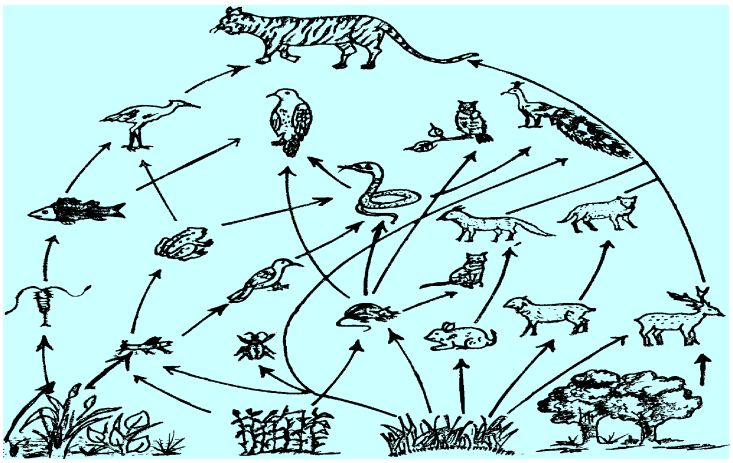
Flow Chart Showing the Movement of Food and Energy in a Food Chain

This sequence of organisms which feed on one another for their survival is known as the food chain. In a food chain, the links are known as trophic levels (food level). The plants are producers and form trophic level-1, the herbivores are primary consumers and form trophic level-2, the small carnivores are secondary consumers and form trophic level-3 and the big carnivores are tertiary consumers and form trophic level-4. They are also called top carnivores.

The food chain in the ecosystem helps to maintain:

(i) The biodiversity of nature.
(ii) The feeding relationship of nature.
(iii) Flow of energy of the ecosystem.
(iv) Passage of nutrients from one organism to another.

The only demerit of a food chain is that along with nutrients it also transports toxic substances from one organism to another which finally results in biomagnification. In the ecosystem, a number of food chains operate simultaneously. These food chains are inter-linked with one another to form a food web. For example, a plant may be food for any herbivore or carnivore such as human beings. A herbivore again becomes food for carnivore-1 or is directly eaten by the top carnivore.



A Food Web in Natural Ecosystem

For example, a mouse feeding on food grains becomes food for a snake which is eaten by a hawk. The mouse can be directly eaten by a hawk. In this way, the inter-related complex food

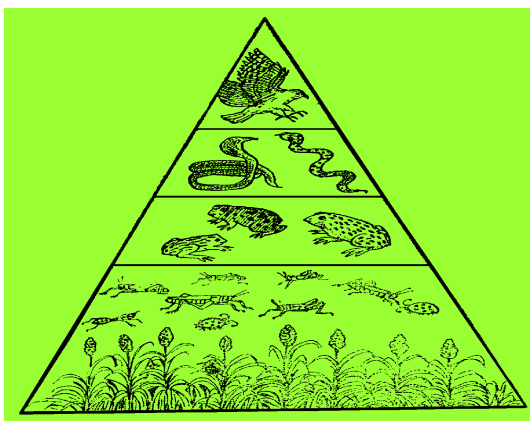
chain forms a food web. A food web constitutes a number of alternative paths for energy flow and provides greater stability to the ecosystem. A food web of a grassland ecosystem is shown in Fig.

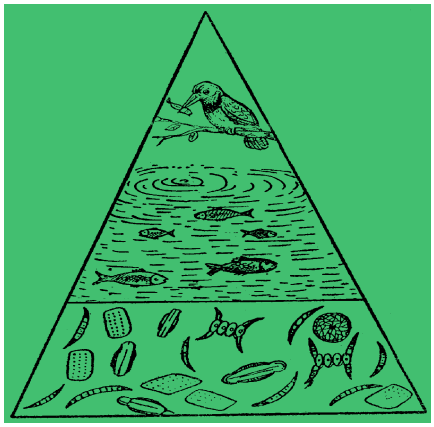
7.5 Ecological Pyramids

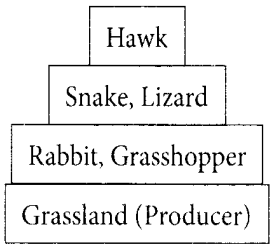
In 1927, scientist Charles Elton observed that the number of animals present at the top of the trophic level is much less compared to the number of animals present at the base of the food chain. He also plotted his findings on a graph to get a pyramid-like structure. He called this pyramid the Eltonian Pyramid after his name. It is also known as the ecological pyramid. Thus, an ecological pyramid is the graphical representation of the trophic structure (the position of organisms in the food chain) and function at successive trophic levels. The base of the pyramid consists of the food producer level. The successive levels make the tiers, with the top carnivores forming the apex. These ecological pyramids are of three types:

(i) Pyramid of numbers.
(ii) Pyramid of biomass.
(iii) Pyramid of energy.

7.5.1 Pyramid of Numbers: This pyramid deals with the relationship between the number of primary producers and consumers (herbivore and carnivore) of different orders. Depending on the nature of the food chain, in the present ecosystem the pyramid of numbers may be upright or inverted. For example, in a grassland ecosystem, the number of grasses (producer) is always high followed by primary consumers (herbivores like rabbits and grasshoppers) that are less, the secondary consumers (carnivores like snakes and lizards) that are lesser and finally the top carnivore, in this case hawks, which are the least in number. So the pyramid is upright in this case as shown in Figure.

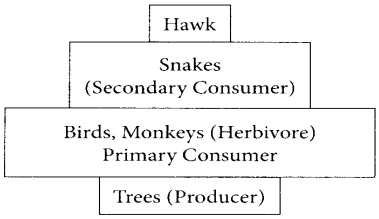






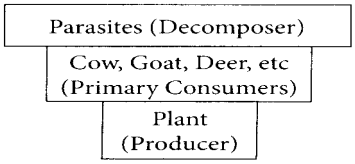
Pyramid of Numbers (Grassland)

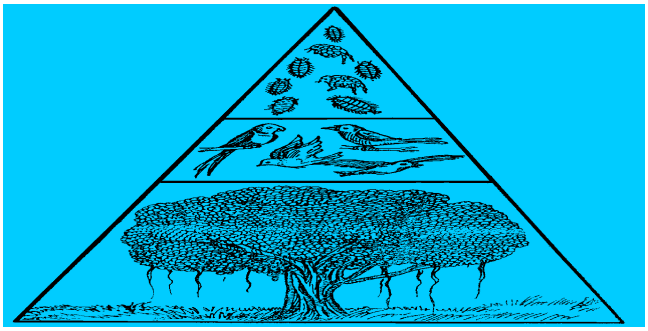
On the other hand, in a forest ecosystem, the producers are big trees on the fruits of which birds and other primary herbivores depend. Thus, the number of primary consumers (birds and monkeys) is always greater than the number of producers (big fruit-bearing trees). Again the number of secondary consumers (carnivores such as snakes and lizards) is less than primary consumers and obviously the number of top (tertiary) carnivores (lions and tigers) is the least. Thus, the shape of the pyramid looks as shown in Figure.



Pyramid of Numbers (Forest Ecosystem)

In case of a parasitic food chain the pyramids are always inverted. This is because a single plant (producer) supports a large number of herbivores (primary consumers). These, in turn, support a large number of parasites. Thus, the ecological pyramid, in this case, is always inverted as shown in Figure.



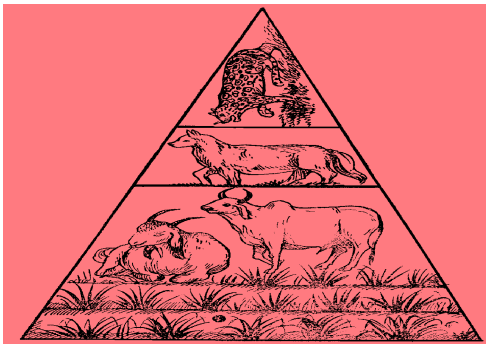


Pyramid of Numbers (Parasitic food chain)

As it is very difficult to count the exact number of all organisms, the pyramid of numbers

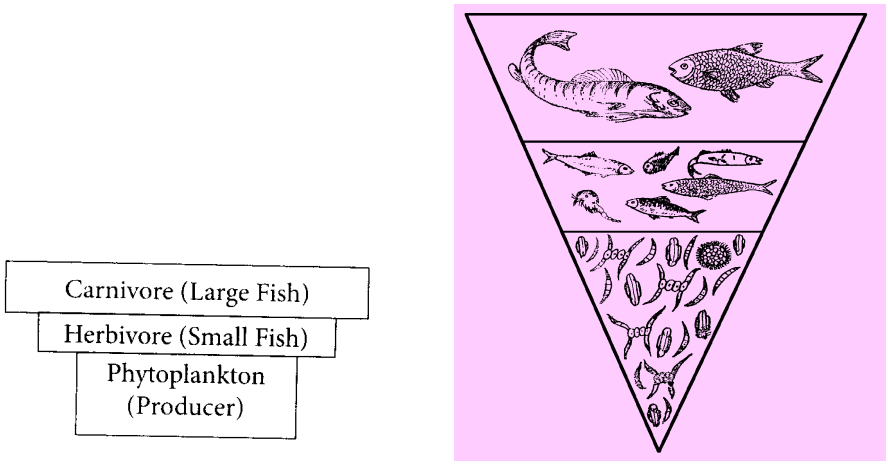
cannot give a true picture of the trophic structure for an ecosystem. They generally vary with different communities having different types of food chains in the same ecosystem.

7.5.2 Pyramid of Biomass: In this concept, the individual in each trophic level is weighed instead of being counted. Thus, in a pyramid of biomass the total weight of each trophic level is represented. For most of the ecosystems on land (for example, forest and grassland), the biomass of producers is large (the base of the pyramid) and it gradually decreases with each successive layer resulting in an upright pyramid as shown in Figure.



Pyramid of Biomass

In the case of a pond ecosystem, the producers are tiny phytoplanktons which grow and reproduce rapidly. These phytoplanktons are consumed as fast as they reproduce (only survivors). In this case, the biomass of the consumer at any instant is more than the producer biomass. Thus, in the case of a pond or any aquatic ecosystem, the pyramid of biomass has an inverted shape as shown in

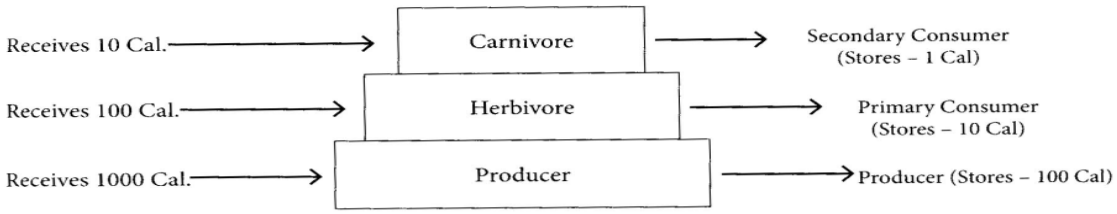


Pyramid of Biomass of an Aquatic Ecosystem

7.5.3 Pyramid of Energy: The pyramid of energy actually depicts the rate at which the food mass is passed through the food chain. It is based on the actual amount of energy that individuals take in, how much is burnt up in the metabolism, how much remains in the waste products and how much they store in the body tissue; this is a reflection of the laws of thermodynamics. Thus, the energy pyramid gives the best picture of the overall nature of the

ecosystem. The actual amount of energy content in successive trophic levels from the producer to various consumers decreases. Hence, the shape of energy pyramid is always upright.

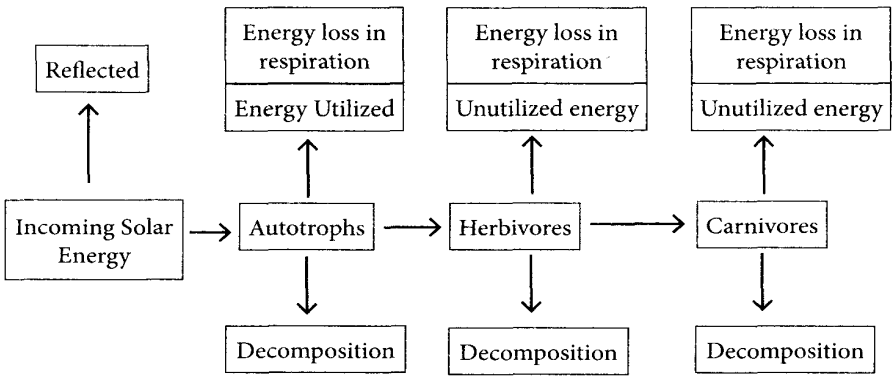
For example, a forest ecosystem receives 1,000 calories of sunlight in a day of which about 100 calories are stored in the plant. When any herbivore (primary consumer such as a deer or a goat) eats the plant, it receives 100 calories. But after its expenditure, its own metabolism lets it store 10 calories of energy. Thus, any carnivore (secondary consumer) eating the above herbivore will receive 10 calories. It can store one calorie of energy after its expenditure for metabolism. Thus, the energy pyramid looks as shown in Figure.



Pyramid of Energy in an Ecosystem

7.6 Energy Flow

It is clear from the food chains that the solar energy which is converted by the autotrophs to chemical energy as carbohydrates, fats and proteins, is transferred to herbivores then to different carnivores and finally to the decomposer level. Decomposers (bacteria, fungi, and microbes) break it into a simpler form which is used as nutrients by the autotrophs. Thereby a complete cycle of the essential nutrients takes place. But the energy does not cycle in the ecosystem rather its flow is unidirectional. According to the first law of thermodynamics, "The total energy of the universe is constant although it can be transferred from one form to another.' That means energy can neither be created nor destroyed only its inter-conversion is possible. The solar energy trapped by plants is transmitted to herbivores grazing on them followed by the carnivores eating the herbivores and finally to the micro-consumers (bacteria, fungi and microbes). In each trophic level there is a loss of energy during transfer. So the top-level consumer does not get the total amount of energy trapped by the autotroph but only 10 per cent of it.



Flow of Energy in an Ecosystem

The dissipation of energy during its transmission from one trophic level to another is in agreement with the second law of thermodynamics which states that 'Processes occur spontaneously only if the sum total of the entropy of the system and its surrounding increases.' In other words, processes involving energy transformation will occur spontaneously if energy degradation takes place from a non-random to a random form of heat energy. From Fig. 3.10 it can be inferred that:

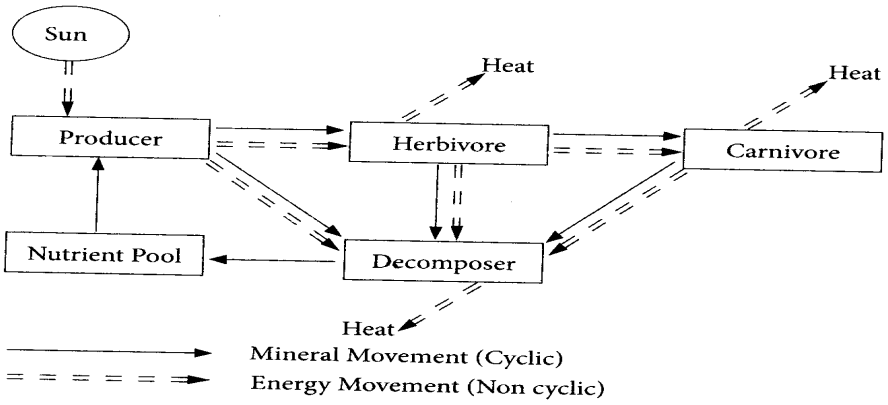
(i) Flow of energy is unidirectional. The solar energy trapped by an autotroph cannot revert to solar input. (ii) Energy passes from herbivore to carnivore not vice versa.

(iii) Due to this unidirectional energy flow, the ecosystem can maintain its entity and prevent the collapse of the system (as shown in Fig. 3.11).

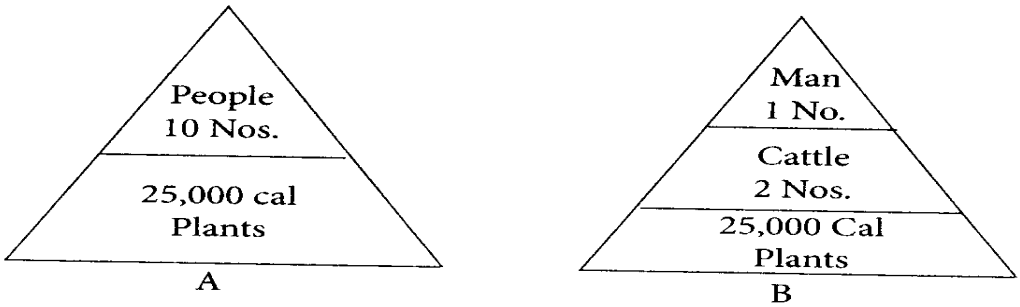
Thus, in an ecosystem there is:

(i) Transfer of materials by cycling in a food chain without any loss of nutrients. (ii) Unidirectional flow of energy with its dissipation to the surroundings.

(iii) As the amount of energy available to the top carnivores is extremely small, organisms nearer the producers get more. Thus, a shorter food chain will support more numbers as shown in Fig. 3.12.



Flow Chart of Energy Mineral Movement in the Ecosystem of Organisms



Relative Efficiency of Vegetarian and Non-Vegetarian Diets

7.7 Balance of Nature

In an ecosystem the component parts like food chains, material cycling and energy flow are closely interrelated to different living organisms thereby maintaining a dynamic equilibrium amongst them. A fluctuation in any of its parameters will disturb the equilibrium and try to affect the total balance of nature. The science of systems of control in an ecosystem is known as cybernetics.

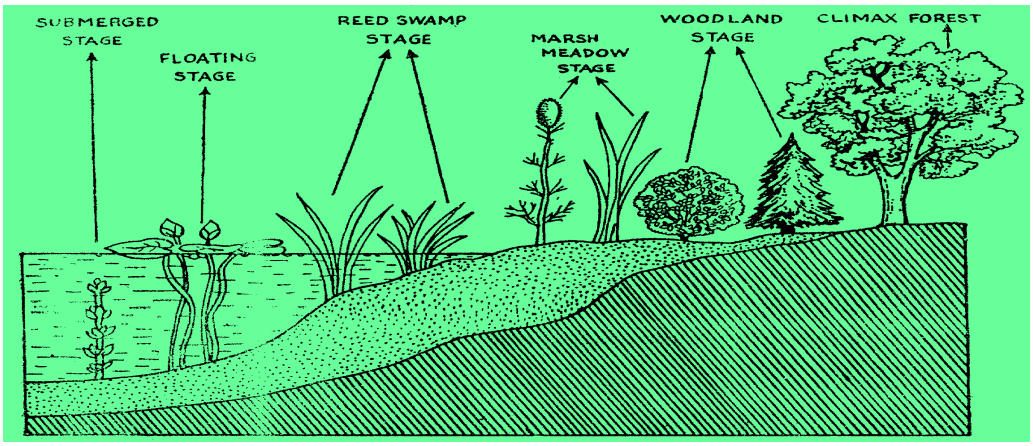
For example, in a forest, the population of carnivorous animals (lions and tigers), herbivorous animals (deer and rabbits) and autotrophs (food for herbivores) are interdependent on each other and maintain a dynamic equilibrium. An increase in the population of lions or tigers (carnivorous) will decrease the population of the herbivores such as, deer, rabbits, buffaloes and so on. As a result, the lion or tiger community will suffer from shortage of food and would either die or migrate to other areas. Ultimately the decrease in herbivore population will decrease the number of carnivores of that area. Similarly, if in a forest the population of herbivores increases then they will eat away more of the grasslands (autotrophs) making the forest an open land. Consequently, the herbivores will face food shortage and will migrate away. This in turn will affect the carnivore community as well. Hence, nature always tries to maintain the balance of the ecosystem for the maintenance of its diversity of species. Different material cycles, namely the oxygen cycle, carbon cycle, nitrogen cycle and water cycle operate in nature due to the interactions of the biotic and abiotic components of the ecosystem and thereby help to maintain the balance of nature. The tendency of the ecosystem to undo the stress and maintain the balance of nature is known as homeostasis. Development of science and technology along with population explosion has resulted in increased human interference with nature. Consequently, the balance of nature is under stress and its dynamic equilibrium is being disturbed.

7.8 Succession and Evolution of the Ecosystem

The conversion of a pond to a deciduous forest through various stages such as the development of mesic community, terrestrial community, scrubland and so on or generation and growth of different biospecies in an exposed parent rock are examples of evolution and succession in an ecosystem. So, ecological succession can be denned as a change of community over time, with modification of the physical environment.

Ecological succession is a two-step process. First, with the modification of the physical environment one community, mainly autotrophs, tries to survive in the most unfavourable environment, such as an open rock, sand dunes, or an aquatic system.

Evolution of a species for the first time in a sterile area is known as primary succession. The first community is always autotrophic and is usually known as the pioneer community as its evolution occurs in a purely inorganic environment. The continuance of the life cycles of the pioneer community makes the environment rich in organic matter which helps the succession of the second community. As a lot of organic matter is available (sewage bed, organic waste), the secondary succession is mainly heterotrophic.



The succession process continues till a stable community is developed. The transitional series of communities which develop during succession are called seres or serai stages while the stable community that develops finally is called climax community which is mostly a deciduous forest.

The major terrestrial communities are different types of forests namely, moist tropical forest, montane subtropical forest, montane temperate forest, rain forest, deciduous forest, coniferous forest and so on. The major aquatic communities are inland water bodies, oceans, estuaries and so on.

Both terrestrial and aquatic communities show abundant biodiversity, depending on the variation of the environment. In an aquatic system, biodiversity depends on the variation of salinity of waters.

7.9 Different Ecosystems

Ecosystems can be defined as the structural and functional unit of ecology. Our earth is a giant ecosystem where abiotic and biotic components are constantly interacting with each other bringing structural and functional changes in it. Due to the vastness, it is subdivided into units of smaller ecosystems like:

(i) Terrestrial ecosystems such as forest, grassland, desert.

(ii) Man-Engineered ecosystems such as cropland. (iii) Aquatic ecosystems such as freshwater, marine water.

These unit ecosystems are open systems with no constraints of boundaries and with constant interaction between biotic and abiotic components.

7.9.1 Forest Ecosystem

The forest as an ecosystem contains interacting biological communities (vegetation) and faunal communities which together interact with the physical environment resulting in an integrated structure. It is always the vegetation which forms the base of the food chain.

According to the forest survey report of 1993, about 19.5 per cent of the total geographical

area of India is under forest cover. Depending on factors such as annual rainfall, its distribution over the year, mean monthly temperature, total annual dry and wet period and relative humidity, the Indian forest can be classified into 16 different types. However, the different components of all forest ecosystems are the same.

Abiotic Component: All inorganic, organic (litters, debris) substances present in the environment and minerals present in the forest constitute the abiotic components. Mainly, the amount of sunlight depends on the stratification condition of the trees.

Biotic Component: The biotic component consists of all living components of the environment which constitute producers, consumers and decomposers.

Producers: The vegetation of the forest is the producer. The term vegetation includes big trees, medium-sized bush and small herbaceous plants. All vegetation contains chlorophyll and performs photosynthesis. The herbaceous vegetation contains maximum green photosynthetic tissues, produces the maximum and being annual, it also decomposes very fast. Thus, herbaceous vegetation contributes to the nutrient cycling and boosts the production in forests.

Consumers:

Primary Consumer: Insects like ants, beetles, flies, spiders, birds and other herbivores such as deer, squirrels, shrews, mongooses and elephants graze over the primary producer and convert it into secondary production. Thus, herbivores are the links between the primary producer and the carnivores.

Secondary Consumer: Carnivorous animals such as snakes, birds, fox and jackal which are the predators of herbivores come under this category. These animals regulate the population size of herbivores and thereby their grazing activity. In this way, the base of the food chain is maintained.

Tertiary Consumers: These are top carnivores, such as lions, tigers and hawks that feed on secondary consumers. Thus, there exists a complete balance between different groups of animals and plants and the forest ecosystem is naturally conserved. When there is a loss of this balance (biodiversity), the destruction of the forest begins.

Decomposers: These organisms remain confined to the soil of the forest floor and have the capacity to degrade all dead plants, herbivore and carnivore tissue to release nutrients into the soil. These nutrients are again used by the producer. A wide variety of micro-organisms such as fungi, bacteria, mites, nematodes, protozoa and earthworms are present in the forest soil to

perform the role of decomposers. The rate of decomposition is more rapid in tropical and subtropical forests than in a temperate one. Thus, decomposers act as scavengers of the forest, have links with all groups of plants and animals and help in recycling the nutrients.

7.9.2 Grassland Ecosystem

Continental interiors, especially in temperate regions with low rainfall are dominated by grasses. Grasslands come under the terrestrial ecosystem and occupy about 19 per cent of the earths total surface. The abiotic and biotic components of a grassland ecosystem are described as follows:

(i) **Abiotic Component:** The nutrients of the environment, such as C, H, 0, N, P, S and so on are supplied by carbon dioxide, water, nitrates, phosphates and sulphates present in the air and soil of the area.

(ii) **Biotic Component:** The biotic component consists of the following:

Producers:

These are mainly grasses, a few forbs (herbaceous flowering plants) and shrubs that contribute to primary production.

Consumers:

Primary Consumers: Herbivores such as bison, antelope, cattle and rodents feed on grasses and insects such as leptocorisa, dysdercus, cicineella, some termites and milllipedes feed on leaves of grasses.

Secondary Consumers: These are carnivores such as foxes, jackals, snakes, frogs, lizards and prairie dogs that feed on herbivores, the primary consumers.

Tertiary Consumer: Birds such as hawks feed on secondary consumers in a grassland ecosystem.

Decomposers: Microbes, some bacteria, actinomycetes and fungi such as mucor, aspergillus, penicillium and rhizopus become active in the decay of dead organic matter and bring back the minerals/nutrients to the soil. This soil is rich in mineral content and is useful for farming.

7.9.3 Desert Ecosystem

Continental interiors with very low sporadic rainfall and with low humidity are converted to deserts. The sun's rays easily penetrate the atmosphere making the ground temperature very high during the day. The nights are very cold. The species composition is quite varied because of the extreme climatic condition.

Biotic Components : The biotic component consists of the following:

Producers: Drought-resistant vegetation like euphorbias, sage bush and cacti are common here. Lower plants such as lichens and xerophytic mosses may also thrive in an oasis area.

Consumers: *A* large number of nocturnal animals, mainly various reptiles and insects are seen here. Some birds and camels that feed on shoots of plants are also present here.

Decomposers: A few fungi and thermophillic bacteria are present in this ecosystem. As the vegetation is less, the decay is also less and is managed by these decomposers.

Aquatic Ecosystem

About 70 per cent of the earths total surface is under the aquatic ecosystem. An aquatic ecosystem can be freshwater, marine or estuarine ecosystem. Thus, a wide variety of species are found in the aquatic ecosystem.

7.9.4 Freshwater ecosystem: A freshwater ecosystem is of two types:

Lotic: Having flowing water. For example, freshwater streams, springs, rivulets, brooks, rivers and so on.

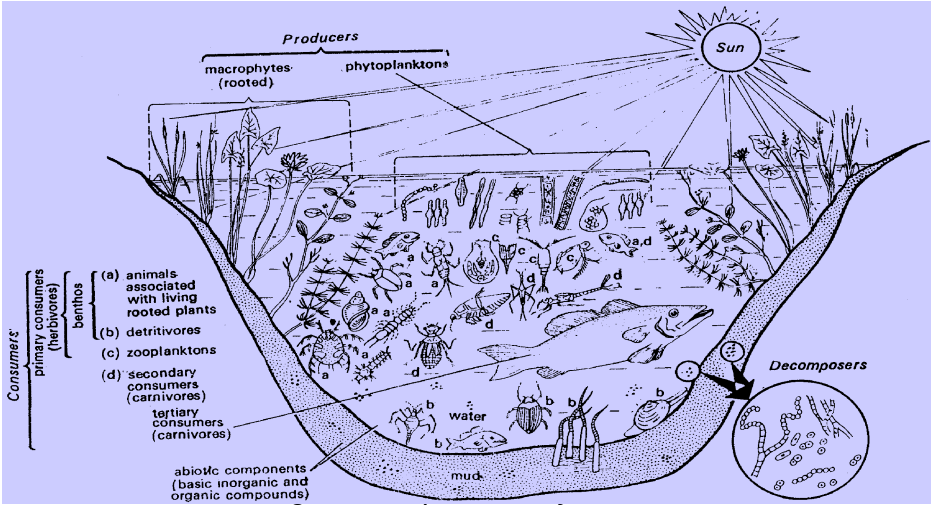
Lentic: Having stagnant or still water, for example, ponds, swamps, bogs and lakes besides others. Lotic water bodies usually start from narrow springs and waterfalls and tend to broaden and become deep and slow-moving. So, in the upstream only those organisms are available which can maintain their position in the fast flowing water and can adhere to an exposed surface. Adhering organisms associated with large aquatic plants are known as periphyton. The main producers of the lotic system are algae and the organic matter brought in from the surrounding terrestrial ecosystem. Consumers are fishes like trout and salmon found upstream and carp and catfish found downstream. Thus, the nutrient level is always higher downstream.

Lentic water bodies include ponds, swamps and lakes. Being a still water system they vary widely in chemical, physical and biological characteristics. Lentic water bodies are considered to have three zones namely littoral, limnetic and profundal.

The littoral zone extends from the shore line to the innermost rooted plants and is dominated by floating vegetation rooted at the bottom (for example, reed, cattail and water lilies). Frogs, snails, snakes and a large number of adult insects and their larvae are found here.

The limnetic zone is the zone of open water down to the depth where light penetrates. Phytoplanktons such as diatoms, green, blue-green algae, zooplanktons from protozoan to micro-arthropods, fish, amphibians, the nekton and larger insects are available in this region.

The profundal zone is present below the limnetic zone. This zone gets food from the limnetic zone and consists mainly of decomposers. The nekton in this zone varies with temperature and nutrient condition. The components of a still water body like a pond (freshwater ecosystem) are self-regulating and self-sufficient. The components of an aquatic system may be classified into two types, biotic and abiotic.



(i) **Abiotic Component:** Abiotic components in this case are carbon dioxide, oxygen, calcium, nitrogen, phosphorous, amino acids and water.

(ii) **Biotic Component:** The biotic component consists of the following:

Producers: The autotrophic green plants and some photosynthetic bacteria fix the radiant energy with the help of nutrients obtained from the mud of the pond.

Consumers:

Primary Consumers: Herbivores like zoo plankton and small invertebrates such as copepods feed on the producers.

Secondary Consumers: Small carnivores like small fishes feed on primary consumers. *Tertiary Consumers:* Large fishes that feed on the small fishes are the tertiary consumers.

Decomposers: Finally, bacteria and fungi present at the base of the pond decompose the organisms and help in the release and recycling of nutrients.

7.9.5 ESTUARINE ECOSYSTEM: Coastal bays, river mouths and tidal marshes form estuaries. Here, freshwater from the rivers mixes with the ocean water. The degree of salinity depends upon the amount of freshwater flow and tidal inflow. Estuaries are more productive than adjacent rivers or oceans due to the high concentration of the nutrients received from land as well as the sea. Rooted plants are supported in shallow water of lesser salinity than the sea.

Organisms present in estuaries are those which are capable of tolerating fluctuation in the salinity of water. Some oysters, crabs and sea shrimps are found here. Estuaries contain producers, such as seaweed, marsh gases, benthic algae and phytoplanktons. They are also used as nurseries by deep-water fishes to bring up their younger ones.

7.10 SELF ASSESSMENT QUESTIONS

1. Write a detailed note on the functional components of an ecosystem.
2. Describe the fundamental role of producers, consumers and decomposers in an ecosystem.
3. What is an ecological pyramid? Differentiate between pyramids of number, biomass and energy.
4. Describe your concept of ecological succession.
5. Describe forest ecosystem.
6. What is a food chain? Describe its role in the ecosystem.
7. Write a note on grassland ecosystem.
8. Describe aquatic ecosystem giving special emphasis on ocean ecosystem.

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Dr. A.V.V.S. Swamy

UNIT – IV: ENVIRONMENTAL POLLUTION

LESSON : 8

TYPES OF POLLUTION

8.0 Objective

After studying this lesson, the student will be able to understand Types of Pollution – Air Pollution, Water Pollution, Soil Pollution, Marine Pollution, Noise Pollution and Nuclear Pollution

Structure

8.1 Introduction

Environmental Pollution is the effect of undesirable changes in our surroundings that have harmful effects on plants, animals and human beings. This occurs when only short-term economic gains are made at the cost of long-term ecological benefits for humanity. No phenomenon has led to greater ecological changes than has been made by mankind. During the last few decades we have contaminated our air, water and land on which life itself depends with a variety of waste products.

Pollutants include solid, liquid or gaseous substances present in greater than natural abundance, produced due to human activity, which have a detrimental effect on our environment.

An average human requires about 12 kg of air each day, which is nearly 12-15 times greater than the amount of food we eat. So, even a small concentration of pollutants in the air becomes more significant in comparison to similar levels present in food. Pollutants that enter water have the ability to spread to distant places, especially in the marine ecosystem. From an ecological perspective, pollutants can be classified as follows:

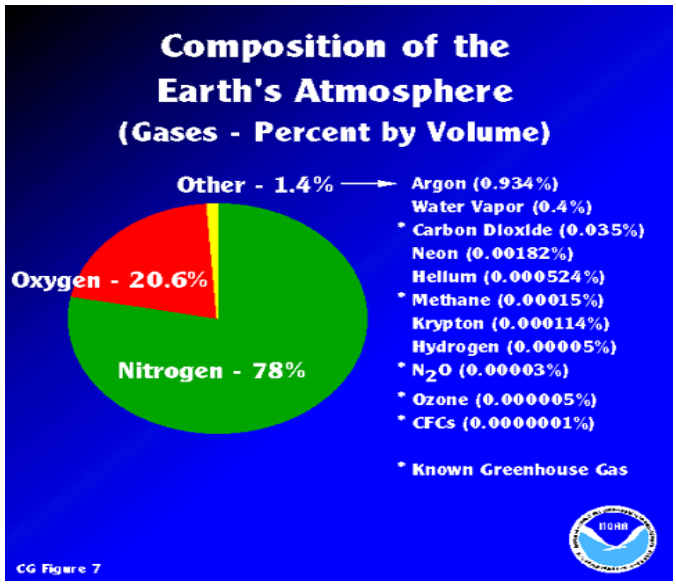
Degradable or non-persistent pollutants: These can be rapidly broken down by natural processes; e.g. domestic sewage, discarded vegetables, etc.

Slowly-degradable or persistent pollutants: These are pollutants that remain in the environment for many years in an unchanged condition and take decades or longer to degrade; e.g., pesticides and most plastics.

8.2 Air Pollution

Air pollution occurs due to the presence of undesirable solid or gaseous particles in the air, in quantities that are harmful to human health and the environment. The air may become polluted by natural causes such as volcanoes, which release ash, dust, sulphur and other gases, or by forest fires that are occasionally naturally caused by lightning. However, unlike pollutants from

human activity, naturally-occurring pollutants tend to remain in the atmosphere for a short time and do not lead to permanent atmospheric change.



8.2.1 Structure of the atmosphere

The atmosphere is normally composed of 79% nitrogen, 20% oxygen and 1% as a mixture of carbon dioxide, water vapor and trace amounts of several other gases such as neon, helium, methane, krypton, hydrogen and xenon. The general structure of the atmosphere has several important features that have relevance to environmental problems. The atmosphere is divided into several layers. The innermost layer, the troposphere, extends 17 km above sea level at the equator and about 8 km over the poles. It contains about 75% of the mass of the Earth's air. Temperature declines with altitude in the troposphere. At the top of the troposphere, temperatures abruptly begin to rise. This boundary where this temperature reversal occurs is called the **'tropopause'.** Stratosphere is the second layer of the atmosphere. The stratosphere extends from 17-48 km above the Earth's surface. While the composition of the stratosphere is similar to that of the troposphere, it has two major differences. The volume of water vapor here is about 1000 times less, while the volume of ozone is about 1000 times greater. The presence of ozone in the stratosphere prevents about 99% of the Sun's harmful ultraviolet (UV) radiation from reaching the Earth's surface, thereby protecting humans from cancer and damage to the immune system. This layer does not have clouds and, hence, airplanes fly in this layer as it creates less turbulence. Temperature rises with altitude in the stratosphere, until there is another reversal. This point is called the **'tropopause'** and it marks the end of the stratosphere.

In the next layer, the **mesosphere**, the temperature decreases with altitude, falling up to -110°C at the top. Above this is a layer where ionization of the gases is a major phenomenon, thus increasing the temperature. This layer is called the *thermosphere.* Only the lower troposphere is routinely involved in our weather and, hence, air pollution. The other layers are not significant in determining the level of air pollution.

Pollutants that are emitted directly from identifiable sources are produced both by natural events (e.g., dust storms and volcanic eruptions) and human activities (emission from vehicles,

industries, etc.). These are called *primary pollutants.* There are five primary pollutants that together contribute to about 90% of the global air pollution. These are carbon oxides (CO and *COx),* nitrogen oxides, sulfur oxides, volatile organic compounds (mostly hydrocarbons), and suspended, particulate matter.

The pollutants that are produced in the atmosphere when certain chemical reactions take place among the primary pollutants are called *secondary pollutants;* e.g., sulfuric acid, nitric acid, carbonic acid, etc.

Carbon monoxide is a colorless, odorless and toxic gas produced when organic materials, like natural gas, coal or wood, are incompletely burnt. Vehicular exhausts are the single largest source of carbon monoxide. The number of vehicles has been increasing over the years all over the world. Many vehicles are also poorly maintained and several have inadequate pollution control equipment resulting in the release of greater amounts of carbon monoxide. However, carbon monoxide is not a persistent pollutant. Natural processes can convert carbon monoxide to other compounds that are not harmful. Therefore, the air can be cleared of its carbon monoxide if no new carbon monoxide is introduced into the atmosphere.

Air Pollution

Sulfur oxides are produced when sulfur containing fossil fuels are burnt.

Nitrogen oxides are found in vehicular exhausts. Nitrogen oxides are significant, as they are involved in the production of secondary air pollutants such as ozone.

Hydrocarbons are a group of compounds consisting of carbon and hydrogen atoms. They either evaporate from fuel supplies or are remnants of fuel that did not burn completely. Hydrocarbons are washed out of the air when it rains and run into surface water. They cause an oily film on the surface and do not as such cause a serious issue until they react to form secondary pollutants. Using higher oxygen concentrations in the fuel-air mixture, using valves to

prevent the escape of gases, and fitting of catalytic converters in automobiles, are some of the modifications that can reduce the release of hydrocarbons into the atmosphere.

Particulates are small pieces of solid material (e.g., smoke particles from fires, bits of asbestos, dust particles and ash from industries) dispersed into the atmosphere. The effects of particulates range from soot to the carcinogenic (cancer-causing) effects of asbestos, dust particles and ash from industrial plants that are dispersed into the atmosphere. Repeated exposure to particulates can cause them to accumulate in the lungs and interfere with the ability of the lungs to exchange gases.

Types of particulates

Term	Meaning	Examples
Aerosol	General term for particles suspended in air	Sprays from pressurized cans
Mist	Aerosol consisting of liquid droplets	Sulfuric acid mist
Dust	Aerosol consisting of solid particles that are blown into the air or are produced from larger particles by grinding them down	Dust storm
Smoke	Aerosol consisting of solid particles or a mixture of solid and liquid particles produced by chemical reaction such as fires	Cigarette smoke, smoke from burning garbage
Fume	Generally means the same as smoke but often applies specifically to aerosols produced by condensation of hot vapors of metals.	Zinc/lead fumes
Plume	Geometrical shape or form of the smoke coming out of a chimney	
Fog	Aerosol consisting of water droplets	
Smog	Term used to describe a mixture of smoke and fog.	

Lead is a major air pollutant that remains largely unmonitored and is emitted by vehicles. High lead levels have been reported in the ambient air in metropolitan cities. Leaded petrol is the primary source of air-borne lead emissions in Indian cities. The use of unleaded petrol is one way of reducing this pollutant.

Pollutants are also found indoors from the infiltration of polluted outside air and from various chemicals used or produced inside buildings. Both indoor and outdoor air pollution are equally harmful.

8.2.2 Effects of air pollution on living organisms:

Our respiratory system has a number of mechanisms that help in protecting us from air pollution. The hair in our nose filters out large particles. The sticky mucus in the lining of the upper respiratory tract captures smaller particles and dissolves some gaseous pollutants. When the upper respiratory system is irritated by pollutants, sneezing and coughing expel the contaminated air and mucus. Ptulonged smoking or exposure to air pollutants can overload or

breakdown these natural defenses causing or contributing to diseases such as lung cancer, asthma, chronic bronchitis and emphysema. Elderly people, infants, pregnant women and people with heart disease, asthma or other respiratory diseases are especially vulnerable to air pollution.

Sulfur dioxide irritates the respiratory tissues; chronic exposure to it causes a condition similar to bronchitis. It also reacts with water, oxygen and other material in the air to form sulfur-containing acids. The acids can become attached to particles which, when inhaled, are very corrosive to the lungs.

Nitrogen oxides, especially NOx can irritate the lungs, aggravate asthma or chronic bronchitis and also increase our susceptibility to respiratory infections, like influenza or common colds.

Suspended particles in the air aggravate our respiratory tract, leading to bronchitis and asthma. Prolonged exposure to these particles damages lung tissue and contributes to the development of chronic respiratory disease and cancer.

Many volatile organic compounds (e.g., benzene and formaldehyde) and toxic particulates (e.g., lead and cadmium) can cause mutations, reproductive problems or cancer. The repeated inhalation of ozone, a component of photochemical smog, causes coughing, chest pain, breathlessness and irritation of the eye, nose and the throat.

8.2.3 Effects on plants

When some gaseous pollutants enter the leaf pores they damage the leaves of crop plants. Chronic exposure of the leaves to air pollutants can break down the waxy coating that helps prevent excessive water loss and leads to damage from diseases, pests, drought and frost. Such exposure interferes" with photosynthesis and plant growth, reduces nutrient uptake and causes the leaves to turn yellow, brown or drop off altogether. At a higher concentrations of sulfur dioxide, most of the flower buds become stiff and hard. They eventually fall off from the plants, as they are unable to flower.

Prolonged exposure to high levels of several air pollutants from iron smelters, coal-burning power plants and industrial units, as well as from vehicles, can damage trees and other plants.

8.2.4 Effects of air pollution on materials

Every year, air pollutants cause damage worth billions of rupees. Air pollutants break down the exterior paint on cars and houses. All over the world, air pollutants have discolored irreplaceable monuments, historic buildings, marble statues, and other heritage and natural beauty sites.

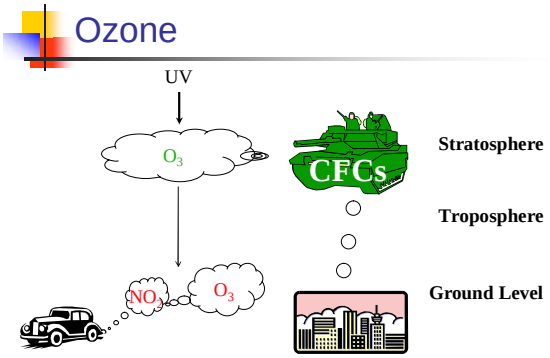
8.2.5 Ozone depletion:

Changes in the ozone layer have serious implications for mankind.

Effects on human health: Sunburn, cataract, aging of the skin and skin cancer are caused by increased UV radiation. It weakens the immune system by suppressing the body's resistance to certain infections like measles, chickenpox and other viral diseases that elicit rash and parasitic diseases such as malaria introduced through the skin.

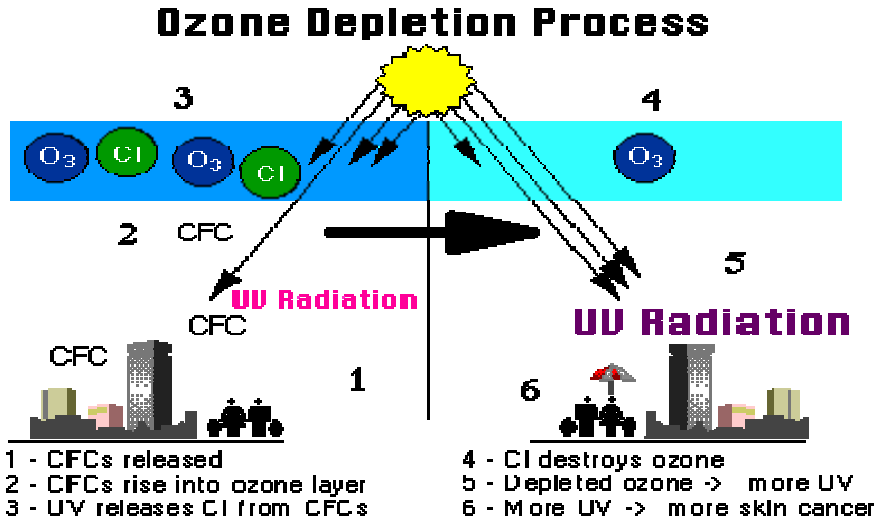
***Food production**:* UV radiation affects the ability of plants to capture light energy during the process of photosynthesis. This reduces the nutrient content and the growth of plants; this is especially seen in the case of legumes and cabbage.

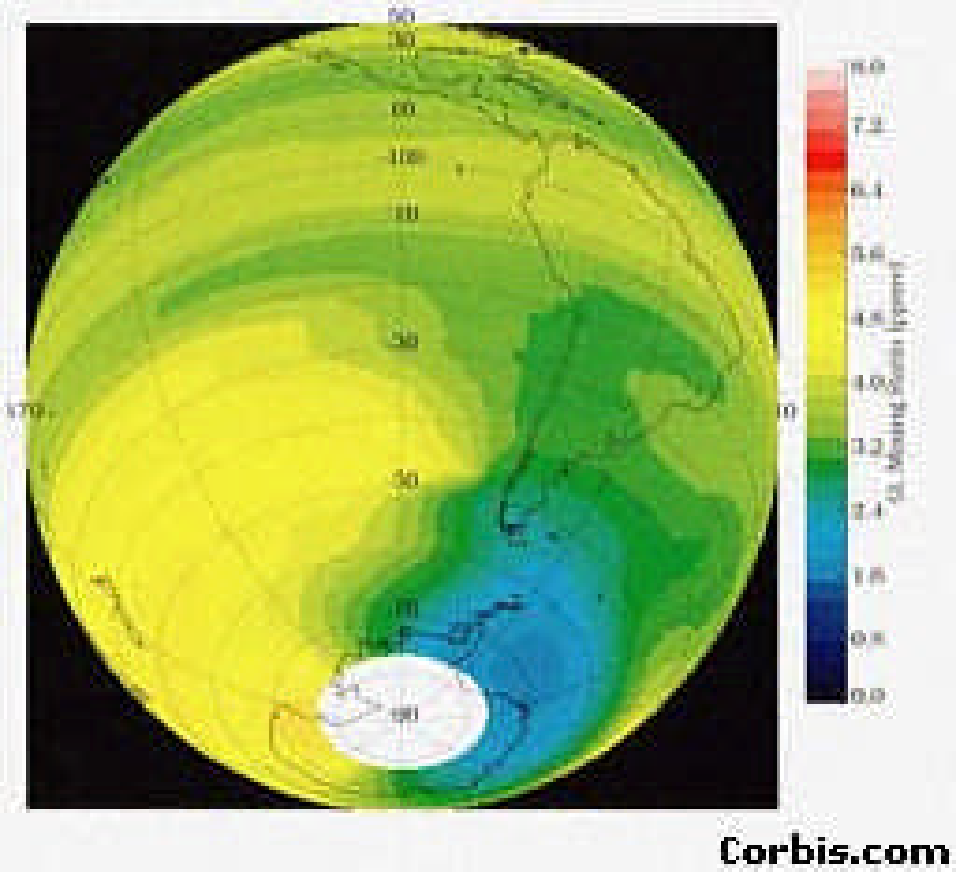
Plant and *animal* planktons are damaged by UV radiation. In zooplanktons (microscopic animals), the breeding period is shortened by changes in radiation. As planktons form the basis of the marine food chain, any change in their number and species composition influences fish and shellfish production.



Effect on climate: Atmospheric changes induced by pollution contribute to *global warming,* a phenomenon which is caused due to the increase in concentration of certain gases like carbon dioxide, nitrogen oxides, methane and CFCs.

Observations of the Earth have shown beyond doubt that atmospheric constituents like water vapor, carbon dioxide, methane, nitrogen oxides and CFCs trap heat in the form of infra-red (IR) radiation near the Earth's surface. This is known as the 'Greenhouse Effect'. The phenomenon is similar to what happens in a greenhouse. The glass in a greenhouse allows solar radiation to enter, which is absorbed by the objects inside. These objects radiate heat in the form of terrestrial radiation, which does not pass out through the glass.





The heat is, therefore, trapped in the greenhouse increasing the temperature inside and ensuring the luxuriant growth of plants.

8.2.6 Control measures for air pollution

Air pollution can be controlled by two fundamental approaches: preventive techniques and effluent control.

One of the effective means of controlling air pollution is to have proper equipment in place. This includes devices for removal of pollutants from the flue gases though scrubbers, closed-collection recovery systems (through which it is possible to collect the pollutants before they escape), the use of dry and wet collectors, filters, electrostatic precipitators, etc.

Building higher smoke-stacks facilitates the discharge of pollutants as far away from the ground as possible. Industries should be carefully located so as to minimize the effects of pollution after considering the topography and the wind directions. The substitution of raw materials that cause more pollution with those that cause less pollution will also help.

8.3 Water Pollution

Introduction: Water is the essential element that makes life on Earth possible. Without water there would be no life. We usually take water for granted. It flows from our taps when they are turned on; most of us are able to bathe when we want to, swim when we choose and water our gardens. Like good health we ignore water when we have it.

Although 71% of the Earth's surface is covered by water, only a tiny fraction of this water is available to us as freshwater. About 97% of the total water available on Earth is found in the oceans and is too salty for drinking or irrigation. The remaining 3% is freshwater. Of this, 2.997% is locked in ice caps or glaciers. Thus, only 0.003% of the Earth's total volume of water is easily available to us as soil moisture, groundwater, water vapor and the water in lakes, streams, rivers and wetlands.

When the quality or composition of water changes directly or indirectly as a result of man's activities such that it becomes unfit for any purpose it is said to be polluted.

8.3.1 Sources of water pollution:

Point sources of pollution: When a source of pollution can be readily identified because it has a definite source and place where it enters the water it is said to come from a point source, e.g., municipal and industrial discharge pipes.

When a source of pollution cannot be readily identified, such as agricultural runoff, acid rain, etc., they are said to be non-point ascertain amount of organic matter is called the biological oxygen demand (BOD). The amount of BOD in the water is an indicator of the level of pollution. If too much organic matter is added to the water, all the available oxygen is used up. This causes fish and other forms of oxygen-dependent aquatic life to die. Thus, anaerobic bacteria (those that do not require oxygen) begin to break down the wastes. Their anaerobic respiration produces chemicals that have a foul odor and an unpleasant taste, which are harmful to human health. The third class of pollutants is inorganic plant nutrients. These are water-soluble nitrates and phosphates that cause the excessive growth of algae and other aquatic plants. This excessive growth due to added nutrients is called eutrophication. This may interfere with the use of the water by clogging up water-intake pipes, changing the taste and smell of the water, and causing a buildup of organic matter. As the organic matter decays, the oxygen levels decrease and fish and other aquatic species die.

The quantity of fertilizers applied in a field is often many times more than is actually required by the plants. The chemicals in fertilizers and pesticides pollute the soil and water. While excess fertilizers cause eutrophication, pesticides cause 'bioaccumulation' and 'biomagnification'. The pesticides that enter water bodies are introduced into the aquatic food chain. They are then absorbed by the phytoplanktons and aquatic plants. These plants are eaten by

A fourth class of water pollutants is water-soluble inorganic chemicals, which are acids, salts and compounds of toxic metals such as mercury and lead. High levels of these chemicals can make the water unfit to drink, harm fish and other aquatic life, reduce crop yields, and accelerate the corrosion of equipment that is in contact with this water.

Another cause of water pollution is a variety of organic chemicals, which includes oil, gasoline, plastics, pesticides, cleaning solvents, detergents and many other chemicals. These are harmful to aquatic life and human health. They enter the water directly from industrial activity, either from improper handling of chemicals in industries and usually from the improper and illegal disposal of chemical wastes.

The sediment of suspended matter is another class of water pollutants. These are insoluble particles of soil and other solids that become suspended in water. This occurs when the soil is eroded from the land. High levels of soil particles suspended in water interfere with the penetration of sunlight. This reduces the photosynthetic activity of aquatic plants and algae, disrupting the ecological balance of the aquatic bodies. When the velocity of water in streams and rivers decreases, the suspended particles settle down at the bottom as sediments. The excessive sediments that settle down destroy the feeding and spawning grounds of fish, clogs and fills lakes, artificial reservoirs, etc.

Water-soluble radioactive isotopes are yet another source of water pollution. These can be concentrated in various tissues and organs as they pass through food chains and food webs. The ionizing radiation emitted by such isotopes can cause birth defects, cancer and genetic damage.

The hot water released by power plants and industries that use large volumes of water to cool the plant, results in a rise in temperature of the local water bodies; thermal pollution occurs due to this. Power plants heat water to convert it into steam, to drive the turbines that generate electricity. To ensure the efficient functioning of the steam turbines, the steam is condensed into water after it leaves the turbines. This condensation is done by taking water from a water body to absorb the heat. This heated water, which is at least 15°C higher than normal, is discharged back into the water body. This warm water not only decreases the solubility of oxygen but changes the breeding cycles of various aquatic organisms.

Oil is washed into the surface water in the run-off from roads and parking lots which also pollutes groundwater. The leakage from underground tanks is another source of pollution. Accidental oil spills from large transport tankers at sea have been causing significant environmental damage.

Though accidents such as the *Exxon Valdez* get worldwide attention, much more oil pollution takes place as a result of small, regular releases from other less visible sources. Nearly two-thirds of all marine oil pollution comes from three sources: run-off from the streets, improper discharge of lubricating oil from machines or automobile crankcases, and intentional oil discharges that occur during the loading and unloading of tankers. Oil tankers often use seawater as ballast to stabilize the ship after they have discharged their oil. This oil-contaminated water is then discharged back into the sea when the tanker is refilled.

8.3.2 Groundwater Pollution*:*

While oil spills are highly visible and often get a lot of media attention, a much greater threat to human life comes from our groundwater, which is used for drinking and irrigation, being polluted. While groundwater is easy to deplete and pollute, it gets renewed very slowly and hence must be used judiciously. Groundwater flows are slow and not turbulent; thus, the contaminants are not as effectively diluted and dispersed as by surface water. Moreover, pumping groundwater and treating it is very slow and costly. So, it is extremely essential to prevent the pollution of groundwater in the first place. Some causes of groundwater pollution

are:

Urban run-off of untreated or poorly treated waste water and garbage Industrial waste storage located above or near aquifers

Agricultural practices such as the application of large amounts of fertilizers and pesticides, animal feeding operations, etc., in the rural sector

Leaks from underground storage tanks containing gasoline and other hazardous substances

8.3.3 Thermal Pollution:

The discharge of warm water into a river is usually called thermal pollution. It occurs when an industry removes water from a source (e.g., a river), uses the water for cooling purposes, and then returns the heated water to its source. Power plants heat water to convert it into steam, to drive the turbines that generate electricity. For efficient functioning of the steam turbines, the steam is condensed into water after it leaves the turbines. This condensation is done by taking water from a water body to absorb the heat. This heated water, which is at least 15°C higher than the normal, is later discharged back into the water body.

Effects: The warmer temperature decreases the solubility of oxygen and increases the metabolism of fish. This changes the ecological balance of the river. Within certain limits, thermal additions can promote the growth of certain fish and the fish catch may be high in the vicinity of a power plant. However, sudden changes in temperature caused by periodic plant shutdowns, both planned and unintentional, can result in the death of these fish that are acclimatized to living in warmer waters.

Tropical marine animals are generally unable to withstand a temperature increase of 2-3°C and most sponges, mollusks and crustaceans are eliminated at temperatures above 37°C. This results in a change in the diversity of fauna, as only those species that can live in warmer water will survive and proliferate excessively.

Control measures*:* Thermal pollution can be controlled by passing the heated water through a cooling pond or a cooling tower after it leaves the condenser. The heat is dissipated into the air and the water can then be discharged into the river or pumped back to the plant for to be reused for cooling. There are several other ways in which thermal pollution can be reduced. One method is to construct a large shallow pond. Hot water is pumped into one end of the pond and cooler water is removed from the other end. The heat gets dissipated from the pond into the atmosphere. Another method is to use a cooling tower; these structures take up less land area than the ponds. Here, most of the heat transfer occurs through evaporation. The warm water coming from the condenser is sprayed downwards over vertical sheets or baffles, where the water flows in thin films. Cool air enters the tower through the water inlet that encircles the base of the tower and rises upwards, causing evaporative cooling. A natural draft is maintained because of the density difference between the cool air outside and the warmer air inside the tower. The excess heat is dissipated into the atmosphere about 100 m above the base of the tower. The cooled water is collected at the floor of the tower and recycled back to the power plant condensers. The disadvantage in both these methods, however, is that large amounts of water are lost due to evaporation.

8.3.4 Control measures for preventing water pollution

While the foremost necessity is prevention, setting up effluent treatment plants to treat waste can reduce the pollution load in the recipient water. The treated effluent can be reused for either gardening or cooling purposes, wherever possible. A few years ago a new technology, called the Root Zone Process, has been developed by Thermax. This system involves running contaminated water through the root zones of specially-designed reed beds. The reeds, which are essentially wetland plants, have the capacity to absorb oxygen from the surrounding air through their stomatal openings. The oxygen is pushed through the porous stem of the reeds into the hollow roots where it enters the root zone and creates conditions suitable for the growth of numerous bacteria and fungi. These microorganisms oxidize impurities in the wastewaters, so that the water which finally comes out is clean.

8.4 Soil Pollution

Introduction: We can no more manufacture a soil with a tank of chemicals than we can invent a rainforest or produce a single bird. We may enhance the soil by helping its processes along, but we can never recreate what we destroy. The soil is a resource for which there is no substitute. (Environmental historian Donald Worster reminds us that fertilizers are not a substitute for fertile soil).

Land Pollution

The soil is a thin covering over the land consisting of a mixture of minerals, organic material, living organisms, air and water, that together support the growth of plant life. Several factors contribute to the formation of soil from the parent material. This includes the mechanical weathering of rocks due to temperature changes and abrasion, wind, moving water, glaciers, chemical weathering activities, and lichens. Climate and time are also important in the development of soils. In extremely dry or cold climates soils develop very slowly, while in humid

and warm climates soils develop more rapidly. Under ideal climatic conditions, soft parent material may develop into 1 cm of soil within 15 years. Under poor climatic conditions, a hard parent material may require hundreds of years to develop into soil.

Mature soils are arranged in a series of zones called 'soil horizons'. Each horizon has a distinct texture and composition that varies with different types of soils. A cross-sectional view of the horizons in a soil is called a 'soil profile'.

The top layer or the surface litter layer, called the '0-horizon', consists mostly of freshly-fallen and partially-decomposed leaves, twigs, animal waste, fungi and other organic materials. Normally, it is brown or black.

The uppermost layer of the soil, called the 'A-horizon', consists of partially-decomposed organic matter (humus) and some inorganic mineral particles. It is usually darker and looser than the deeper layers. The roots of most plants are found in these two upper layers. As long as these layers are anchored by vegetation, the soil stores water and releases it in a trickle throughout the year instead of in a force like a flood. These two top layers also contain a large amount of bacteria, fungi, earthworms, and other small insects, which form complex food webs in the soil, help recycle soil nutrients, and contribute to soil fertility.

The 'B-horizon', often called the subsoil, contains less organic material and fewer organisms than the A horizon. The area below the subsoil is called the 'C-horizon' and consists of weathered parent material. This parent material does not contain any organic materials. The chemical composition of the C-horizon helps to determine the pH of the soil and also influences the soil's rate of water absorption and retention.

Soils vary in their content of clay (very fine particles), silt (fine particles), sand (medium-size particles) and gravel (course to very coarse particles). The relative amounts of the different sizes and types of mineral particles determine the soil texture. Soils with approximately equal mixtures of clay, sand, silt and humus are called loams.

8.4.1 Causes of soil degradation

Erosion

Soil erosion can be defined as the movement of surface litter and topsoil from one place to another. While erosion is a natural process, often caused by wind and flowing water, it is greatly accelerated by human activities such as farming, construction, overgrazing by livestock, burning of grass cover, and deforestation.

The loss of the topsoil makes a soil less fertile and reduces its water-holding capacity. The topsoil, which is washed away, also contributes to water pollution by clogging lakes and increasing the turbidity of the water, ultimately leading to the loss of aquatic life. For one inch of topsoil to be formed it normally requires 200-1000 years, depending upon the climate and soil type. Thus, if the topsoil erodes faster than it is formed, the soil becomes a non-renewable resource.

Therefore, it is essential that proper soil conservation measures are used to minimize the loss of the topsoil. There are several techniques that can protect the soil from erosion. Today, both water and soil are conserved through integrated treatment methods. The two types of

treatment generally used are:

Area treatment, which involves treating the land, and Drainage-line treatment, which involves treating the natural water courses (no/as).

8.4.2 Area Treatment

Purpose	Treatment Measure	Effect
Reduces the impact of rain drops on the soil	Develop vegetative cover on the non arable land	Minimum disturbance and displacement of soil particles
Infiltration of water where it falls	Apply water infiltration measures on the area	*In-situ* soil and moisture conservation
Minimum surface run-off	Store surplus rain water by constructing *bunds*, ponds in the area	Increased soil moisture in the area, facilitate ground water recharge
Ridge to valley sequencing	Treat the upper catchment first and then proceed towards the outlet	Economically viable, less risk of damage and longer life of structures of the lower catchments

8.4.3 Drainage-line treatment

Purpose	Treatment measure	Effect
Stop further deepening of gullies and retain sediment run-off	Plug the gullies at formation	Stops erosion, recharges groundwater at the upper level
Reduce run-off velocity, pass cleaner water to the downstream side	Create temporary barriers in nalas	Delayed flow and increased groundwater recharge
Minimum sedimentation in the storage basins	Use various methods to treat the catchments	
Low construction cost	Use local material and skills for constructing the structures	Structures are locally maintained

Continuous contour trenches can be used to enhance the infiltration of water, reduce the run-off, and check soil erosion. These are actually shallow trenches dug across the slope of the land and along the contour lines, basically for the purpose of soil and water conservation. They are most effective on gentle slopes and in areas of low to medium rainfall. These *bunds* are stabilized by fast-growing tree species and grasses. In areas with steep slopes where *bunds* are not possible, continuous contour benches (CCBs) made of stones are used for the same purpose.

8.4.4 Problems with pesticide use

Pesticides not only kill the pests but also a large variety of living things, including humans. They may be persistent or non-persistent. Persistent pesticides, once applied, are effective for a long time. However, as they; do not break down easily they tend to accumulate in the soil and in the bodies of animals in the food chain.

For example, DDT, one of the first synthetic organic insecticide to be used, was thought to be the perfect insecticide. During the first ten years of its use (1942-1952), DDT is estimated to have saved about five million lives primarily because of its use to control disease-carrying mosquitoes. Problems with pesticide use

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Other problems associated with insecticides are the ability of insect populations to become resistant to them, thus rendering them useless in a couple of generations. Most pesticides kill beneficial as well as pest species. They kill the predator as well as the parasitic insects that control the pests. Thus, the pest species increase rapidly following the use of a pesticide as there are no natural checks to their population growth. The short-term and the long-term health effects to the persons using the pesticide and the public that consumes the food grown by using the pesticides are also major concerns. Exposure to small quantities of pesticides over several years can cause mutations, produce cancers, etc.

Another way to reduce these impacts is through the use of *integrated pest* management-*(IPM).* This is a technique that uses a complete understanding of all the ecological aspects of a crop and the particular pests to which it is susceptible to establish pest control strategies that uses no or few pesticides. IPM promotes the use of biopesticides. Biopesticides are derived from three sources:

Microbial, botanical and biochemical. Microbial pesticides are microorganisms such as bacteria, fungus, virus or protozoa that fight pests through a variety of ways. They produce toxins specific to the pests and produce diseases in them. Biochemical pesticides contain several chemicals that affect the reproductive and digestive mechanisms of the pests. The most commonly used biopesticides are *Bacillus thurinyensis (Bt),* neem *{Azadirachta indica)* and trichogramma. Although they are available in the market, they are yet to become market favorites.

8.5 Marine Pollution

Marine pollution can be defined as the introduction of substances to the marine environment directly or indirectly by man resulting in adverse effects such as hazards to human health, obstruction of marine activities, and lowering the quality of sea water. While the causes of marine pollution may be similar to that of general water pollution, there are some very specific causes that pollute marine waters.

The most obvious inputs of waste is through pipes directly discharging wastes into the sea. Very often, municipal waste and sewage from residences and hotels in coastal towns are directly discharged into the sea.

Pesticides and fertilizers from agriculture, which are washed off the land by rain, enter water courses and eventually reach the sea.

Petroleum and oils washed off from the roads normally enter the sewage system but storm water overflows carry these materials into rivers and eventually into the seas.

Ships carry many toxic substances such as oil, liquefied natural gas, pesticides, industrial chemicals, etc., in huge quantities sometimes to the capacity of 350,000 t. Ship accidents and accidental spillages at sea can, therefore, be very damaging to the marine environment. Shipping channels in estuaries and at the entrances to ports often require frequent dredging to keep them open. This dredged material that may contain heavy metals and other contaminants is often dumped out at sea.

Offshore oil exploration and extraction also pollute the seawater to a large extent.

8.5.1 Pollution due to organic wastes

The amount of oxygen dissolved in the water is vital for the plants and animals living in it. Wastes, which directly or indirectly affect the oxygen concentration, play an important role in determining the quality of the water. Normally, the greatest volume of waste discharged to water courses, estuaries and the sea is sewage, which is primarily organic in nature and is degraded by bacterial activity. Using the oxygen present in the water, these wastes are broken down into stable inorganic compounds. However, as a result of this bacterial activity the oxygen concentration in the water is reduced. When the oxygen concentration falls below 1.5 mg/l, the rate of aerobic oxidation is reduced and replaced by the anaerobic bacteria that can oxidize the organic molecules without the use of oxygen. This results in end products such as hydrogen sulfide, ammonia and methane, which are toxic to many organisms. This process results in the formation of an anoxic zone which is low in its oxygen content; from which most life disappears except for anaerobic bacteria, fungi, yeasts and some protozoa; and renders the water foul smelling.

Control measures*:* One way of reducing the pollution load on marine waters is through the introduction of sewage treatment plants. This will reduce the biological oxygen demand (BOD) of the final product before it is discharged to the receiving waters. Various stages of treatment such as primary, secondary or advanced can be used, depending on the quality of the effluent that is required to be treated.

Tanker operations Half the world production of crude oil, which is close to three billion tones a year, is transported by sea. After a tanker has unloaded its cargo of oil, it has to take on seawater as ballast for the return journey.

Tanker accidents A large number of oil tanker accidents happen every year. Sometimes this can result in major disasters, such as that of the *Exxon Valdez,* described in the section on water pollution.

8.5.2 Offshore oil production

The oil that is extracted from the seabed contains some water. Even after it is passed through oil separators the water that is discharged contains some oil, which adds to marine pollution. Drilling muds, which are pumped down oil wells when they are being drilled, normally contain 70-80% of oil. They are dumped on the seabed beneath the drilling platform, thus

heavily contaminating the water. In addition, the uncontrolled release of oil from the wells can be catastrophic events resulting in oil pollution.

8.5.3 Control measures for oil pollution*:*

Cleaning oil from surface waters and contaminated beaches is a time-consuming and labor-intensive process. The natural process of emulsification of oil in the water can be accelerated through the use of *chemical dispersants,* which can be sprayed on the oil. A variety of *slick-Uckers* in which a continuous belt of absorbent material dips through the oil slick and is passed through rollers to extract the oil have been designed. Rocks, harbor walls can be cleaned with high-pressure steam or dispersants after which the surface must be hosed down.

8.5.4 Effects of marine pollution*:*

Apart from causing eutrophication a large amount of organic wastes can also result in the development of 'red tides'. These are phytoplankton blooms of such intensity that the whole area is discolored. Many important, commercially-important marine species are also killed due to clogging of gills or other structures.

When liquid oil is spilled on the sea, it spreads over the surface of the water to form a thin film called an *oil slick.* The rate of spreading and the thickness of the film depend on the sea temperature, winds, currents, and the nature of the oil.

Oil slicks damage marine life to a large extent. Salt marshes and mangrove swamps are likely to trap oil and the plants which form the basis for these ecosystems thus suffer. For salt-marsh plants, oil slicks can affect the flowering, fruiting and germination.

Drill cuttings dumped on the seabed create anoxic conditions and result in the production of toxic sulphides in the bottom sediment thus eliminating the benthic fauna.

Fish and shellfish production facilities can also be affected by oil slicks. However, the most important commercial damage can come from 'tainting', which imparts an unpleasant flavor to fish and seafood and is detectable even at extremely low levels of contamination. This reduces the market value of seafood.

8.6 Noise Pollution

Noise may not seem as harmful as the contamination of air or water, but it is a pollution problem that affects human health and can contribute to a general deterioration of environmental quality.

Noise is undesirable and unwanted sound. Not all sound is noise. What may be considered as music to one person may be noise to another! It is not a substance that can accumulate in the environment like most other pollutants. Sound is measured in a unit called the 'decibel' (dB).

There are several sources of noise pollution that contribute to both indoor and outdoor noise pollution. Noise emanating from factories, vehicles, and playing of loudspeakers during various festivals can contribute to outdoor noise pollution, while loudly played radio or music

systems, and other electronic gadgets can contribute to indoor noise pollution. A study conducted by researchers from the New Delhi-based National Physical Laboratory show that noise generated by firecrackers (presently available in the market) is much higher than the prescribed levels. The permitted noise level is 125 decibels, as per the Environment (Protection) (second amendment) Rules, 1999.

The differences between sound and noise is often subjective and a matter of personal opinion. There are, however, some very harmful effects caused by exposure to high sound levels. These effects can range in severity from being extremely annoying to being extremely painful and hazardous.

Decibel levels of common sounds

dB	Environmental Condition
0	Threshold of hearing
10	Rustle of leaves
20	Broadcasting studio
30	Bedroom at night
40	Library
50	Quiet office
60	Conversational speech (at 1m)
70	Average radio
74	Light traffic noise
90	Subway train
100	Symphony orchestra
110	Rock band
120	Aircraft takeoff
146	Threshold of pain

8.6.1 Effects of noise pollution on physical health

The most direct harmful effect of excessive noise is physical damage to the ear and the temporary or permanent hearing loss often called a 'temporary threshold shift' (TTS). People suffering from this condition are unable to detect weak sounds. However, hearing ability is usually recovered within a month of exposure. In Maharashtra, people living in close vicinity of Ganesh *mandals* that play blaring music for ten days of the Ganesh festival are usually known to suffer from this phenomenon. Permanent loss, usually called 'noise-induced permanent threshold shift' (NIPTS) represents a loss of hearing ability from which there is no recovery.

Below a sound level of 80 dB hearing loss does not occur at all. However, temporary effects are noticed at sound levels between 80 and 130 dB. About 50% of the people exposed to 95 dB sound levels at work will develop NIPTS and most people exposed to more than 105 dB will experience permanent hearing loss to some degree. A sound level of 150 dB or more can physically rupture the human eardrum.

The degree of hearing loss depends on the duration as well as the intensity of the noise. For example, 1 hour of exposure to a 100 dB sound level can produce a TTS that may last for about one day. However, in factories with noisy machinery, workers are subjected to high sound levels for several hours a day. Exposure to 95 dB for 8 hours everyday for over a period of 10 years may cause about 15 dB of NIPTS. In addition to hearing losses, excessive sound

levels can cause harmful effects on the circulatory system by raising blood pressure and altering pulse rates.

8.6.2 Effects of noise pollution on mental health:

Noise can also cause emotional or psychological effects such as irritability, anxiety and stress. Lack of concentration and mental fatigue are significant health effects of noise. It has been observed that the performance of school children is poor in comprehension tasks when schools are situated in busy areas of a city and suffer from noise pollution.

As noise interferes with normal auditory communication, it may mask auditory warning signals and hence increases the rate of accidents especially in industries. It can also lead to lowered worker efficiency and productivity and higher accident rates on the job.

Thus, noise is just more than a mere nuisance or annoyance. It definitely affects the quality of life. It is therefore important to ensure the mitigation or control of noise pollution.

Permitted noise levels

Zone	Day-time	Night-time
Silent Zone	50	40
Residential Zone	55	45
Commercial Zone	65	55
Industrial Zone	70	70

A standard safe time limit has been set for exposure to various noise levels. Beyond this 'safe' time continuing exposure over a period of a year will lead to hearing loss.

Duration	dB
8 hours	90
4 hours	93
2 hours	96
1 hour	99
30 minutes	102
15 minutes	105
7 minutes	108
4 minutes	111
2 minutes	114
1 minute	117
30 seconds	120
Instantaneous rupture of membrane	150

8.6.3 Noise-control techniques:

There are four fundamental ways in which noise can be controlled: reduce noise at the source, block the path of noise, increase the path-length, and protect the recipient. In general, the best control method is to reduce noise levels at the source.

Source reduction can be done by effectively muffling vehicles and machinery to reduce the noise. In industries, noise reduction can be done by using rigid sealed enclosures around machinery lined with acoustic absorbing material. Isolating machines and their enclosures from the floor, using special spring mounts or absorbent mounts and pads, and using flexible couplings for interior pipelines also contribute to reducing noise pollution at the source.

However, one of the best methods of noise source reduction is the regular and thorough maintenance of operating machinery. Noise levels at construction sites can be controlled using proper construction planning and scheduling techniques. Locating noisy air-compressors and other equipment away from the site boundary, along with creating temporary barriers to physically block the noise, can contribute to reducing noise pollution.

Most of the vehicular noise comes from the movement of the vehicle tires on the pavement and wind resistance. However, poorly-maintained vehicles can add to the noise levels. Traffic volume and speed also have significant effects on the overall sound. For example, doubling the speed increases the sound levels by about 9 dB and doubting the traffic volume (number of vehicles per hour) increases sound levels by about 3 dB. A smooth flow of traffic also causes less noise than does a stop-and-go traffic pattern. Proper highway planning and design are essential for controlling traffic noise. Establishing lower speed limits for highways that pass through residential areas, limiting traffic volume, and providing alternative routes for truck traffic, are effective noise- control measures. The path of traffic noise can also be blocked by constructing vertical barriers alongside the highway.

Planting trees around houses can also act as effective noise barriers. In industries, different types of absorptive material can be used to control interior noise. Highly- absorptive interior finish material for walls, ceilings and floors can greatly decrease indoor noise levels. Sound levels drop also significantly with increasing distance from the noise source. Increasing the path-length between the source and the recipient offers a passive means of control. Municipal land use ordinances pertaining to the location of airports make use of the attenuating effect of distance on sound levels. The use of earplugs and earmuffs can protect individuals effectively from excessive noise levels; specially-designed earmuffs can reduce the sound level reaching the eardrum by as much as 40 dB. However, very often workers tend not to wear them on a regular basis despite company requirements for their use.

8.7 Nuclear Pollution

One of the most important and dangerous type of pollution is nuclear pollution. Nuclear pollution is produced by nuclear explosion which are carried out for performing nuclear tests and which is used fro making nuclear weapons. Due to this explosion about 15 to 20% of the radioactive particles enter into the stratosphere. Once they entered into the air they continue to fall on the earth after about every 6 month up to several years. Almost 5% of the radioactive material entered into the troposphere, which is the lowermost layer of the atmosphere.

After the explosions the debris finally settled down in a few weeks. The smaller particles or fallout produced by the after the explosion or blast effects the leaves of the plant and damaging the tissue leaf. There leave are ingested by grazing animals and other living organisms which becomes so dangerous for their life. This radioactive iodine entered into the body of the man by the process of food chain. It further results into the thyroid cancer. Fallouts that stay in the atmosphere for year there slow accumulation in sea; vegetation is threat for living organism. Industrial plants, factories, power generating plants and solid wastes are responsible to add pollution. However, nuclear pollution is extremely hazardous in nature. It occurs as a result of

nuclear explosions that are performed while conducting nuclear tests. These nuclear tests are carried out to invent better nuclear weapons. The explosions cause release of 15 to 20% radioactive material into the stratosphere. On entering this layer, they start falling into the earth's atmosphere. This fall can take any where from 6months to several years. 5% of these radioactive particles enter troposphere, which is the lowest layer of the atmosphere.

The smallest particles of the radioactive material are called fallout. The fallout settles on the leaves of plants and trees. These leaves are eaten by the grazing animals. Radioactive material now enters the ecosystem. Humans consume these particles through the process of food chain. Serious health problems now arise. Ingestion of radioactive material can lead to cancer and genetic mutation in humans. Fallouts that do not drop on leaves accumulate over the sea. This can be harmful for the sea life, which ultimately affects the humans.

It isn't necessary that only nuclear power stations cause nuclear pollution. Even other industries, not related to nuclear power production, can also contribute to it. Coal has small amounts of radioactive material in the form of uranium and thorium. These do not burn completely and become part of fly ash. Even while producing oil and gas, radium and similar elements are released in to the air.

8.7.1 Nuclear hazards

Nuclear energy can be both beneficial and harmful, depending on the way in which it is used. We routinely use X-rays to examine bones for fractures, treat cancer with radiation, and diagnose diseases with the help of radioactive isotopes. Approximately 17% of the electrical energy generated in the world comes from nuclear power plants. However, on the other hand, it is impossible to forget the devastation that nuclear bombs caused in the cities of Hiroshima and Nagasaki. The radioactive wastes from nuclear energy have caused, and continue to cause, serious environmental damage.

Kinds of Radioactive Pollution.

(i) *Natural Source.* It comprises of *cosmic rays* coming from space and terrestrial radiations from *radio nuclides* present in the earth's crust occurring naturally in rocks, soil an water. Examples of radio nuclides are Radium 224, Uranium 235, Uranium 238, Thorium 232, Radon 222, Potassium 40 and Carbon 14.

(ii) *Man*-made Sources. These are a result of many man-made activities like:

(a) Mining and refining of plutonium and thorium.

(b) Production and explosion of nuclear weapons.

(c) Nuclear power plants producing nuclear energy.

(d) Preparation of radioactive isotopes like C^{14}, P^{35}.

Though man has always been exposed to low levels of radiation from natural sources for several million years, now the danger has increased due to man-made sources.

The nuclear weapons were used in the form of *atomic bombs* during Second World War. The

first bomb was exploded in Nagasaki and the second in Hiroshima (Japan, 1945). They caused huge devastation of innocent people, animals and plants.

Even today the craze for acquiring more and more of nuclear weapons by big powers is continuing unabated. At present there is enough stock-pile to destroy the complete earth.

Large unstable nuclei of some atoms lie Uranium 238 have a tendency to break up on their own (though found rarely in natural conditions). If Uranium 238 is *bombarded* with a slow moving neutron, splitting of uranium occurs which is known as *fission.* It is in the form of a chain reaction. During the fission, a large amount of *nuclear energy* is released.

- The nuclear fuels as well as the coolants have radioactive substance.
- The radioactive wastes contain activation products.
- Inert gases and halogens that may escape from nuclear reactors contain radioactive particles.
- People working in nuclear reactors may get it accidentally.

Radioactive pollution affects both plants and animals.

(i) In higher doses it causes instant deaths.

(ii) In lower doses it can affect all organs seriously and impair their functions.

(iii) Long or repeated exposure can causes cancer and leukaemia and may induce mutations.

(iv) The mutated genes can persist in the organism and the effects are passed on to the offspring.

In Japan, handicapped children were born to mothers exposed to radiations even after many years.

Nuclear fission is the splitting of the nucleus of the atom; the resulting energy can be used for a variety of purposes. The first controlled fission of an atom was carried out in Germany in 1938. However, the United States was the first country to develop an atomic bomb, which was subsequently dropped on the Japanese cities of Hiroshima and Nagasaki. The world's first electricity-generating reactor was constructed in the United States in 1951 and the Soviet Union built its first reactor in 1954. In December 1953, President Dwight D Eisenhower in his 'Atoms for Peace' speech made the following prediction:

'Nuclear reactors will produce electricity so cheaply that it will not be necessary to meter it. The users will pay a fee and use as much electricity as they want. Atoms will provide a safe, clean and dependable source of electricity.'

The degree and the kind of damage from nuclear accidents vary with the kind of radiation, the amount of radiation, the duration of exposure, and the types of cells irradiated. Radiation can also cause mutations, which are changes in the genetic makeup of the cells. Mutations can occur in the ovaries or the testes leading to the formation of mutated eggs or sperms, which in turn can lead to abnormal offspring. Mutations can also occur in the tissues of the body and may manifest themselves as abnormal tissue growths known as cancer. Two common cancers that are linked to increased radiation exposure are leukemia and breast cancer

8.8 SELF ASSESSMENT QUESTIONS:

1. Write an essay on the Air pollution.
2. What are the various sources and effects of Water Pollution
3. Describe the various aspects of marine pollution
4. Give an account of nuclear pollution and effects of radioactive materials.
5. Justify how noise acts as a pollutant and delineate its effects.

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Dr. P. Brahmaji Rao

LESSON – 9

SOLID WASTE POLLUTION AND MANAGEMENT AND ROLE OF INDIVIDUALS IN POLLUTION CONTROL

9.0 Objective

After studying this lesson, the student will be able to understand the Solid Waste Pollution, its management, Control Measures and Role of individuals in control of pollution

Structure

9.1 Solid Waste Management: Causes, Effects and Control Measures of Urban and Industrial Waste

In ancient cities, food scraps and other wastes were simply thrown into the unpaved streets where they accumulated. Around 320 BC in Athens, the first known law forbidding this practice was established and a system of waste removal began to evolve in several eastern Mediterranean cities. The initial disposal methods were very crude and were often just open pits outside the city walls. As populations increased, efforts were made to transport the wastes out further away from cities, thus creating city dumps. Until recently, the disposal of municipal solid waste did not attract much public attention. The favored means of disposal was to dump solid wastes outside the city or village limits, and occasionally burn or compact them.

Around most towns and cities in India, the approach roads are littered with multicolored plastic bags and other garbage. Waste is also burnt to reduce its volume. Modern methods of disposal such as incineration and the development of sanitary landfills, etc., are now attempting

to solve these problems. The lack of space for dumping solid waste has become a serious problem in several cities and towns all over the world. Dumping and burning wastes is not an acceptable practice today, from either an environmental or a health perspective. The disposal of solid waste should be part of an integrated waste management plan. The method of collection, processing, resource recovery and the final disposal should be synchronized to achieve a common objective.

9.2 Characteristics of Municipal Solid Waste

Solid wastes are grouped or classified in several different ways. These different classifications are necessary to address the complex challenges of solid waste management in an effective manner. The term municipal solid waste (MSW) is generally used to describe most of the non-hazardous solid waste from a city, town or village that requires routine collection and transport to a processing or disposal site. Sources of MSW include private homes, commercial establishments and institutions, as well as industrial facilities. However, MSW does not include wastes from industrial processes, construction and demolition debris, sewage sludge, mining wastes or agricultural wastes.

Municipal solid waste contains a wide variety of materials. It can contain food waste (like vegetable and meat material, leftover food, eggshells, etc.), which is classified as wet garbage as well as paper, plastic, tetra packs, plastic cans, newspaper, glass bottles, cardboard boxes, aluminum foil, metal items, wood pieces, etc., which is classified as dry garbage

9.3 Control measures of urban and industrial wastes:

An integrated waste management strategy includes three main components:

1. Source reduction

2. Recycling

3. Disposal.

9.3.1 Source reduction is one of the fundamental ways to reduce waste. This can be done by using less material when making a product, reusing products on site, designing products or packaging to reduce their quantity. On an individual level, we can reduce the use of unnecessary items while shopping, buy items with minimal packaging, avoid buying disposable items and also avoid asking for plastic carry bags.

9.3.2 Recycling is reusing some components of the waste that may have some economic value. Recycling has readily visible benefits like the conserving resources, reducing energy used during manufacture, and reducing pollution levels. Some materials, such as aluminum and steel, can be recycled many times. Metat, paper, glass and plastics are recyclable. Mining of new aluminum is expensive and, hence, recycled aluminum has a strong market and plays a significant role in the aluminum industry. Paper recycling can also help preserve forests, as it takes about 17 trees to make one ton of paper. Crushed glass *(cutlet}* reduces the energy required to manufacture new glass by 50%. Cullet lowers the temperature requirement of the glassmaking process thus conserving energy and reducing air pollution. However, even if recycling is a viable alternative, it presents several problems.

The problems associated with recycling are either technical or economical. Plastics are difficult to recycle because of the different types of polymer resins used in their production. Since each type has a distinct chemical composition, different plastics cannot be recycled together. Thus, separation of different plastics before recycling is necessary. Similarly, in recycled paper, the fibers are weakened and it is difficult to control the colour of the recycled product. Recycled paper is banned for use in food containers to prevent the possibility of contamination. It very often costs less to transport raw-paper pulp than scrap paper. Collection, sorting and transport account for about 90% of the cost of paper recycling. The processes of pulping, de-inking and screening wastepaper are generally more expensive than making paper from virgin wood or cellulose fibers. So, very often recycled paper is more expensive than virgin paper. However, as technology improves the cost will come down.

9.3.3 Disposal of solid waste is done most commonly through a sanitary landfill or through incineration. A modern sanitary landfill is a depression in an impermeable soil layer that is lined with an impermeable membrane. The three key characteristics of a municipal sanitary landfill

that distinguish it from an open dump are:

Solid waste is placed in a suitably selected and prepared landfill site in a carefully prescribed manner.

The waste material is spread out and compacted with appropriate heavy machinery. The waste is covered each day with a layer of compacted soil.

The problems with older landfills are usually associated with groundwater pollution. Pollutants seeping out from the bottom of a sanitary landfill (leachates) very often percolate down to the groundwater aquifer, no matter how thick the underlying soil layer. Today, it is essential to have suitable bottom-liners and leachate-collection systems along with the installation of monitoring systems to detect groundwater pollution. The organic material in the buried solid waste will decompose due to the action of microorganisms. At first the waste decomposes aerobically until the oxygen that was present in the freshly-placed fill is used up by the aerobic microorganisms. Then the anerobes take over, producing methane, which is poisonous and highly explosive when mixed with air in concentrations between 5 and 15%. The movement of the gas can be controlled by providing impermeable barriers in the landfill. A venting system to collect the blocked gas and vent it to the surface, where it can be safely diluted and dispersed into the atmosphere, is thus a necessary component of the design of sanitary landfills.

Although land filling is an economic alternative for solid waste disposal, it has become increasingly difficult to find suitable land filling sites that are within economic hauling distance and very often citizens do not want landfills in their vicinity. Another reason is that no matter how well-engineered the design and operation may be, there is always the danger of some environmental damage in the form of leakage of leachates.

Incineration is the process of burning municipal solid waste in a properly-designed furnace under suitable temperature and operating conditions. Incineration is a chemical process in which the combustible portion of the waste is combined with oxygen forming carbon dioxide and water, which are released into the atmosphere. This chemical reaction, called oxidation, results in the release of heat. For complete oxidation, the waste must be mixed with appropriate volumes of air at a temperature of about 815°C for about one hour. Incineration can reduce the municipal solid waste by about 90% in volume and 75% in weight. The risks of incineration, however, involve air-quality problems and toxicity and disposal of the fly- and bottom-ash produced during the incineration process. Fly-ash consists of finely-divided particulate matter, including cinders, mineral dust and soot. Most of the incinerator ash is bottom-ash while the remainder is fly-ash. The possible presence of heavy metals in incinerator ash is harmful. Thus, toxic products and materials containing heavy metals (e.g., batteries and plastics) should be segregated. Extensive air-pollution control equipment, high-level technical supervision and skilled employees for proper operation and maintenance are required.

So while sanitary landfills and incinerators have their own advantages and disadvantages, the most effective method of solid waste management is source reduction and recycling.

9.4 Vermi Composting

Nature has perfect solutions for managing the waste it creates, if left undisturbed. The biogeochemical cycles are designed to clear the waste material produced by animals and plants. We can mimic the same methods that are present in nature. All dead and dry leaves

and twigs decompose and are broken down by organisms such as worms and insects, and finally by bacteria and fungi, to form a dark rich soil-like material called compost.

These organisms in the soil use the organic material as food, which in turn provides them with nutrients for their growth and activities. These nutrients are returned to the soil to be used again by trees and other plants. This process recycles nutrients in nature.

This soil can be used as a manure for farms and gardens.

Earthworms used for Vermi composting

Steps for Vermicomposting

- Dig a pit about half a meter square, one meter deep
- Line it with straw or dried leaves and grass

- Organize the disposal of organic waste into the pit as and when generated
- Introduce a culture of worms that is now produced commercially
- Ensure that the contents are covered with a sprinkling of dried leaves and soil everyday
- Water the pit once or twice a week to keep it moist
- Turn over the contents of the pit every 15 days
- In about 45 days the waste will be decomposed by the action of the microorganisms
- The soil derived is fertile and rich in nutrients.

9.5 Hazardous Wastes

Modern society produces large quantities of hazardous waste that are generated by chemical manufacturing companies, petroleum refineries, paper mills, smelters, and other industries. Hazardous wastes are those that can cause harm to humans or the environment. Wastes are normally classified as hazardous wastes when they cause or significantly contribute to an increase in mortality, or an increase in serious irreversible or incapacitating reversible illness, or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of.

Characteristics of hazardous wastes

A waste is classified as a hazardous waste if it exhibits any of four primary characteristics based on the physical or chemical properties of toxicity, reactivity, ignitability and corrosivity. In addition to this, waste products that are either infectious or radioactive are also classified as hazardous.

Toxic *wastes* are those substances that are poisonous even in very small or trace amounts. Some may have an acute or immediate effect on humans or animals, causing death or violent illness. Others may have a chronic or long-term effect slowly causing irreparable harm to the exposed persons. Acute toxicity is readily apparent because organisms respond to the toxin shortly after being exposed. Chronic toxicity is much more difficult to determine because the effects may not be seen for years. Certain toxic wastes are known to be carcinogenic (causing cancer) and others may be mutagenic causing biological changes in the children of exposed people and animals.

Reactive wastes are those that have a tendency to react vigorously with air or water, are unstable to shock or heat, generate toxic gases, or explode during routine management; e.g., gunpowder, nitroglycerine, etc.

Ignitable wastes are those that burn at relatively low temperatures (less than 60°C) and are capable of spontaneous combustion during storage, transport or disposal; e.g., gasoline, paint thinners, and alcohol.

Corrosive wastes are those that destroy materials and living tissue by chemical reaction; e.g., acids and bases.

Infectious wastes include human tissue from surgery, used bandages and hypodermic needles, microbiological materials, etc.

9.6 Role of Individuals in Control of Pollution

There are a host of environmental problems caused by human actions on the environment. If we are to respond to these problems, we have to recognize that each of us is individually responsible for the quality of the environment we live in. Our personal actions can either worsen or improve our environmental quality. Several people may feel that environmental problems can be solved with quick technological solutions. While a majority of individuals want a cleaner environment, not many of them want to make the major changes in their lifestyle that would contribute to a cleaner environment. To a large extent, the decisions and actions of individuals determine the quality of life for everyone. This necessitates that individuals should not only be aware of various environmental issues and the consequences of their actions on the environment, but also make a firm resolve to develop environmentally-ethical lifestyles.

With the help of solar energy, natural processes developed over billions of years can indefinitely renew the topsoil, water, air, forests, grasslands and wildlife on which all forms of life depend, but only so long as we do not use these potentially renewable resources faster than they are replenished. Some of our wastes can be diluted, decomposed and recycled by natural processes indefinitely as long as these processes are not overloaded. Natural processes also provide services of flood prevention and erosion control at no cost at all. We must therefore learn to value these resources and use them sustainably.

Some concepts that help individuals contribute towards a better quality of our environment and human life are:

Develop respect for all forms of life.

Each individual must try to answer four basic questions:

Where do the things that I consume come from?

What do I know about the place where I live?

How am I connected to the Earth and other living things? What is my purpose and responsibility as a human being?

Try to plant trees wherever you can and more importantly take care of them. They reduce air pollution.

Reduce the use of wood and paper products wherever possible. Manufacturing paper leads to pollution and loss of forests which release oxygen and absorb carbon dioxide. Try to recycle paper products and use recycled paper wherever possible.

From the mail you receive reuse as many envelopes as you can.

Do not buy furniture, doors or window frames made from tropical hardwoods such as teak and mahogany. These are forest based.

Help in restoring a degraded area near your home or join an afforestation program.

Use pesticides in your home only when absolutely necessary and use them in small amounts.

Some insect species help to keep a check on the populations of pest species.

Advocate organic farming by asking your grocery store to stock organically-grown vegetables and fruits. This will automatically help to reduce the use of pesticides.

Reduce the use of fossil fuels by either walking short distances or using a car pool, sharing a bike or using public transport. This reduces air pollution.

Shut off the lights and fans when not needed. Don't use aerosol spray products and commercial air-fresheners. They damage the ozone layer.

Do not pour pesticides, paints, solvents, oil or other products containing harmful chemicals down the drain or onto the ground.

Buy consumer goods that last, keep them as long as possible and have them repaired as far as possible instead of disposing of them. Such products end up in landfills that could pollute groundwater.

Buy consumer goods in refillable glass containers instead of cans or throwaway bottles.

Use rechargeable batteries.

Try to avoid asking for plastic carry bags when you buy groceries or vegetables or any other items. Use your own cloth bag instead.

Use sponges and washable cloth napkins, dish towels and handkerchiefs instead of paper ones.

Don't use disposable paper and plastic plates and cups when reusable versions are available.

Recycle all newspaper, glass, aluminum and other items accepted for recycling in your area. You might have to take a little trouble to locate such dealers.

Set up a compost bin in your garden or terrace and use it to produce manure for your plants to reduce the use of fertilizers.

Try to lobby for setting up garbage separation and recycling programs in your localities. Choose items that have the least packaging or no packaging.

Start individual or community composting or vemi composting plants in your neighborhood and motivate people to join.

Do not litter the roads and surroundings just because the sweeper from the Municipal Corporation will clean it up. Take care to put trash into dustbins or bring it back home with you where it can be appropriately disposed.

You must realize that you cannot do everything and have solutions for every problem in the world. You can, however, concentrate on issues that you feel strongly about and can do something about. Focusing your energy on a particular issue will help you get better results.

You could join any of the several NGOs that exist in our country or become volunteers. Organize small local community meetings to discuss positive approaches to pollution

prevention.

Learn about the biodiversity of your own area. Understand the natural and cultural assets. This will help you to develop a sense of pride in your city/town/village and will also help you understand the problems facing their survival.

You cannot improve your world by not voting. You have the option to make a choice rather than complain later.

It is important that you do not get discouraged at the first sign of trouble. Do not dwelt on the negative aspects, but take positive actions wherever you can to make the world a better place to live.

When talking to elected officials always be courteous and reasonable. You may disagree with a particular position but be respectful in doing so as you will gain little by being hostile and brash.

Take care to put into practice what you preach. Remember environment protection begins with YOU.

9.7 SELF ASSESSMENT QUESTIONS

1. Describe the nuisance caused by solid waste.
2. Write an essay on the Vermicomposting
3. Explain the role of citizens in pollution control.
4. Explain the various management techniques of solid wastes.

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Dr. P. Brahmaji Rao

LESSON :10

ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

10.0 Objective :

After studying this lesson, the student will be able to understand the Environment, its effects on Population, Human Health, problems and impacts of urbanization

Structure

10.1 Population Growth:

Population growth is the change in a population over time, and can be quantified as the change in the number of individuals of any species in a population using "per unit time" for measurement. In biology, the term population growth is likely to refer to any known organism, but this article deals mostly with the application of the term to human populations in demography. Population growth rate

In demographics and ecology, Population growth rate (PGR) is the fractional rate at which the number of individuals in a population increases. Specifically, PGR ordinarily refers to the change in population over a unit time period, often expressed as a percentage of the number of individuals in the population at the beginning of that period. This can be written as the formula:

$$\text{Growth rate} = \frac{(\text{population at end of period} - \text{population at beginning of period})}{\text{population at beginning of period}}$$

Globally, the growth rate of the human population has been declining since peaking in 1962 and 1963 at 2.20% per annum. In 2009 the estimated annual growth rate was 1.1%. The CIA World Factbook gives the world annual birthrate, mortality rate, and growth rate (somewhat inconsistently) as 1.986%, 0.837%, and 1.13% respectively The last one hundred years have seen a rapid increase in population due to medical advances and massive increase in agricultural productivity made possible by the Green Revolution.

10.2 Environmental Effects of Population Growth

I want to do this! What's This?

Advances in technology, medicine and sanitation have lead to the growth of the human population at an exponential rate. However, unchecked population growth can negatively impact the environment. Aspects of the environment that population growth impacts includes resource use, habitat destruction, habitat fragmentation, pollution and public health problems.

10.2.1 Resource Use

A large population puts a great strain on resources. Non-renewable resources, such as fossil fuels (including coal and petroleum products) and freshwater, are particularly affected. Areas where access to freshwater is of particular concern include locations in the American West and places in the Middle East.

10.2.2 Habitat Destruction

A growing population requires a lot of space. As populations in cities grow, urban sprawl also grows, resulting in the destruction of critical habitat for a number of plant and animal species. The loss of habitat can result in the encroachment of animals, such as mountain lions, deer and coyotes, into suburban neighborhoods as they have nowhere else to go.

10.2.3 Habitat Fragmentation

Another impact of overpopulation is habitat fragmentation. Habitat fragmentation refers to natural habitats that are broken into separate pieces due to the construction of buildings, roads and other man-made objects. Habitat fragmentation is especially harmful to animal migration routes, as animals are often unable to access a critical portion of their migration pathway due to obstructions.

10.2.4 Pollution

Overpopulation has a negative impact on the environment due to pollution. The more people there are, the more resources they use, and the more pollution that results. This pollution may

include air pollution due to increased fossil fuel emissions from vehicles, or land or water pollution due to increased amounts of waste.

10.3 Environment and Human Health

Environment-related issues that affect our health have been one of the most important triggers in the increasing awareness of the need for better environmental management. The changes in our environment induced by human activities in nearly every sphere of life have had an influence on our health patterns. The assumption that the only indicator of human progress is economic growth is not true. We expect urbanization and industrialization to bring in prosperity, but on the downside, it leads to diseases related to overcrowding and poor quality drinking water, resulting in an increase in water-borne diseases like infective diarrhea and air-borne bacterial diseases like tuberculosis. High-density city traffic leads to an increase in respiratory diseases like asthma. Agricultural pesticides that enhanced food supplies during the green revolution have affected both the farm worker and all of us who consume the produce. Modern medicine promised to solve many health problems, especially associated with infectious diseases through antibiotics, but bacteria have found ways to develop resistant strains frequently even changing their behavior in the process, making it necessary to keep on creating newer in antibiotics. Many drugs have been found to have serious side-effects. Sometimes, the cure is as damaging as the disease process itself.

Thus, development has created several long-term health problems. While better health care has led to longer life-spans, coupled with lowered infant mortality, it has also led to an unprecedented growth in our population which has negative implications on environmental quality. A better health status of society will bring about a better way of life only if it is coupled with stabilizing population growth.

10.3.1 Environmental health

Environmental health, as defined by WHO, comprises those aspects of human health, including the quality of life, that are determined by physical, chemical, biological, social, and psychosocial factors in the environment. It also refers to the theory and practice of assessing, correcting, controlling, and preventing those factors in the environment that adversely affect the health of present and future generations.

Our environment affects health in a variety of ways. Climate and weather affect human health. Public health depends on sufficient amounts of good quality food, safe drinking water, and adequate shelter. Natural disasters such as storms, hurricanes, and floods still kill many people every year. Unprecedented rainfall triggers epidemics of malaria and water-borne diseases.

Global climate change has serious health implications. Many countries will have to adapt to uncertain climatic conditions due to global warming. As our climate is changing, we may no longer know what to expect. There are increasing storms in some countries, drought in others, and a temperature rise throughout the world. The *El Nino* winds affect weather world-wide. The *El Nino* event of 1997/98 had serious impacts on health and well-being of millions of people in many countries. It created serious drought, floods, and triggered epidemics. New strategies must be evolved to reduce our vulnerability to climate variability and changes.

10.3.2 Environmental Problems and Health Risks caused by Hazardous Wastes

As most of the hazardous wastes are disposed of on or in land, the most serious environmental effect is contaminated groundwater. Once groundwater is polluted with hazardous wastes it is very often not possible to reverse the damage.

Pesticides are used increasingly to protect and increase food production. They form residues in the soil that are washed into streams which then carry them forward. The residues may persist in the soil or in the bottom of lakes and rivers. Exposure can occur through ingestion, inhalation and skin contact, resulting in acute or chronic poisoning. Today, we have an alternative to the excessive use of pesticides through the use of Integrated Pest Management (IPM). The IPM system uses a wide variety of plants

and insects to create a more natural process. The natural balance between climate, soil and insect populations can help to prevent an insect from overpopulating an area and destroying a particular crop.

Lead, mercury and arsenic are hazardous substances, which are often referred to as heavy metals. Lead is an abundant heavy metal and is relatively easy to obtain. It is used in batteries, fuel, pesticides, paints, pipes and other places where resistance to corrosion is required. Most of the lead absorbed by people and wildlife is stored in the bones. Lead can affect red blood cells by reducing their ability to carry oxygen and shortening their lifespan. Lead may also damage nerve tissue, resulting in brain disease.

Mercury occurs in several different forms. Mercury is used in the production of chlorine, and as a catalyst in the production of some plastics. Industrial processes, such as the production of chlorine and plastics, are responsible for most of the environmental damage resulting from mercury. Our body has a limited ability to eliminate mercury. In the food web, mercury becomes more concentrated as it is taken up by various organisms. In an aquatic environment, mercury can be absorbed by plankton, which are then consumed by fish. In addition, fish absorb mercury through their gills and by eating other fish contaminated with mercury. Generally, the older the fish greater the mercury concentration in its body. Birds that eat the fish concentrate even more mercury in their bodies. It is a cumulative poison (it builds up in the body over long periods of time) and is known to cause brain damage.

Thousands of chemicals are used in industries everyday. When used incorrectly or inappropriately they can become health hazards. PCBs (Polychlorinated biphenyls) are resistant to fire and do not conduct electricity very well, which makes them excellent materials for several industrial purposes. Rainwater can wash PCBs out of disposal areas in dumps and landfills thus contaminating the water. PCBs do not break down very rapidly in the environment and thus retain their toxic characteristics. They cause long-term exposure problems to both humans and wildlife. PCBs are concentrated in the kidneys and liver and cause damage; they cause reproductive failure in birds and mammals.

Vinyl chloride is a chemical that is widely used in the manufacture of plastic. Usually people are only exposed to high levels of vinyl chloride if they work with it or near it, but exposure can also occur from vinyl chloride gas leaks. After a long continuous exposure (one to three years) in humans, it can cause deafness, vision problems, circulation disorders and bone deformities. Vinyl chloride can also cause birth defects.

It is essential to substitute the use of PCBs and vinyl chloride with chemicals that are less

toxic. Polyvinyl chloride use can be lowered by reducing our use of plastics. Thus, by reducing waste, encouraging recycling and using products that are well-made and durable we can greatly reduce our consumption of these chemicals thereby curtailing our exposure to these substances.

We' may not realize it, but many household chemicals can be quite toxic to humans as well as wildlife. Most of the dangerous substances in our homes are found in various kinds of cleaners, solvents and products used in automotive care. When these products are used incorrectly they have the potential to be harmful.

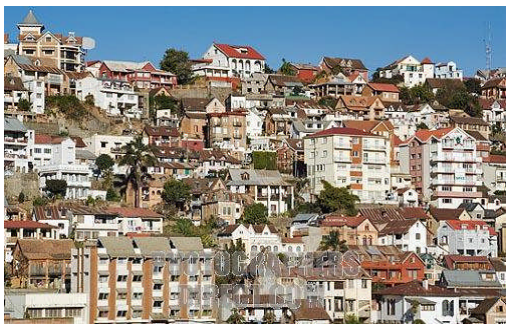
Today, the most common methods for disposing of hazardous wastes are land disposal and incineration. In countries where there is abundant land available for disposal, for example, North America, the most widely used method. In countries like Europe and Japan, where land is not readily available and is expensive, incineration is the preferred method for disposal. Despite strong laws, however, illegal dumping of these wastes continues. Hazardous waste management must move beyond burying and burning. Industries need to be encouraged to generate less hazardous waste in their manufacturing processes. Although toxic wastes cannot be entirely eliminated, technologies are available for minimizing, recycling and treating wastes. An informed public can also contribute in a big way towards this end. It is essential for us to understand the ill-effects of chemical substances so that we can make informed decisions about its use. We might decide that the benefits of the use of a toxic substance do not outweigh the risks and choose not to use it at all, or we may decide that it is acceptable to use a substance under certain specific circumstances where it is adequately controlled and exposure to toxic levels are prevented.

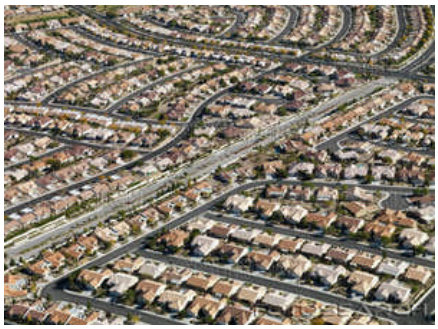
10.4 Problems of Urbanization

Urbanization 1975, only 27% of the people in the developing world lived in urban areas. By 2000, this had grown to 40% and by 2030, well informed estimates state that this will grow to 56%. The developed world is already highly urbanized with 75% of its population living in urban areas.

Urban population growth is both due to migration of people to towns and cities from the rural areas in search of better job opportunities as well as population growth within cities.

As a town grows into a city, it not only spreads outwards into the surrounding agricultural lands or natural areas such as forests, grasslands and wetlands, but also grows skywards with high- rise buildings. The town often loses its open spaces and green cover unless consciously preserved leading to the destruction of the quality of life in urban areas.





Good urban planning is essential for rational landuse, for upgrading slum areas, improving water supply and drainage systems, providing adequate sanitation, developing effective waste water treatment plants and an efficient public transport system.

While all these issues appear to be under the purview of local Municipal Corporations, better living conditions can become a reality only if every citizen plays an active role in managing the environment. This includes a variety of "DOS and Don'ts" that should become an integral part of our personal lives.

Unplanned and haphazard growth of urban complexes has serious environmental impacts. Increasing solid waste, improper garbage disposal and air and water pollution are frequent side effects of urban expansions.

10.5 Impacts of Urbanization

Unemployment is now considerable in many towns and informal sector opportunities (including market trade, food and betel nut selling and cleaning) cannot absorb growing population numbers. Low incomes and large household sizes have posed problems.

Though many migrants have achieved success, social problems, with domestic violence and family breakdown have sometimes occurred away from kin support and the 'subsistence safety net' of rural areas. Crime has worsened, creating a new security industry, raising the costs of business development and straining the judicial system. Socio-economic inequalities have grown.

Health and nutrition are sometimes poor in town where low incomes, poor access to gardens and the rise of a 'junk food' industry exist. Service provision (water, sewerage, electricity, waste removal etc.) is sometimes inadequate, especially in the squatter settlements that exist in marginal areas (such as remote, swampy or steeply sloping land). Housing is costly, low-cost housing scarce and rents are high.

Urban land is increasingly scarce, whether for housing, industrial development, recreation or opens space. Land tenure issues complicate urban management and planning as customary land remains in or close to most towns. Land use plans are therefore difficult to construct whilst town planning remains in its infancy.

Population densities are very high in some towns, especially in Micronesia, whilst lack of land has made waste disposal a problem. There is little recycling and a scarcity of landfill sites, especially in atoll environments. Many urban rivers and coastal lagoons are polluted and water supplies contaminated, posing threats to health.

10.6 SUSTAINABLE DEVELOPMENT

Sustainable development is a pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but also for generations to come. The term was used by the Brundtland Commission which coined what has become the most often-quoted definition of sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs.

Sustainable development ties together concern for the carrying capacity of natural systems with the social challenges facing humanity. As early as the 1970s "sustainability" was employed to describe an economy "in equilibrium with basic ecological support systems." Ecologists have pointed to The Limits to Growth,[citation needed] and presented the alternative of a "steady state economy" in order to address environmental concerns.

The field of sustainable development can be conceptually broken into three constituent parts: environmental sustainability, economic sustainability and sociopolitical sustainability.

Sustainable development in India now encompasses a variety of development schemes in social, cleantech (clean energy, clean water and sustainable agriculture) and human resources segments, having caught the attention of both the Central and State governments and also public and private sectors.

In fact, India is expected to begin the greening of its national income accounting, making depletion in natural resources wealth a key component in its measurement of gross domestic product (GDP).

Earlier man had limited needs and led a harmonious life with nature. With the advancement of science and technology, man has tried to manipulate the environment according to his needs, comfort and security. The needs have changed and the natural environment is shaped, and directed by socioeconomic consideration. It has caused depletion and degradation of natural resources.

Chances that have occurred in the natural environment are as under:

1. Old villages, hills, beaches and agricultural lands have been converted into cities and big towns.
2. For communication, a network of roads and transport has been established in villages as well as urban areas.
3. Importance to tourism had led to construction of big hotels occupying large areas.
4. Agricultural lands have been used to construct big hotels and industries.
5. To generate electricity for industries and large population, big dams have been constructed.

6. Conversion of forests into croplands or for human settlement has taken place.
7. Shrinking of water bodies has occurred.

The continuous increase in population and rapid development in the last century have imposed excessive demand on natural resources. There is a need to maintain a balance between the environment and development.

The need is to increase the production that is essential but at the same time to protect the environment and conserve the resources for future generation. This can be achieved by *sustainable development.* Conservation, sustainability and biological diversity are all inter-related. Sustainable development aims at harmony of man with nature and the practices that reduce dependence or use of natural resources. It can be achieved by various means like.

- Planting of more trees.
- Having more green grassy patches interspersed between concrete buildings.
- Adoption of technologies that are based on maximizing the recycling of materials.
- Making judicious and efficient use of natural resources.
- Adoption of environmental friendly techniques like crop rotation mixed cropping, bio-fertilizers and manures etc.

10.7 SELF ASSESSMENT QUESTIONS:

1. Explain how population growth influences the quality of Environment.
2. What are the impact of health on hazardous wastes
3. What is a Sustainable development.

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Dr. P. Brahmaji Rao

LESSON - 11

GLOBAL ENVIRONMENTAL PROBLEMS

11.0 Objective :

After studying this lesson, the student will be able to understand the Global Environmental Problems

STRUCTURE

11.1 Introduction

The industries in the area do not have proper effluent treatment plants. Among the big coal-based industries, the washeries account for the bulk of the pollution in terms of the total suspended solids (TSS), oil and grease. About 20% of the coal handled goes out in the form of slurry, which is deposited in the ponds outside. After the slurry settles, coalfine (the sediment) is collected manually. Due to inadequate retrieval methods very often the water discharges into the river from the pond carries high amounts of fine coal particles and oil, thus polluting the river. The other major coal-based polluters are the coke oven plants that heat coal to temperatures as high as 1100°C in the absence of oxygen to prepare it for use in blast furnaces and foundries. The volatile components in the coal are removed, leaving hot, non-volatile coke in the oven, which is washed with huge quantities of water. This water that contains oil and suspended particles is then discharged into the river.

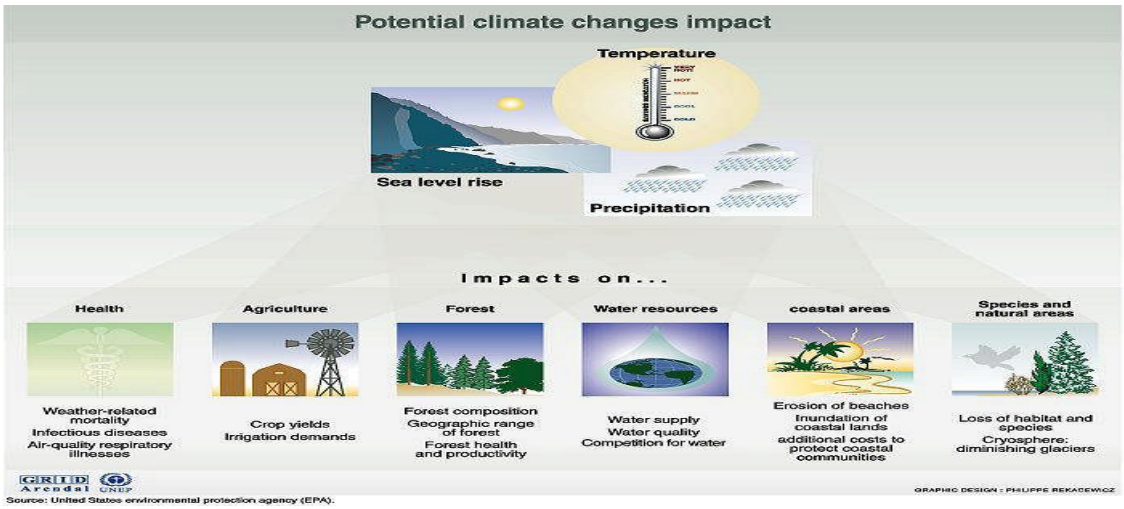
11.2 Fly-ash from the thermal power plants

Only one of the thermal power plants has an electrostatic precipitator to collect the fly-ash, while the other just make do with mechanical dust collectors. As most of these plants are located on the banks of the river, the fly-ash eventually finds its way into the river. The bottom-ash from the boilers is mixed with water to form a slurry, which is then drained into ash ponds. Most of the ponds are full and in several cases the drainage pipes are choked. The slurry is, therefore, directly discharged into the river.

11.3 Climate Change

The average temperature in many regions has been increasing in recent decades. The global average surface temperature has increased by 0.6°-0.2°C over the last century. Globally, 1998 was the warmest year and the 1990 the warmest decade on record. Many countries have experienced increases in rainfall, particularly in the countries situated in the mid- to high-latitudes.

These are calculated based on factors like future population growth and energy use. Climatologists of the Intergovernmental Panel on Climate Change (IPCC) have reviewed the results of several experiments in order to estimate changes in climate in the course of this century. These studies have shown that in the near future the global mean surface temperature will rise by 1.4°-5.8°C. This 'warming' will be greatest over land areas, and at high latitudes. A changing climate would bring about changes in the frequency and/or intensity of these extremes. This is also a fundamental concern for human health. To a large extent, public health depends on safe drinking water, sufficient food, secure shelter, and good social conditions. All these factors are affected by climate change. Freshwater supplies may be seriously affected, reducing the availability of clean water for drinking and washing during drought as well as floods. Water can be contaminated and sewage systems may be damaged. The risk of spread of infectious diseases such as diarrheal diseases will increase. Food production will be seriously reduced in vulnerable regions directly and also indirectly through an increase in pests and plant or animal diseases. The local reduction in food production would lead to starvation and malnutrition with long-term health consequences, especially for children. Food and water shortages may lead to conflicts in vulnerable regions. Climate change-related impacts on human health could lead to displacement of a large number of people, creating environmental refugees and lead to further health issues.

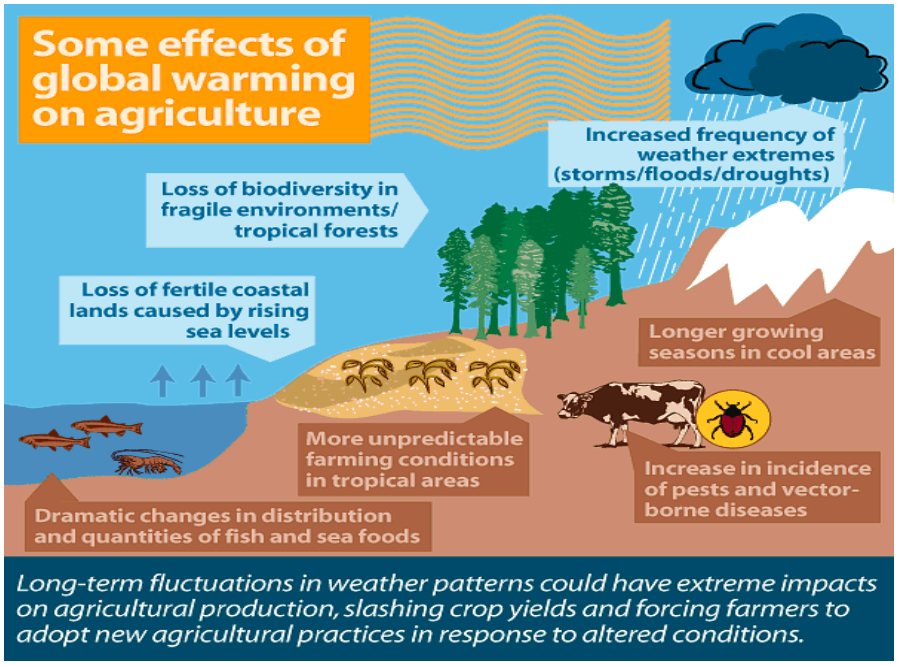


Changes in climate may affect the distribution of vector species (e.g., mosquitoes) which, in turn, will increase the spread of disease, such as malaria and filariasis, to new areas which lack a strong public health infrastructure. The seasonal transmission and distribution of many diseases that are transmitted by mosquitoes (dengue, yellow fever) and by ticks (Lyme disease, tick-^or^ encephalitis) may spread due to climate change.

11.4 Global Warming

About 75% of the solar energy reaching the Earth is absorbed by the Earth's surface, which increases its temperature. The rest of the heat radiates back to the atmosphere. Some of the heat is trapped by greenhouse gases (GHGs), mostly carbon dioxide. As carbon dioxide is released by various human activities, it is rapidly increasing. This is causing global warming.

The average surface temperature is about 15°C. This is about 33°C higher than it would be in the absence of the greenhouse effect. Without such gases, most of the Earth's surface would be frozen with a mean air temperature of -18°C.



Human activities during the last few decades of industrialization and population growth have polluted the atmosphere to the extent that it has begun to seriously affect the climate. The carbon dioxide in the atmosphere has increased by 31% since pro-industrial times, causing more heat to be trapped in the lower atmosphere. There is evidence to show that carbon dioxide levels are still increasing. Many countries have signed a convention to reduce GHGs under the United Nations Framework Convention on Climate Change (UNFCC). However, the current international agreements are not still effective enough to prevent the significant changes in climate and a rise in sea levels.

Global warming is accelerating faster than what climatologists had calculated a few years ago. In 1995, the IPCC predicted that global warming would raise temperatures by 3.5°-10°C during the 21st century, if the present trends continue. It is now believed that it could be much

greater. This would lead to not only to changes in temperature but also in the amount of rainfall. India may see great annual fluctuations in rainfall leading to floods and droughts.

11.5 Acid rains

When fossil fuels such as coal, oil and natural gas are burned, chemicals like sulfur dioxide and nitrogen oxides are produced. These chemicals react with water and other chemicals in the air to form sulfuric acid, nitric acid and other harmful pollutants like sulfates and nitrates. These acid pollutants spread upwards into the atmosphere, and are carried by air currents, to finally return to the ground in the form of acid rain, fog or snow. The corrosive nature of acid rain causes many forms of environmental damage. Acid pollutants also occur as dry particles and gases, which when washed from the ground by rain, add to the acids in the rain to form an even more corrosive solution. This is called acid deposition.

Damage from acid rain is widespread in North America, Europe, Japan, China and South-east Asia. In the US, coal-burning power plants contribute to about 70% of sulfur dioxide, in Canada, oil refining, metal smelting and other industrial activities account for 61% of the sulfur dioxide pollution. Motor vehicle exhaust fumes are the main source of nitrogen oxides. The acids in acid rain chemically react with any object they come into con, act with.

Effects

1. Acid rain dissolves and washes away nutrients in the soil, which are needed by plants. It can also dissolve naturally occurring toxic substances like aluminum and mercury, freeing them to pollute water or poison plants.

2. Acid rain indirectly affects plants by removing nutrients from the soil in which they grow. It affects trees more directly by creating holes in the waxy coating of leaves, causing brown dead spots which affect the plant's photosynthesis. Such trees are also more vulnerable to insect infestations, drought and cold. Spruce and fir forests at higher elevations seem to be most at risk. Farm crops are less affected by acid rain than forests.

3. Acid rain that falls or flows as ground water to reach rivers, lakes and wetlands, causes the water in them to become acidic. This affects plant and animal life in aquatic ecosystems.

4. Acid rain also has far reaching effects on wildlife. By adversely affecting one species, the entire food chain is disrupted, ultimately endangering the entire ecosystem. Different aquatic species can tolerate different levels of acidity. For instance clams and mayflies have a high mortality when water has a pH of 6.0. Frogs can tolerate more acidic water, although with the decline in supply of mayflies, frog populations may also decline. Land animals that are dependent on aquatic organisms are also affected.

5. Acid rain and dry acid deposition damages buildings, automobiles, and other structures made of stone or metal. The acid corrodes the materials causing extensive damage and ruins historic buildings. For instance the Parthenon in Greece and the Tajmahal in India have been affected by acid rain.

6. Although surface water polluted by acid rain does not directly harm people, the toxic substances leached from soil can pollute the water supply. Fish caught in these waters may be harmful for human consumption. Acid, along with other chemicals in the air, produces urban smog, which causes respiratory problems.

The best way to stop the formation of acid rain is to reduce the emissions of sulfur dioxide and nitrogen oxides into the atmosphere. This can be achieved by using less energy from fossil fuels in power plants, vehicles and industries. Switching to cleaner burning fuels is also a way out. For instance using natural gas which is cleaner than coal or using coal with lower sulfur content. Developing more efficient vehicles will reduce pollutants from being released into the air. If pollutants have already been formed by burning fossil fuels, they can be prevented from entering the atmosphere by using scrubbers in the smokestacks of factories. These spray a mixture of water and limestone into the polluting gases, recapturing the sulfur.

In catalytic converters, the gases are passed over metal coated beads that convert harmful chemicals into less harmful ones. These are used in cars to reduce the effects of exhaust fumes on the atmosphere. Once acid rain has affected soil, powdered limestone can be added to the soil by a process known as liming to neutralize the acidity of the soil.

11.6 Ozone Depletion

Ozone is formed by the action of sunlight on oxygen. It forms a layer 20 to 50 kms above the surface of the Earth. This action takes place naturally in the atmosphere, but is very slow. Ozone is a highly poisonous gas with a strong odor. It is a form of oxygen that has three atoms in each molecule. It is considered a pollutant at ground level and constitutes a health hazard by causing respiratory ailments like asthma and bronchitis. It also causes harm to vegetation and leads to a deterioration of certain materials like plastic and rubber. Ozone in the upper atmosphere however, is vital to all forms of life as it protects the Earth from the Sun's harmful UV radiation. The ozone layer in the upper atmosphere absorbs the Sun's UV radiation, preventing it from reaching the Earth's surface.

In the 1970s, scientists discovered that chemicals called chlorofluorocarbons or CFCs, which are used as refrigerants and aerosol spray propellants, pose a threat to the ozone layer. The CFC molecules are virtually indestructible until they reach the stratosphere, where UV radiation breaks them down to release chlorine atoms. These chlorine atoms react with ozone molecules which break down into oxygen molecules. These oxygen molecules do not absorb UV radiation. Since the early 1980s, scientists have detected a thinning of the ozone layer in the atmosphere above Antarctica. This phenomenon is now being detected in other places as well including Australia.

The destruction of the ozone layer causes increased incidence of skin cancer and cataracts. It also causes damage to certain crops and plankton, thus affecting natural food chains and food webs. This decrease in vegetation leads to an increase in carbon dioxide.

With the signing of the Montreal Protocol in 1987, a treaty for the protection of the ozone layer, the use of CFCs was to be banned by the year 2000, after which the ozone layer is expected to slowly recover over a period of about 50 years. Although the use of CFCs has been reduced and now banned in most countries, other chemicals and industrial compounds such as bromine, halocarbons and nitrous oxides from fertilizers continue to attack the ozone layer.

Ozone depletion: What does it do?

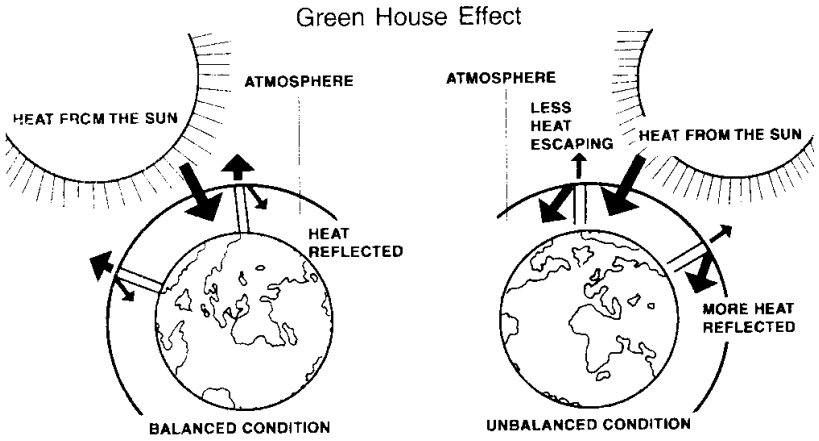
Changes in the ozone layer have serious implications for mankind.

Effects on human health: Sunburn, cataract, aging of the skin and skin cancer are caused by increased UV radiation. It weakens the immune system by suppressing the body's resistance to certain infections like measles, chickenpox and other viral diseases that elicit rash and parasitic diseases such as malaria introduced through the skin.

Food production: UV radiation affects the ability of plants to capture light energy during the process of photosynthesis. This reduces the nutrient content and the growth of plants; this is especially seen in the case of legumes and cabbage.

Plant and *animal* planktons are damaged by UV radiation. In zooplanktons (microscopic animals), the breeding period is shortened by changes in radiation. As planktons form the basis of the marine food chain, any change in their number and species composition influences fish and shellfish production.

Effect on materials: Increased UV radiation damages paints and fabrics, causing them to fade faster.



Effect on climate: Atmospheric changes induced by pollution contribute to *global warming,* a phenomenon which is caused due to the increase in concentration of certain gases like carbon dioxide, nitrogen oxides, methane and CFCs.

Observations of the Earth have shown beyond doubt that atmospheric constituents like water vapor, carbon dioxide, methane, nitrogen oxides and CFCs trap heat in the form of infra-red (IR) radiation near the Earth's surface. This is known as the 'Greenhouse Effect'. The phenomenon is similar to what happens in a greenhouse. The glass in a greenhouse allows solar radiation to enter, which is absorbed by the objects inside. These objects radiate heat in the form of terrestrial radiation, which does not pass out through the glass.

The heat is, therefore, trapped in the greenhouse increasing the temperature inside and ensuring the luxuriant growth of plants.

There could be several adverse effects of global warming.

With a warmer Earth, the polar ice caps will melt causing a rise in ocean levels and flooding of coastal areas.

In countries like Bangladesh or the Maldives this would be catastrophic. If the sea level rises by 3 m, the Maldives will disappear completely beneath the waves.

The rise in temperature will bring about a fall in agricultural produce.

Changes in the distribution of solar energy can bring about changes in habitats. A previously productive agricultural area will suffer severe droughts, while rains will fall in locations that were once deserts. This could bring about changes in the species of natural plants, agricultural crops, insects, livestock, and microorganisms.

In the Polar Regions, temperature rises caused by global warming would have disastrous effects. Vast quantities of methane are trapped beneath the frozen soil of Alaska. When the permafrost melts, the methane that will be released can accelerate the process of global warming.

11.7 SELF ASSESSMENT QUESTIONS:

1. Write an essay on global warming.
2. What are the sources and effects of acid rains
3. Explain the impacts of ozone depletion
4. What are the environmental impacts of climate change.

11.8 REFERENCES

1. Environmental Studies from Crisis to Cure, Rajagopalan, Oxford University Press, New Delhi
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